

# ZERO DEBRIS TECHNICAL FORUM

Webinar

22.04.26





# Zero Debris Webinar Agenda

Time	Session	Duration	Content	Speaker
16:00–16:05	<b>Zero Debris Technical Forum updates</b>	5 min	<b>Updates:</b> change of name & structure (Zero debris technical forum), vision, definition of 2026 roadmap & priorities	Tiago
16:05-16:10	<b>Coordination Group</b>	5 min	<b>-Roles &amp; responsibilities</b> of the CG (communication, outreach etc. ) - Ongoing activities (White Papers) -Coordination Platform	Noelia
16:10–16:40	<b>Booklet Technical Updates</b>	30 min	<b>-Overview of the Booklet</b> <b>-Summary of the mapping and prioritization tasks</b> <b>- Zero Debris Database</b>	Jesus and Bradley
16:40–16:50	<b>Q&amp;A</b>	10 min	Questions from the audience	All



# **Zero Debris Technical Forum**

## **Introduction and Updates**

# Zero Debris Charter – Principles and Targets

## Principles

### Release of space debris

No intentional release of space debris and minimise unintentional generation

1

### Adverse consequences of Space Debris

Adverse impacts of space debris on the population, infrastructure, earth environment, and dark and quiet skies should be minimised.

2

### Common knowledge and understanding of Space Debris

Constant and collaborative efforts to improve our understanding of the space debris population and its impacts

3

## Targets

### Probability of Debris generation by break-ups or collisions

The probability of space debris generation through collisions and break-ups should remain below 1 in 1000 per object during the entire orbital lifetime.

1

### Timely and successful clearance

Timely clearance of low Earth orbit and geostationary Earth orbit regions should be achieved with a probability of success of at least 99% after end of mission, including through external means when necessary.

2

### Casualty risk on ground

The casualty risk from re-entering objects should remain significantly lower than 1 in 10 000, striving towards zero casualty. A suitable aggregate risk threshold for constellations of satellites in the low Earth orbit region should be identified.

3

### Space Traffic Coordination

Routine and transparent information sharing should be facilitated and active participation in strengthening global space traffic coordination mechanisms should be encouraged.

4

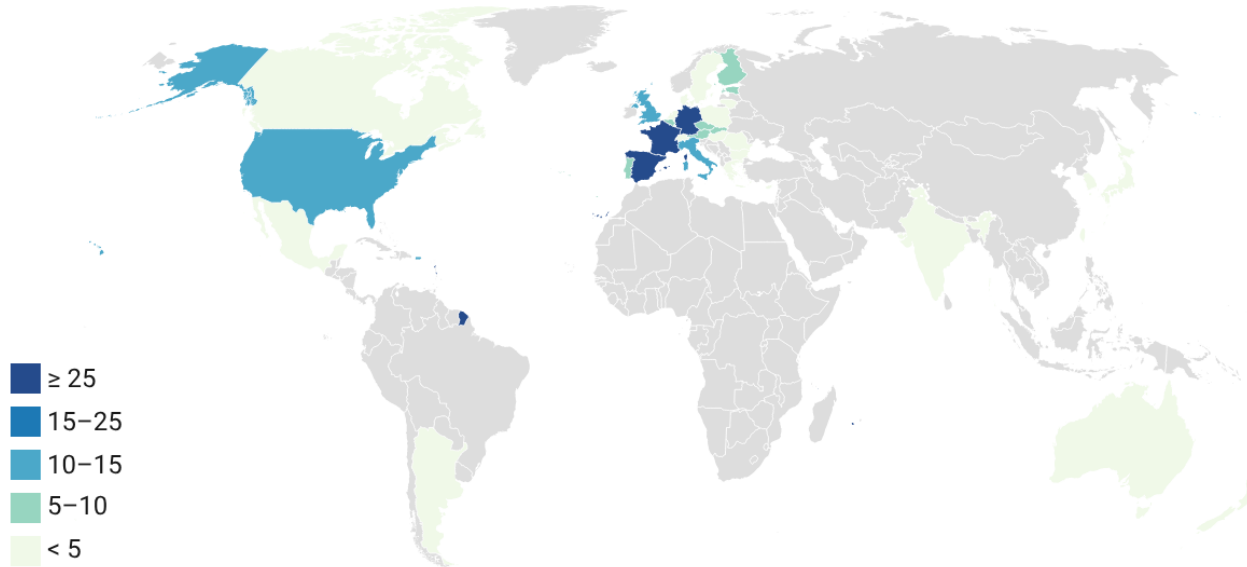
### Space Surveillance and Tracking

Access to timely and accurate data on space objects down to a size of 5 cm or smaller in low Earth orbit and 20 cm or smaller in geostationary Earth orbit should be improved to enhance decision making capabilities for collision avoidance.

5

# ZD Charter Signatories

Number of signatories per country



**228 (+46)**  
signatories from  
**34 (+1)**  
countries, incl.  
**21 (+1)**  
States  
(since Sep. 2025)

States signatories



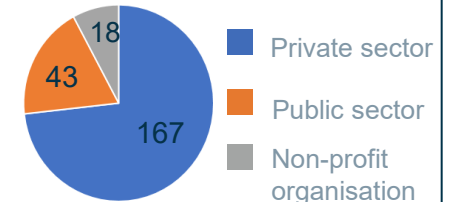
**Spain signed the Charter on 16 Oct. 2025**

The **IEEC<sup>®</sup>**, one of the first Charter signatory, co-organised a signature ceremony on 19 November 2025 at the Space Tech Expo, where 17 new signatories joined the Zero Debris Community.



a leading research institute in the Netherlands, **co-organised** a signature ceremony on 4 March 2026 at the Amsterdam Space Symposium, where 6 additional organisations joined the community.

Among the **new signatories**:





# ZD Charter and ZD Booklet

Where we want to be by 2030?

## Zero Debris Charter



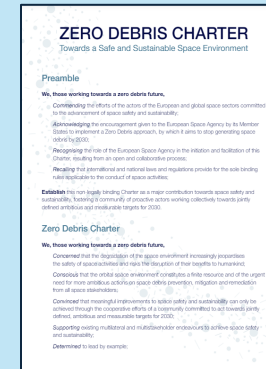
Published in  
**Oct 2023**



**Signature ceremonies** ongoing



**228 signatories**  
as of April 2026.



How to get there?

## Zero Debris **Technical Booklet**

How can the booklet be useful?

As a support for :

- Defining **sustainability strategy** and **priorities**
- Engaging with the community for **collaboration**
- Identifying **contributions** and **needs**



1st issue  
released  
on **January 15th 2025**



ZD Week – June 2025

# Differences Between Booklet vs Charter

The **ZD Technical Booklet** and the **ZD Charter** are both community driven, are **aiming at 2030**. The Booklet is a **crowd-sourced portfolio of technical solutions** that need to be developed **to reach the 2030 targets** defined in the ZD Charter.



## TECHNICAL BOOKLET

Technical needs, solutions and contributions gathered through the Zero Debris community to achieve the jointly defined targets by 2030



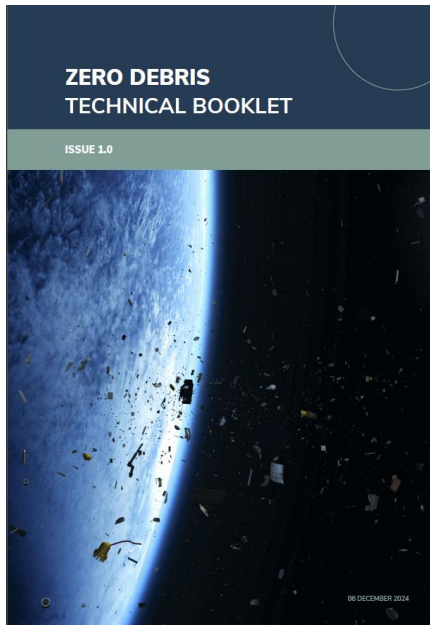
## CHARTER

Engaging like-minded actors of the space sector in a collective effort towards space safety and sustainability



# ZD Booklet to ZD Technical Forum: what changed?

A transition was made from the **ZD Technical Booklet** to a community of technical experts producing new outputs and collaborations within the **Zero Debris Technical Forum**.



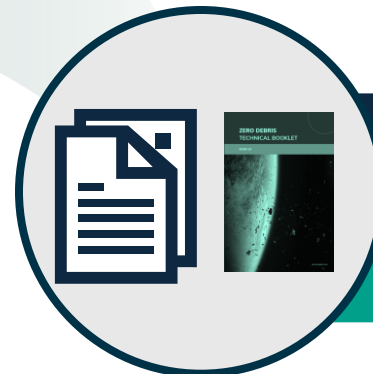
Technical Domain Leads (Technical)

Coordination Group (Logistical)



Zero Debris Database

Coordination Platform



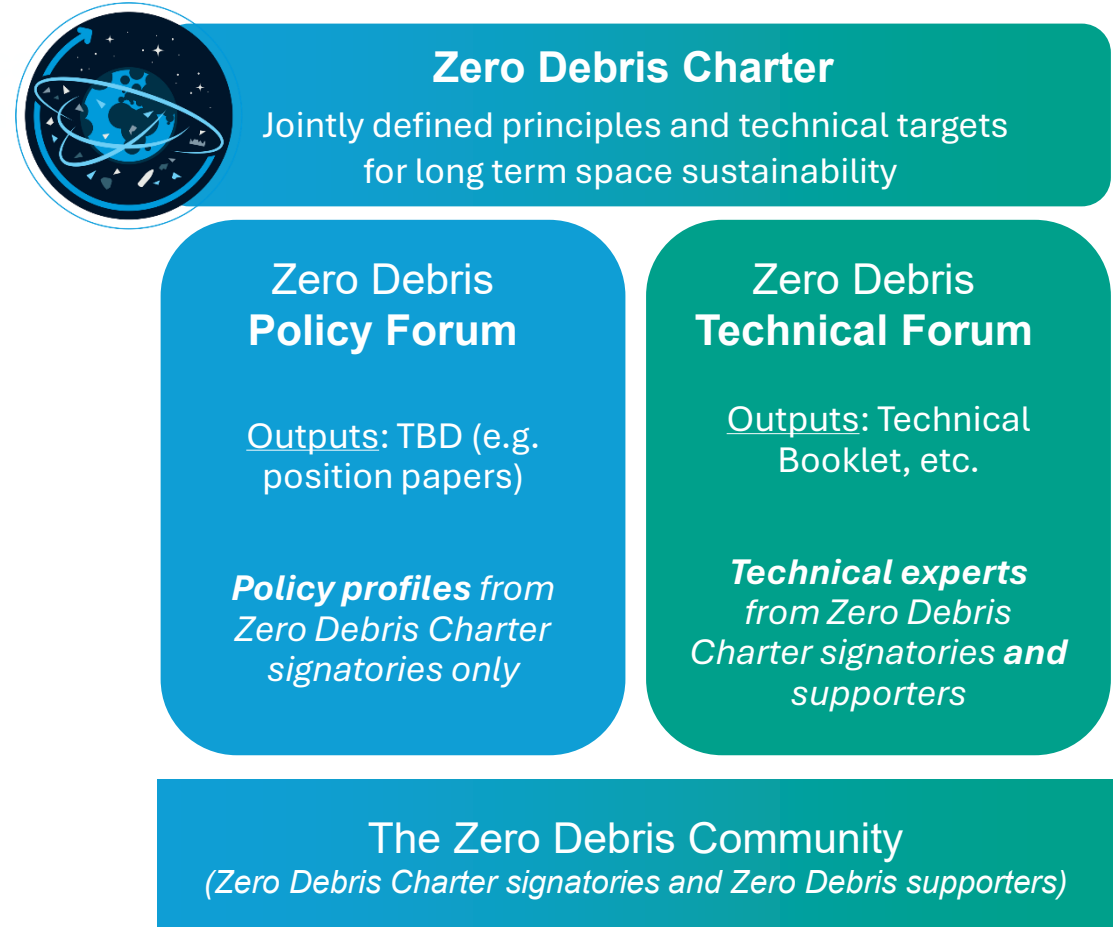
White Papers

Future Booklet Issues

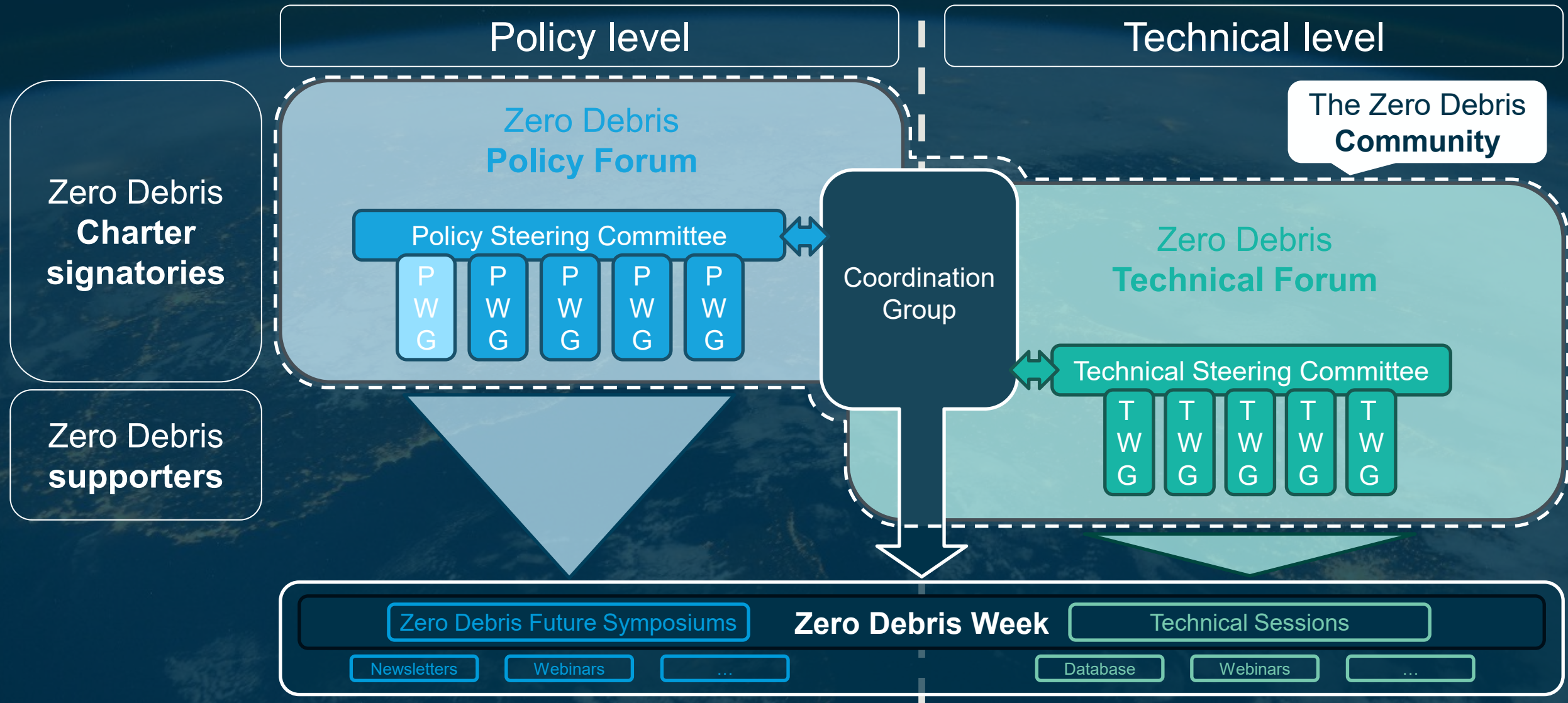
# Technical Forum vs Policy Forum

The **Zero Debris Technical Forum** has been successful in creating the ZD Booklet and active **technical working groups** addressing different technical domains.

The new **Zero Debris Policy Forum** will apply the same approach to questions of policy around Zero Debris, forming new **Policy Working Groups** in different domains.



# New Zero Debris Structure





# ZD Community Upcoming Events

## **CLEAN SPACE DAYS**

**29 June – 3 July 2026**

ESA – ESTEC, The Netherlands

- **Conference on Zero Debris, In-Orbit Servicing and Eco Design**
- Zero Debris Topics:
  - Zero Debris Platform activities
  - Space Debris Mitigation requirements
  - compliance & evolution
  - Design for Demise
  - Design for Removal
  - Dark and Quiet Skies
  - Deorbit & passivation devices
  - Design for Robustness to Hypervelocity Impact
  - Collision Risk Management
  - Enhanced health monitoring & reliability
- **ZD Technical Forum Workshop:**
  - Prioritization Task finalization
  - Working Session on White Papers



ESA – ESTEC, The Netherlands

**Registration Deadline May 15th**



**ZERO DEBRIS TECHNICAL FORUM | WEBINAR**

# ZD Community Upcoming Events



## ZERO DEBRIS WEEK

8 Sept- 11 Sept

Spanish Space Agency – Seville. Spain

- **3rd Zero Debris Future Symposium** and a workshop on the **Zero Debris Technical Forum**
- **Technical Sessions:**
  - Mapping and prioritisation tasks summary
  - Pitches of enablers identified as priorities
  - Working session on white papers
  - Working session on database updates
  - Training session on outreach/internationalisation
  - Discussions on next steps
  - B2B meetings

**Registration Deadline May 15th**



## Seville. Spain

Image credit: Francisco Colinet via Wikimedia Commons

**ZERO DEBRIS TECHNICAL FORUM | WEBINAR**



**Zero Debris Technical Forum:  
Coordination Group**

# Coordination Group Members

The Coordination Group consists of **elected representatives of ZD Charter Signatories** and are responsible for the logistics and coordination of Zero Debris community



**Noelia Sánchez-Ortiz**  
Co-Founder of Arribes Enlightenment



**Juan Carlos Dolado Pérez**  
Co-Founder and CTO of Look Up Space



**Tiago Soares**  
Head of Clean Space and Circular Economy  
Office – ESA ESTEC



**Carolin Frueh**  
Harold DeGross Associate Professor, School of  
Aeronautics and Astronautics, Purdue University



**Thomas Reiter**  
Former ESA Astronaut and Head  
of the Space and Security Division  
at the Federal Ministry of  
Research, Technology and Space

➔  
Replacement  
under  
discussion



**Pedro Duque**  
Former ESA Astronaut and  
former Minister of Science and  
Innovation of Spain



# Coordination Group Ongoing Actions



**Provide a vision, roadmap, and clear goals** for the Zero Debris community



**Internal Communication:** set up a communication platform and define proper guidelines for community interactions



**Development of a technical database:** a centralised resource to trigger synergies and collaboration in the community



**White papers:** position papers and technical perspectives from the ZD community



**Outreach and internationalisation:** increase the profile of the Zero Debris effort and broaden its international reach

# Coordination Group Current Roles



**Noelia Sánchez-Ortiz**

Co-Founder of Arribes  
Enlightenment



Internal Communication  
and Outreach



**Juan Carlos Dolado Pérez**

Co-founder and CTO of Look Up  
Space



White Papers  
Coordination



**Tiago Soares**

Head of Clean Space and Circular  
Economy Office – ESA ESTEC



Database set-up



**Carolin Frueh**

Harold DeGross Associate Professor, School  
of Aeronautics and Astronautics, Purdue  
University



White Papers  
Coordination and  
Outreach

# Updates



## White Papers

**Co-development with  
Technical Leads** on  
White Papers



## Outreach

Ongoing development of  
**shared communication  
materials.**

Presentation of the Zero Debris  
Initiative to the IAA Space Debris  
Committee during IAF Spring  
Meetings 2026, Paris



## Communication Platform

**Creating a dedicated  
Teams platform** for the  
Zero Debris community.



If you would like to contribute to these projects, please contact [cleanspace@esa.int](mailto:cleanspace@esa.int)



# Communication Platform



## Requirements & Survey Results

### 1. Top Priority: Core Features

- **Single Unified Platform:** Preference for a standalone solution over a mix of disjointed tools.
- **Knowledge Management:** Centralized **shared file repository** and organized **discussion channels**.
- **Live Collaboration:** High demand for **real-time co-editing** and instant messaging/chat.
- **Project Governance:** Integrated **task management** and formal **voting/decision-making** features.
- **Direct Interaction:** Seamless support for voice and video meetings.

### 2. Current Ecosystem

Category	Primary Tools
Mainstream Suites	MS Teams, SharePoint, OneDrive
Communication	Slack
Storage	Google Drive

### 3. Organization “Red Lines”

- **IT Security:** Strong internal constraints and restrictive policies on external collaboration tools.
- **Active Collaboration:** Popular tools like Webex and Zoom are strictly limited to attending meetings, not for active project development.
- **Platform Approval:** High effectiveness is currently limited only to internally approved environments (Teams/SharePoint).



# Communication Platform



## Proposed Approach

### Microsoft Teams based

- High level of adoption across participating organisations
- Compliance with corporate IT and security constraints
- Integrated collaboration functionalities (files, chat, meetings, co-editing)
- Scalability and structured governance



### Platform Structure

#### Channels

- General Channel (all members)
- Technical Group Channels (restricted per group)
- Coordination Group Channel (restricted)

#### Functional Capabilities

- Communication threads (posts)
- Document repository (SharePoint)
- Notes (Minutes of Meeting)
- Task tracking (Planner / Lists where applicable)

Additional tools may include: Member directories, Calendars, Surveys (Forms), Voting mechanisms

# Communication Platform



## Proposed Approach

The screenshot displays the 'Zero Debris Community' interface. At the top, there is a navigation bar with a back arrow, a 'ZD' logo, and the community name. Below this, a secondary navigation bar includes 'Channels', 'Members', 'Pending requests', 'Settings', 'Analytics', 'Apps', and 'Tags'. The main content area features a filter bar with 'All', 'Shown for you', and '4 more' buttons, along with a 'Sort: A-Z' dropdown, an '+ Add channel' button, and a 'Search channels' input field. The channel list includes:

- Coordination Group** (Last active: about 2 months ago)
- General** (Last active: 30 days ago) - Central hub for the Zero Debris community to share information, coordinate activities, and enable structured and efficient communication among members.
- Policy Working Group** (Last active: 7 days ago)
- TD 1 and 3 – Prevent Debris Release or Generation** (Last active: 7 days ago)
- TD 2 – Guarantee Timely and Successful Clearance** (Last active: 7 days ago)
- TD 4 – Improve Space Traffic Surveillance and Coordination** (Last active: 7 days ago)
- TD 5 – Prevent Casualties on Ground** (Last active: 7 days ago)
- TD 6 – Understand and Mitigate Adverse Consequence** (Last active: 7 days ago)
- TD 7 – From Zero Debris to a Circular Economy** (Last active: 7 days ago)



# Communication Platform



## Governance Model (under review)

### Microsoft Teams based

**Platform Ownership.** The platform will be managed by:

- Tenant owner representatives
- ZD Technical Secretariat

**Responsibilities.** They are responsible for:

- Platform administration
- Access management (granting/removal)
- Technical oversight (best-effort basis)

**Channel Management.** Each channel will be managed by:

- Working Group Managers
- Platform administrators

### Access Rules

- Members can read, upload, and edit content
- Members cannot grant access to third parties
- Access is strictly limited to authorised ZD participants
- 

### Code of Conduct ( to be agreed)

- Responsible Use of the Platform
- Data Protection (GDPR)
- IP and Information Usage
- Liability and Responsibility
- Compliance and Enforcement
- Platform Provision and Continuity
- Membership Management



# Joining the Zero Debris Community

We are currently transitioning towards a smoother, centralized subscription approach.

Until this is in place, you can join us through the following methods:

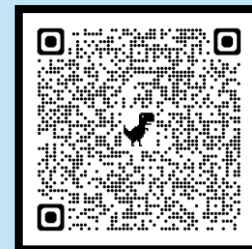
## ZERO DEBRIS CHARTER



- **Participate** in regular **community events**, such as the Zero Debris Week, Webinars, and Conferences
- Receive the **Zero Debris Community Newsletter** and stay informed on updates and opportunities

## ZERO DEBRIS TECHNICAL FORUM

- **Participation in one or more Technical Working Groups** linked to the different **Booklet** chapters is possible, allowing contributors to **directly support** the related technical work





# **Zero Debris Technical Booklet: Technical Updates**

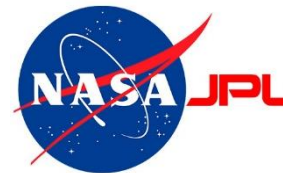
# ZD Charter - Coordinator Domain 2



**Jesús Manuel Muñoz Tejeda**

- 2023 – Present, CEO & Cofounder of **PERSEI Space**, a Spanish company to develop autonomous deorbit devices and propellant-free space propulsion
- 2024-2025, Visiting research at **NASA-Jet Propulsion Laboratory** on new space propulsion concepts
- 2020-2024, Co-funded PhD research at the **European Space Agency** and Imperial College London
- 2023, Visiting Research at **Stanford University**
- 2020-2021, Design and Development Engineer at the **European Centre for Nuclear Research (CERN)**

*Useful links: [Personal Website](#), [ResearchGate](#), [LinkedIn](#)*



# ZD Booklet - Coordinator Domain 5



**Bradley Lockett**

## Process Qualification Engineer, OHB System

As of  
2026:

- Primary work focus on D4D
- Working on R&D topics within Materials and Processes

2023 –  
2025:

- Working on Casualty Risk topics (primarily D4D)
- Demisability Systems Engineer for Zero Debris Platform Phase 1

2018 –  
2023:

- Working on Casualty Risk R&D topics (primarily D4D) from end of 2019
- Primary work focus on project platform needs



# Technical Steering Group

The Technical Steering Group consists of the elected **Technical Working Groups Coordinators** and handles the technical content of the Booklet.



**Jesús Manuel Muñoz Tejada**

PERSEI Space CEO and Co-Founder



**Yash Chandramouli**

Space Sustainability Engineer at Project Kuiper



**Trunal Patil**

R&T Scientist in Lunar Sustainability



**Vitali Braun**

Space Debris Engineer at ESA



**Naman Chawla**

Founder of OrbitArch



**Siegfried Eggl**

Assistant Professor at University of Illinois Urbana-Champaign



**Christophe Bonnal**

Senior Expert at MaiaSpace



**Alessandra Rossetti**

Satellite Operations at Viasat



**Bradley Lockett**

Process Qualification Engineer at OHB



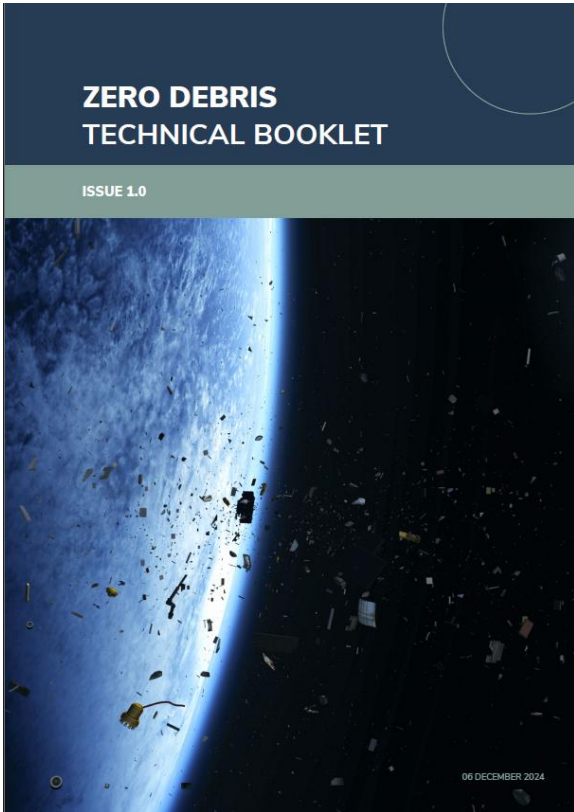
**Enrique Allona**

Satellite Fleet Engineer at Eutelsat

# Introduction to the Zero Debris Booklet



- The Booklet serves as a **resource to support the Zero Debris Community** in directing its resources **towards research and future technology developments.**
- It is **technically focussed, non-binding, and collaborative.**
- First Issue published in 2025

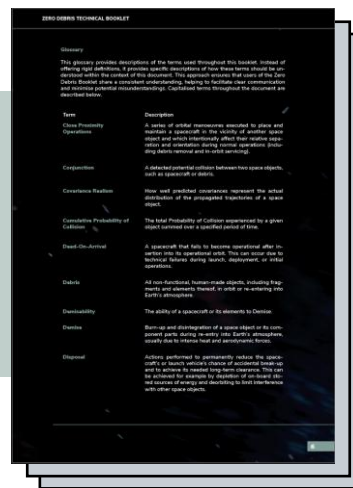


## Introduction



- Background
- Scope

## Glossary



- Description of terms used

## 6 Technical Chapters



- Needs, Key Enablers and Solutions for Zero Debris by 2030

## Vision for a Circular Economy in Space



- Long-term Vision
- Becoming Technical Chapter

# Needs, solutions and key enablers

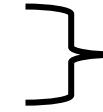
## 2.1. IMPROVE ORBITAL CLEARANCE WITH HIGH PROBABILITY OF SUCCESSFUL DE-ORBITING

De-orbiting systems and architectures that enable an object to de-orbit itself at End of Mission currently exist for some use cases (e.g. de-orbit systems for spacecraft in LEO) but need to be made affordable and more reliable in order to reach high clearance success rates and widespread adoption. In addition, other solutions could be explored for different orbital regions and use cases (e.g. Disposal from MEO, mission extension, etc.) Solutions to address this issue include:

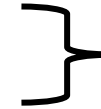
### A. Development /and adoption of safe and reliable de-orbiting systems and operations for different orbital regions and object characteristics

Key Enablers:

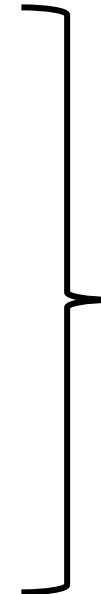
- I Affordable Disposal solutions for Small Spacecraft (e.g. propulsion systems, drag-sails, aerobrakes, tethers, plug and play Disposal subsystem for CubeSats, based on COTS<sup>7</sup> technology)
- II Evaluation and use of alternative strategies for orbital clearance and backup options for objects in Earth orbit (e.g. technical implications of Disposal strategies for MEO, GEO, GTO, HEO, etc.)
- III Spacecraft architectures which increase the probability of successful Disposal by accounting for possible mission extensions, failures and external factors (e.g. redundancy for Disposal capabilities, back-up deorbiting systems, incorporating margins)
- IV Technologies enabling safe autonomous and/or independent de-orbiting that can be integrated before launch or in-orbit (e.g. autonomous activation of de-orbiting devices, etc.)
- V Improved understanding of operational practices for de-orbiting (e.g. sharing of best practices, operational procedures, de-orbiting in degraded/safe mode, high-drag attitude control)



Example of  
**NEED**



Example of  
**SOLUTION**



Examples of  
**KEY ENABLERS**  
considered essential to achieve the  
2030 targets of the ZD Charter

# Next Steps

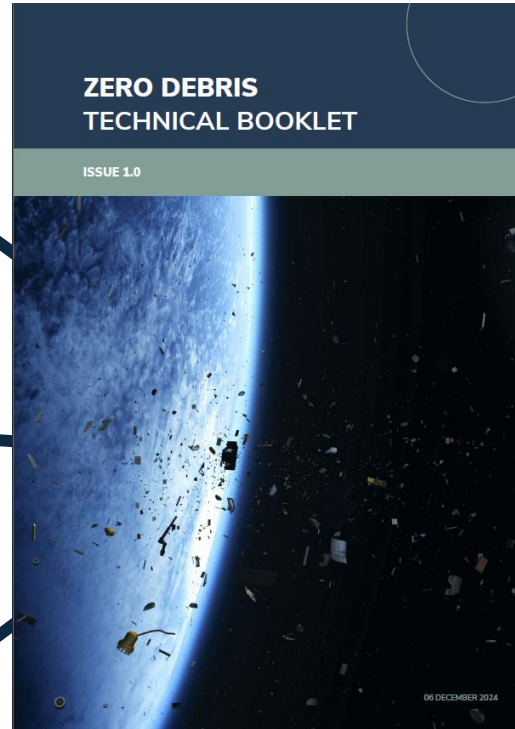
**Authorship**  
Imprint with list of contributing organisations



**Metrics**  
How to track progress



**Outreach**  
Raising awareness and increasing uptake



**Database**  
Online library of needs, solutions, and key enablers



**Prioritisation**  
What is most urgent to work on first?



**Mapping**  
Who is working on what?



# ZERO DEBRIS TECHNICAL BOOKLET

OVERVIEW OF PROGRESS  
Mapping





# Mapping: Why do we map needs and solutions?

*Before we can act, we need to know what exists and what is still missing. Mapping gives the whole community a clear, shared picture.*



## Build a shared starting point

All identified needs and existing solutions are brought together in one place. Everyone looks at the same picture, which makes it far easier to agree on priorities and avoid working from incomplete information.



## Capture knowledge from across the community

No single organisation has the full picture. By gathering inputs from industry, agencies, and academia, the mapping avoids blind spots and reflects the real state of the field rather than one group's perspective.



## Find what is missing

Once everything is mapped, the gaps become visible. The community can see which needs have no solution yet, which areas have too many overlapping efforts, and what capabilities are still completely absent.



## Give everyone visibility

The mapping makes it clear what already exists and what is still needed. Any organisation can see at a glance where they might contribute, where collaboration is possible, and where investment is most urgently needed.



## Make complex information easy to use

Inputs from many different organisations are organised into needs, solutions, and key enablers. This structure makes it much simpler to navigate the landscape and understand how everything fits together.



## Create the foundation for everything that follows

Prioritisation, the database, and future updates all depend on having a solid, agreed-upon map. Without it, every subsequent step would be built on guesswork rather than evidence.



# Mapping: How does the community benefit?

*The mapping exercise is only the beginning. Here is how the community can use it to create real visibility, collaboration, and momentum. Some ideas are listed before, **to be confirmed** with the respective entities:*



## Published on ESA platforms

Needs and solutions are published on ESA's Supporting Entities webpage and in white papers. This makes the information accessible to the wider space community.



## A matchmaking space on the ZD Charter site

A dedicated section connects organisations that have a need with those that have a solution or want to collaborate. Finding the right partner becomes simple.



## Featured in ESA newsletters and events

Selected solutions can be highlighted in ESA Clean Space newsletters and presented at ESA and EU space events, giving contributors visibility across the sector



## Workshops where members pitch their solutions

The community gathers in dedicated workshops to present needs and solutions, get feedback, and start conversations that lead to real partnerships.



## Open calls and challenges launched from real needs

Identified needs become the basis for open calls, prizes, and challenges. This turns the mapping into a direct funding pathway for the most promising solutions.

## Outreach campaigns featuring one need or solution per week

Short, consistent posts that spotlight real community needs and solutions. This keeps the conversation alive between events, attracts new contributors, and helps the broader public understand why space sustainability work matters.

**+200**

Solutions mapped  
in all technical  
domains

**+100**

Needs mapped  
in all technical  
domains

**+100**

Entities have already  
provided needs and  
solutions in all  
domains

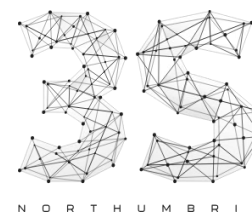
# Mapping Example: Needs and Solutions TD2

Technical Domain 2 collected an excel file with solutions and needs shared by the community.

Here there is summary of the number of solutions and needs identified:

- 73 Solutions (from those, 63 were inputs confirmed by members and 10 were taken from the Zero Debris Week; not yet confirmed).
- 20 Needs (all confirmed by members)

Many thanks to all contributors!





# Mapping: Needs and Solutions [TD2]

Entries not confirmed, but taking from the Zero Debris Week 2025, have been marked in yellow. In this way, we do not lose information collected previously, though we acknowledge they have not been confirmed yet

LIST OF ORGANISATIONS WITH SOLUTIONS FOR DOMAIN 2 TECHNOLOGIES					Legend color meaning	Input gathered through the ESA Zero Debris week, but not confirmed despite trying to contact the organisation.				
Organisation [Name]	Type	Country	Service within Domain 2	Name of the solution/service/product/experiment	TRL	Description	Applicability	Needs to commercialise /mature /improve	Contact	Partnership
3S Northumbria	Small Enterprise	United Kingdom	3.B Development of technologies for rendezvous and capture required to enable approach, capture and removal by an external spacecraft	SEAS modelling and simulation tool	Software - A	Modelling tool	RPO operations	Commercialised	<a href="mailto:kсениа.hvshchuk@northumbria.ac.uk">kсениа.hvshchuk@northumbria.ac.uk</a>	
ADS	Large Enterprise	France	2.A Development of interoperable interfaces and requirements that facilitate removal for different types and sizes of objects	Detumbler	(To be filled)	Technology element	ADR	None specified		
AIKO	Start-up	France	1.A Development /and adoption of safe and reliable de-orbiting systems and operations for different orbital regions and orbits	Autonomous deorbiting algorithm	Software - C	Autonomous guidance	LEO	Early stage; needs testing and validation	<a href="mailto:aurelie.baker@aikospace.com">aurelie.baker@aikospace.com</a>	
AIKO	Start-up	France	1.B Development, validation and adoption of improved Health Monitoring systems and methods	On-board health monitoring algorithm	Software - C	Developing on-board	LEO satellites	Refined version planned for international operations	<a href="mailto:aurelie.baker@aikospace.com">aurelie.baker@aikospace.com</a>	
AIKO	Start-up	France	3.A Improved characterisation of objects to be removed, including improved knowledge of Spacecraft States, and structure	Software for autonomous rendezvous	Software - C	Implementing software	RPO operations	Testing in robotic facilities planned	<a href="mailto:aurelie.baker@aikospace.com">aurelie.baker@aikospace.com</a>	
Astroscale	Medium Enterprise	UK	2.A Development of interoperable interfaces and requirements that facilitate removal for different types and sizes of objects	Interface for servicing and removal	TRL 9 - Actual	Magnetic, interplanetary	Servicing and de-orbiting	None specified	<a href="mailto:z.tenacci@astroscale.com">z.tenacci@astroscale.com</a>	
Astroscale	Medium Enterprise	UK	3.A Improved characterisation of objects to be removed, including improved knowledge of Spacecraft States, and structure	ESS and STA activities with ELSA	TRL 5 - Technology	Characterisation	Debris objects	None specified	<a href="mailto:z.tenacci@astroscale.com">z.tenacci@astroscale.com</a>	
Astroscale	Medium Enterprise	UK	3.C Mature Removal Services ecosystem	Safety standardisation and regulation	Other (specified)	Working on how to implement	ADR safety and de-orbiting	None specified	<a href="mailto:z.tenacci@astroscale.com">z.tenacci@astroscale.com</a>	
ClearSpace	Medium Enterprise	Luxembourg	3.C Mature Removal Services ecosystem	Disposal (End of life removal)	TRL 5 - Technology	ClearSpace	LEO 2028 - GEO	None specified	<a href="mailto:kees@clearspace.eu">kees@clearspace.eu</a>	Active contract
ClearSpace	Medium Enterprise	Luxembourg	3.A Improved characterisation of objects to be removed, including improved knowledge of Spacecraft States, and structure	Inspection (Space Domain Awareness)	TRL 5 - Technology	In-space inspection	LEO 2027 - GEO	None specified	<a href="mailto:kees@clearspace.eu">kees@clearspace.eu</a>	Short to long range
CNES	Public Sector	France	1.C Verification methods for timely and successful clearance	Stella tool	Software - A	Verification tool	Satellite reentry	None specified		
D-Orbit	Medium Enterprise	Italy	1.A Development /and adoption of safe and reliable de-orbiting systems and operations for different orbital regions and orbits	Drag-based deorbit satellites	TRL 5 - Technology	Affordable drag	LEO / GEO	Needs partners for GEO version and further testing		
D-Orbit	Medium Enterprise	Italy	1.B Development, validation and adoption of improved Health Monitoring systems and methods	Cloud computing platform for health monitoring	(To be filled)	Cloud-based computing	LEO	None specified		
D-Orbit	Medium Enterprise	Italy	2.A Development of interoperable interfaces and requirements that facilitate removal for different types and sizes of objects	"Otterpact" (starfish) magnetic	(To be filled)	Demonstration	ADR demonstration	None specified		
D-Orbit	Medium Enterprise	Italy	3.C Mature Removal Services ecosystem	RISE mission concept	(To be filled)	Deorbit demonstration	ADR missions	None specified		
ESA-promoted	Public Sector	Europe	1.B Development, validation and adoption of improved Health Monitoring systems and methods	Artificial intelligence-based system	TRL 3 - Experimental proof of concept	On-board and ground operations			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.B Development, validation and adoption of improved Health Monitoring systems and methods	Integrated space-ground system	TRL 3 - Experimental proof of concept	On-board and ground operations			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.B Development, validation and adoption of improved Health Monitoring systems and methods	Artificial Intelligence end-to-end	TRL 3 - Experimental proof of concept	On-board and ground operations			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.B Development, validation and adoption of improved Health Monitoring systems and methods	Machine learning based on-board	TRL 3 - Experimental proof of concept	On-board and ground operations			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.B Development, validation and adoption of improved Health Monitoring systems and methods	Advanced simulation for resilient	TRL 3 - Experimental proof of concept	On-board and ground operations			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.B Development, validation and adoption of improved Health Monitoring systems and methods	Intelligent signal monitoring unit	TRL 3 - Experimental proof of concept	On-board and ground operations			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.A Development /and adoption of safe and reliable de-orbiting systems and operations for different orbital regions and orbits	Solid Propellant de-orbit motor	TRL 5 - Technology validated	LEO mainly			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.A Development /and adoption of safe and reliable de-orbiting systems and operations for different orbital regions and orbits	Solid Propellant Rocket Motor Thruster	TRL 5 - Technology validated	LEO mainly			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.A Development /and adoption of safe and reliable de-orbiting systems and operations for different orbital regions and orbits	Disruptive propulsion technology	TRL 4 - Technology validated	LEO			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.A Development /and adoption of safe and reliable de-orbiting systems and operations for different orbital regions and orbits	Disruptive propulsion technology	TRL 4 - Technology validated	LEO			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.A Development /and adoption of safe and reliable de-orbiting systems and operations for different orbital regions and orbits	AQUAMAG - A Water & Magnesium	(To be filled)	LEO			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.A Development /and adoption of safe and reliable de-orbiting systems and operations for different orbital regions and orbits	ADEO Family Development and	TRL 8 - Actual system complete	LEO			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.A Development /and adoption of safe and reliable de-orbiting systems and operations for different orbital regions and orbits	In-orbit experiment of an inflatable	TRL 3 - Experimental proof of concept	LEO			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	
ESA-promoted	Public Sector	Europe	1.A Development /and adoption of safe and reliable de-orbiting systems and operations for different orbital regions and orbits	Tether based system for passive	TRL 6 - Technology demonstrated	LEO			<a href="mailto:vitali.braun@esa.int">vitali.braun@esa.int</a>	



# Mapping: Needs and Solutions [TD5]

LIST OF ORGANISATIONS WITH SOLUTIONS FOR DOMAIN 5 TECHNOLOGIES

Organisation [Name]	Type	Country	Domain 5 Solutions	Name of the solution / service / product / expertise	TRL	Description	Applicability	Needs to commercialise / mature / improve
AIRBUS DS	Large Enterprise (25)	FR	5.1.d) Evaluate alternative re-entry and Disposal methods focusing	Natural assisted reentry	Expertise in specific domain (specify in Description)		LEO	
AIRBUS DS	Large Enterprise (25)	UK	5.1.a) Development of Technologies for Design for Demise	Demisable Joints	TRL 4 – Technolo	Passive device designed to facilitate demise of a space system during re-entry into the earth's atmosphere.	LEO	
AIRBUS DS	Large Enterprise (25)	FR	5.1.a) Development of Technologies for Design for Demise	Demisable bipods and brackets	TRL 3 – Experime	Passive device designed to facilitate demise of a space system during re-entry into the earth's atmosphere.	LEO	
AIRBUS DS	Large Enterprise (25)	UK	5.1.a) Development of Technologies for Design for Demise	Demisable propellant tanks (hydrazine)	TRL 6 – Technolo	Passive device designed to facilitate demise of a space system during re-entry into the earth's atmosphere.	LEO	
AIRBUS DS	Large Enterprise (25)	Ge	5.1.b) Development of techniques and processes for Design for Dem	Thermites	TRL 2 – Technolo	Inside bulk materials	LEO	
Belstead Research	Microenterprise (few	GB	5.1.c) Improved and standardised tools, models and databases to a	Re-entry Simulation Tools for both testing and re-entry, and state of the art material model development	TRL 6 – Technolo	Development of tools for test analysis, development of standard material models (eg as used in DRAMA)		
Belstead Research	Microenterprise (few	GB	5.1.b) Development of techniques and processes for Design for Dem	Development of shape designs which enhance demisability	TRL 4 – Technolo	Assist component designers to improve the demisability of their component by adapting the external shape		
Collins Aerospace		DE	5.1.a) Development of Technologies for Design for Demise	Demisable Reaction Wheel				
German Aerospace Center (DLR)	Large Enterprise (25)	DE	5.1.a) Development of Technologies for Design for Demise	a) Demisable Joints	TRL 4 – Technolo	a) Passive triggering demisable inserts for Land T joints, available for sandwich panels as well as thin panels	LEO	Need of reference components ofr validation at different components
German Aerospace Center (DLR)	Large Enterprise (25)	DE	5.1.a) Development of Technologies for Design for Demise	b) Demisable Topology Optimized Structures	TRL 4 – Technolo	b) 3D printed aluminum/titanium alloys, topology optimized bionic geometries (TRL3)	LEO	Need of reference components ofr validation at different components
German Aerospace Center (DLR)	Large Enterprise (25)	DE	5.1.a) Development of Technologies for Design for Demise	c) Bio-based demisable structures (Wood-based composites, flax/carbon hybrid facesheets)	TRL 4 – Technolo	c) Available as replacement of sandwich panels or thin panels for platforms up to 1 ton, no additional mass or thickness needed (TRL 3)	LEO	Need of reference components ofr validation at different components
German Aerospace Center (DLR)	Large Enterprise (25)	DE	5.1.a) Development of Technologies for Design for Demise	d) 3D printed porous and demisable Titanium - topology optimization possible	TRL 4 – Technolo	d) Demisability was demonstrated in VKI Plasmatron; early mechanical characterization shows similar mechanical strength to solid Titanium for different porosity levels; 3D printing of bionic geometries is demonstrated to be functioning (TRL 2/3)	LEO	Need of reference components ofr validation at different components
Invent		DE	5.1.a) Development of Technologies for Design for Demise	Structure: separation technologies (inserts/joints/secondary structures)				
Jena Optronik		DE	5.1.a) Development of Technologies for Design for Demise	Development of Demisable Star Trackers				
LusoSpace		PT	5.1.a) Development of Technologies for Design for Demise	Demisable Magnetorquer	TRL 6 – Technolo	Demisable AOCS unit; reducing casualty risk likelihood	LEO	
Lazar Jetic, Independent R&D Engineer	Microenterprise (few	RS	5.3 Minimising Debris Impacts on Human Population and Infrastru	Webmap of Recovered Space-Orbital Debris locations				
MTA	Medium Enterprise (1	DE	5.1.a) Development of Technologies for Design for Demise	Demisable Hydrazine Tank				
OHB System	Large Enterprise (25)	DE	5.1.a) Development of Technologies for Design for Demise	Demisable Joints	TRL 4 – Technolo	Primary structural joining to enable earlier demise.	LEO	
OHB System	Large Enterprise (25)	DE	5.1.a) Development of Technologies for Design for Demise	Demisable Bipods	TRL 2 – Technolo	Demisable bipods for optical benches using known demisability techniques.	LEO	
OHB System	Large Enterprise (25)	DE	5.1.a) Development of Technologies for Design for Demise	Demisable Optical Bench	TRL 2 – Technolo	Demisable CFRP optical bench through applying demisability techniques.	LEO	
OHB System	Large Enterprise (25)	DE	5.1.c) Improved and standardised tools, models and databases to a	Re-entry Tools		Development of reentry tools / benchmarking.		
Peak		DE	5.1.a) Development of Technologies for Design for Demise	Demisable COPV Tank				
Persei Space		ES	5.1.d) Evaluate alternative re-entry and Disposal methods focusing	ElectroDynamic Tether		- potential solution (TBC)		
Safran		FR		Hall Effect thruster				
SITael						the Air-breathing Electric Thruster		
Thales Alenia Space (TAS)	Large Enterprise (25)	IT	5.1.a) Development of Technologies for Design for Demise	Demisable Bipods	TRL 4			
Thales Alenia Space (TAS)	Large Enterprise (25)	IT	5.1.a) Development of Technologies for Design for Demise	Demisable Joints	TRL 4 – Technolo	Passive device designed to facilitate demise of a space system during re-entry into the earth's atmosphere.	LEO	
Thales Alenia Space (TAS)	Large Enterprise (25)	IT	5.1.d) Evaluate alternative re-entry and Disposal methods focusing	Expertise on re-entry analysis, controlled, natural assisted and uncontrolled				
ZARM Technik AG	Small Enterprise (10	DE	5.1.a) Development of Technologies for Design for Demise	Demisable Magnetorquer	TRL 3 – Experime	Demisable AOCS unit; reducing casualty risk likelihood		

# ZERO DEBRIS TECHNICAL BOOKLET

OVERVIEW OF PROGRESS  
Prioritisation





# Prioritisation: Needs and Solutions

After the needs and solutions have been identified and associated to a service and key enabler, the next step corresponds to setting a priority for the key enablers in order to understand what needs and solutions are more important to develop and pay attention to, according to the community

## MAPPING



Needs and Solutions

associated to

Key Enablers

## PRIORITISATION



Key Enablers

Example from Technical Domain 2 (Guarantee timely and successful clearance):

### 2.1. IMPROVE ORBITAL CLEARANCE WITH HIGH PROBABILITY OF SUCCESSFUL DE-ORBITING

De-orbiting systems and architectures that enable an object to de-orbit itself at End of Mission currently exist for some use cases (e.g. de-orbit systems for spacecraft in LEO) but need to be made affordable and more reliable in order to reach high clearance success rates and widespread adoption. In addition, other solutions could be explored for different orbital regions and use cases (e.g. Disposal from MEO, mission extension, etc.) Solutions to address this issue include:

#### A. Development and/or adoption of safe and reliable de-orbiting systems and operations for different orbital regions and object characteristics

Key Enablers:





- 1 Affordable Disposal solutions for Small Spacecraft (e.g. propulsion systems, dragsails, aerobrakes, tethers, plug and play Disposal subsystem for CubeSats, based on COTS<sup>7</sup> technology)

Key Enabler (prioritisation)

Needs and Solutions within this key enabler (mapping)

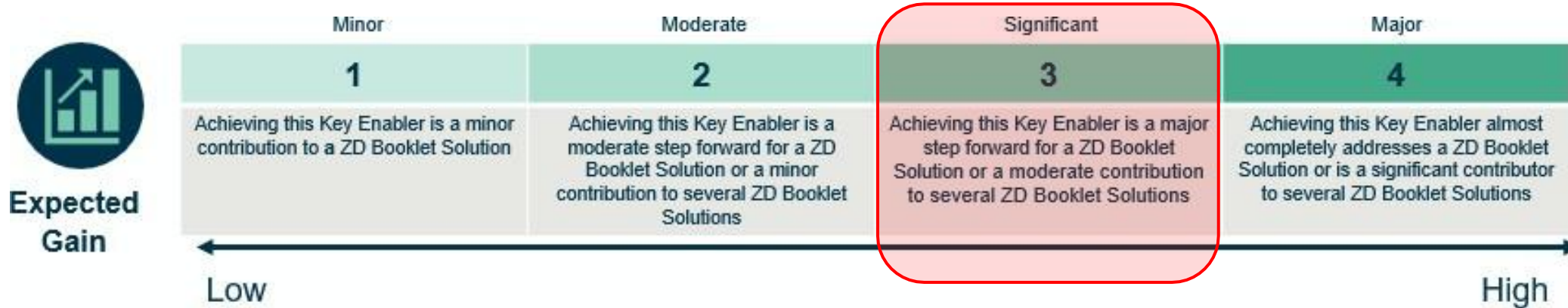
# Prioritisation Ranking Matrix

The community was asked to rank each key enabler according to four metrics and select each score from 1-4:

	Minor	Moderate	Significant	Major
 <b>Complexity</b>	<b>1</b> Normal work, just requires an allocation of existing resources	<b>2</b> Moderate technical or organisational complexity, could require a dedicated project team	<b>3</b> Some level of coordination required, organisational or geopolitical complexity may be an issue	<b>4</b> Major effort requiring a dedicated team, and/or multi stakeholder alignment and advocacy.
 <b>Resources Required</b>	<b>1</b> No extra resources required other than allocation of staff time	<b>2</b> Moderate resources required, for example developing a software tool or carrying out a research project	<b>3</b> Significant funding required, for example developing a new technology and qualifying it for space or setting up a new organisation to align stakeholders	<b>4</b> Major funding required, for example implementing a mission or fundamentally re-designing existing spacecraft architectures
 <b>Current Maturity</b>	<b>1</b> Technologies: TRL 0-1 Tools & Processes: Ad-hoc developments	<b>2</b> Technologies: TRL 3-4 Tools & Processes: Prototypes and feasibility studies	<b>3</b> Technologies: TRL 5-7 Tools & Processes: Operational demonstrations	<b>4</b> Technologies: TRL 8-9 Tools & Processes: Institutionalised and standard practice
				

# Prioritisation Ranking Matrix

The community is requested to rank each key enabler according to four metrics and select each score from 1-4:



*Available space is included for the community to include open feedback and describe their level of expertise and familiarity with the solutions evaluated, including whether your assessment is based on direct professional experience, technical involvement, prior collaboration, publicly available documentation, or solely on the information provided in this form.*

*It is also encouraged to provide constructive feedback to improve future versions of this form, such as additional data fields, clarification of evaluation criteria, standardised TRL references, cost ranges, performance metrics, or operational constraints that would enable a more robust and consistent assessment process. 😊*

# Prioritisation work in progress [TD2]

In Technical Domain 2, the prioritisation is shared as a Google Form, shared periodically and divided into batches. The first batch compiles all the key enablers within one need:

## 2.1. IMPROVE ORBITAL CLEARANCE WITH HIGH PROBABILITY OF SUCCESSFUL DE-ORBITING

De-orbiting systems and architectures that enable an object to de-orbit itself at End of Mission currently exist for some use cases (e.g. de-orbit systems for spacecraft in LEO) but need to be made affordable and more reliable in order to reach high clearance success rates and widespread adoption. In addition, other solutions could be explored for different orbital regions and use cases (e.g. Disposal from MEO, mission extension, etc.) Solutions to address this issue include:

### A. Development /and adoption of safe and reliable de-orbiting systems and operations for different orbital regions and object characteristics

Key Enablers:

- I Affordable Disposal solutions for Small Spacecraft (e.g. propulsion systems, drag-sails, aerobrakes, tethers, plug and play Disposal subsystem for CubeSats, based on COTS<sup>7</sup> technology)
- II Evaluation and use of alternative strategies for orbital clearance and backup options for objects in Earth orbit (e.g. technical implications of Disposal strategies for MEO, GEO, GTO, HEO, etc.)
- III Spacecraft architectures which increase the probability of successful Disposal by accounting for possible mission extensions, failures and external factors (e.g. redundancy for Disposal capabilities, back-up deorbiting systems, incorporating margins)
- IV Technologies enabling safe autonomous and/or independent de-orbiting that can be integrated before launch or in-orbit (e.g. autonomous activation of de-orbiting devices, etc.)
- V Improved understanding of operational practices for de-orbiting (e.g. sharing of best practices, operational procedures, de-orbiting in degraded/safe mode, high-drag attitude control)

Example of  
**NEED**

Example of  
**SOLUTION**

Examples of  
**KEY ENABLERS**  
considered essential to achieve the  
2030 targets of the ZD Charter

*All key enablers within this Need 2.1 are shared, giving time to the community to assess them. Then, another Google Form is open for the subsequent need (in this case, Need 2.2)*

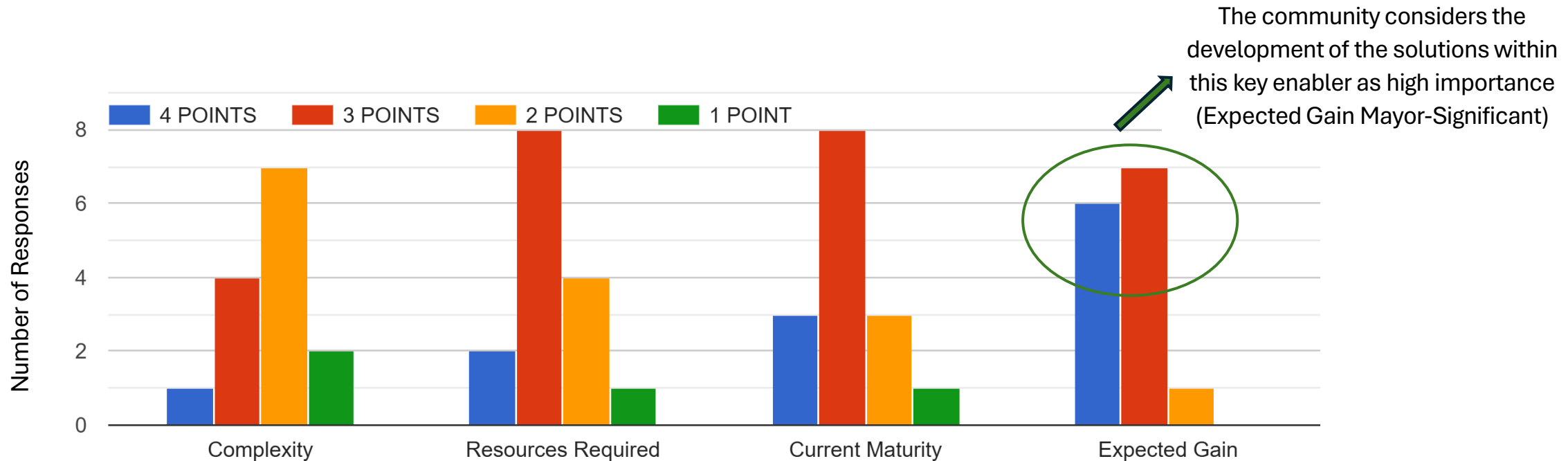


# Prioritisation work in progress [TD2]

Some early results for the Key Enablers within Need 2.1 of TD2 are shared here. Note that this Google Form is still open for more responses, although the current status is work in progress within the Need 2.2:

## KEY ENABLER:

Affordable Disposal solutions for Small Spacecraft (e.g. propulsion systems, dragsails, aerobrakes, tethers, plug and play Disposal subsystem for CubeSats, based on COTS7 technology)



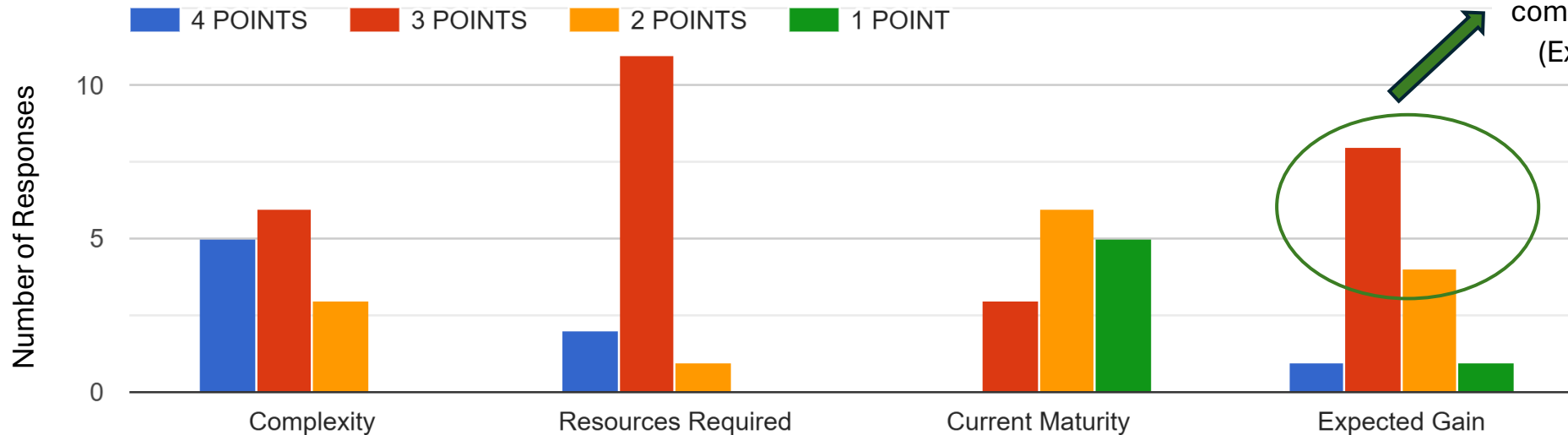


# Prioritisation work in progress [TD2]

Some early results for the Key Enablers within Need 2.1 of TD2 are shared here. Note that this Google Form is still open for more responses, although the current status is work in progress within the Need 2.2:

## KEY ENABLER:

Operational practices and technologies for Dead-On-Arrival spacecraft (e.g. smart deployer/upper stage performing health check, low-altitude injection, time-tagged de-orbiting systems)



The community considers the development of the solutions within this key enabler as lower importance compared to the previous key enabler (Expected Gain Moderate-Mayor)



# Prioritisation: Why does it matter?

*With so many needs and solutions identified, how do we decide where to focus first? Prioritisation gives the community a shared, evidence-based answer.*



## Focus on what delivers the most value

Not every enabler has the same impact. By scoring them, the community can identify which ones will move the needle the most and make sure their work on needs and solutions goes to where it matters.



## Guide where funding and effort go

Resources are limited. Prioritisation helps organisations direct their funding, research, and mission planning toward the areas the community has collectively agreed are most critical.



## Compare effort against expected benefit

Each enabler is scored on how hard it is, how much it will cost, how mature it is today, and how much it would help. This gives a clear picture of which investments make the most sense right now.



## Speed up progress toward 2030

By agreeing on what to tackle first, the community avoids spreading its energy too thin. Concentrating effort on the highest-priority developments is the fastest route to meeting the 2030 targets.



## Align everyone around the same plan

When stakeholders across industry, agencies, and academia share the same priority order, coordination becomes easier. Fewer gaps, less duplication, and a clearer sense of who does what.



## Replace gut feeling with real data

Instead of relying on informal opinions, prioritisation gives a transparent and reproducible process. Decisions can be explained, challenged, and updated as new information comes in.

# ZERO DEBRIS TECHNICAL BOOKLET

Database





# Database

*What does the database contain? A structured overview of all the needs, solutions and key enablers identified by the community.*



## Needs Database

Every identified need is recorded with a clear description, which technical domain it belongs to, what orbit or mission type it affects, and how urgent it is. This gives the whole community a shared starting point.



## Solutions Catalogue

Each solution is listed with a plain description, the organisation behind it, how mature the technology is, and what problems it addresses. Anyone can quickly see what already exists before starting something new.



## Key Enablers

For each solution, the database lists what booklet need and key enabler it belongs to; also some comments about what it still needed to make it work: a specific technology, a regulatory step... This makes it clear what needs to happen before a solution can be used.



## Priority Scores

The community results from the prioritization exercise is included: How hard is it? How much will it cost? How mature is it today? And how much would achieving it help? This turns the community expert opinions into a clear, comparable ranking.



## Who is Doing What

The database shows which organisations are already working on each challenge, across industry, agencies, and universities. This avoids duplication and makes it easy to find the right partner for any given problem.



## Search, Filter and Track

Users can filter the database by domain, maturity level, priority, or organisation. Entries are clearly marked as confirmed or still pending, and all updates are tracked over time so nothing gets lost.



# Database

*How does the database create value?  
By connecting the right people, surfacing what already exists, and turning information into action.*



## Open to Everyone

The full database is freely available to all Zero Debris community members through a searchable online platform. Any organisation can browse, submit, and update entries, so the resource grows naturally as the community expands.



## Connecting Needs with Solutions

The platform links organisations that have a need with those who have a solution or want to collaborate. A dedicated section lists open collaboration opportunities, making it simple to find the right partner.



## Getting the Word Out

Selected solutions are featured in ESA webpages, newsletters, and reports. They are also highlighted at major events like IAC and ESA workshops, giving contributors real visibility across the space sector.



## Turning Knowledge into Action

Workshops and pitching sessions are run based on what the database reveals. Open calls and funding challenges are launched directly from identified needs, so the platform does not just store information but drives real outcomes.



## Ecosystem Acceleration

Today, organisations often work in parallel without knowing others are tackling the same challenge. This database changes that. It gives everyone a single place to look, share, and connect. By bringing needs and solutions together in one place, it speeds up the adoption of what works and reduces wasted effort across the community.

**From a static document to a living tool that evolves with the community**

<b>7</b>	<b>182+</b>	<b>2026/2027</b>
Technical Domains	Charter Signatories	Target Year

# ZERO DEBRIS TECHNICAL BOOKLET

Conclusions



# Wrap-up

- **A growing and active community**

The Zero Debris community is thriving, and the Charter has proven to be an ongoing success.

- **What's next**

New developments are underway, including concrete tools such as the database and the communication platform.

- **Upcoming outputs**

A series of White Papers is currently in preparation.

- **Evolving structure**

The community is no longer defined solely by the Technical Booklet, but by a broader and more structured framework of the ZD Technical and Policy Forums

### Join the Technical Booklet:

scan the QR code to become part of the community!



### Upcoming Events:

Scan the QR codes to register.



Clean Space Days 2026



Zero Debris Week 2026



**Zero Debris Technical Forum:**  
Q&A