CLEAN SPACE INDUSTRY DAYS 2023

The Deorbiting Kit: Optimised solution for ESA's Zero Debris Policy Implementation

D-ORBIT

Leader in Space Logistics and Orbital Transportation

280+ people and growing

D-Orbit SpA
Production and HQ,
Como, Italy

D-Orbit PT
Critical software and
new space subsidiary,
Lisbon, Portugal

D-Orbit Inc.
Commercial subsidiary,
Washington DC, USA

D-Orbit UK, Ltd
AI Data Processing &
Robotics, Space
Safety, Responsive Launch
Harwell, UK

TODAY

Last-mile delivery solution
for satellites and advanced
infrastructure services

World's first
to provide in-space satellite transportation for paying customers

TOMORROW

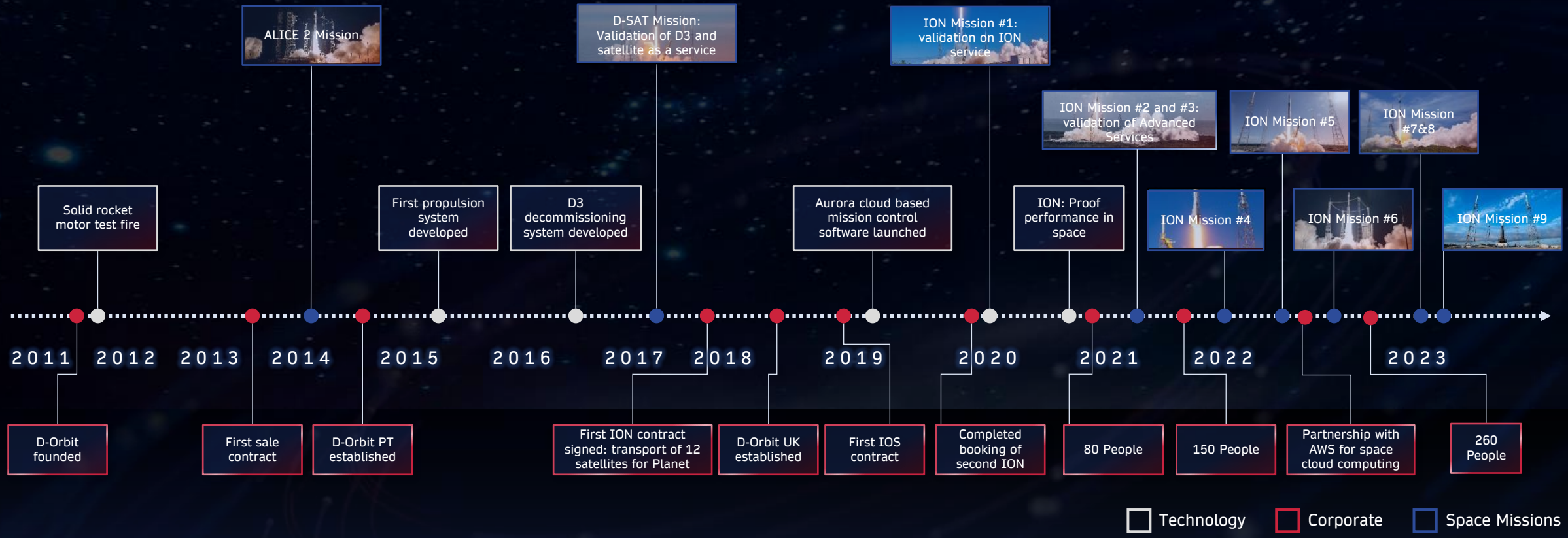
Next-gen in-orbit
services across entire
satellite lifecycle

World's first
to demonstrate satellite-as-a-service capabilities in space

BEYOND

In-orbit recycling, manufacturing
& infrastructure

D-ORBIT STORY



D-ORBIT IS IN START-UP PHASE FOCUSING ON INITIAL R&D ACTIVITIES

CONSTELLATIONS START HAVING TRACTION: ***D-ORBIT BEGINS GAINING CREDIBILITY***

PIONEER IN SPACE LOGISTICS

D-ORBIT OF TODAY…

- **Pioneer and leading commercial provider of in-orbit "last-mile" delivery**, able to deploy **satellites across all orbits**
- **ION** – the proprietary motorised **OTV (Orbital Transfer Vehicle)** – is a **multi-purpose spacecraft**
  - **Only commercial OTV** that has demonstrated capability to perform **all manoeuvres**
  - **Launching and commissioning in LEO up to 200kg, compatible with most launchers**
- Unique **proven capabilities**, large **backlog** and strength of relationships with **launch suppliers = High revenue visibility**
- Already offering **advanced services** (Validation, Demonstration, Edge Computing, Satellite-As-A-Service)

MULTIPURPOSE & MODULAR PLATFORM ENABLING MANY HIGH-MARGIN SERVICES

ION Orbital Transfer Vehicle
(4th Generation)

…IS ENABLING D-ORBIT OF TOMORROW

FROM 2023

ION ADVANCED SERVICES

- SATELLITE FOR RENT
- SPACE CLOUD COMPUTING

FROM 2026

IOS: IN-ORBIT-SERVICING

- LIFE EXTENSION
- RE-POSTIONING
- VISUAL INSPECTION
- DECOMMISSIONING

- Once each **ION** completes its **primary mission of deploying passenger satellites** it then joins **D-Orbit's growing fleet of multi-purpose spacecrafts** to undertake **high margin secondary missions**
- **D-Orbit's constellation** delivers advanced services enabled by **logistics business** at marginal extra cost
- **Capabilities** needed **already embedded** in current ION design (e.g. edge computing; AI)

Our Heritage

Ten Orbital Transportation Missions to date and a Growing Degree of Complexity

2020	2021	2022	2023
1 ION LAUNCHED	2 IONs LAUNCHED	3 IONs LAUNCHED	4 IONs LAUNCHED As of April
First successful commercial orbital transportation mission in the space industry	**Successful testing in orbit of innovative plug-and-play system for hosted payloads**	**ION performs the first RAAN shift maneuver in orbit ever performed by an OTV***	**First launch featuring two IONs**
• 12 Satellites deployed • 2 Hosted payloads tested in orbit	• 26 Satellites deployed • 15 Hosted payloads tested in orbit	• 15 Satellites deployed • 5 Hosted payloads tested in orbit	• 5 satellites deployed, 9 to be deployed • 7hosted payload tested in orbit, 3 to be tested
TESTING FOR FUTURE SERVICES • Orbital maneuvering • Full cargo validation • Propulsion subsystems tested	• Earth Observation payload • Satellite for rent • Propulsion characterization • Laser communication – space to ground • Orbital data-center / in-orbit edge computing • Drag sail	• Orbital data-center / in-orbit edge computing advanced functions	• Orbital data-center / in-orbit edge computing advanced functions

* Note: Orbital Transfer Vehicle

PROGRAM INTRODUCTION

CLEANSPACE DEORBITING KIT DEVELOPMENT AND IN-ORBIT DEMONSTRATION

D-Orbit is contracted by ESA to carry out the design and in-orbit demonstration of a ground-installed deorbit kit for the controlled re-entry of a dual launch adaptor.

PART OF THE SPACE SAFETY PROGRAMME (S2P)

The objective S2P is to contribute to the protection of our planet, humanity, and assets in space and on Earth from threats originating in space, including In-orbit servicing/debris removal missions to address debris and at the same time support the market of in-orbit servicing.

SAFEGUARDING EARTH'S ORBITAL ENVIRONMENT

As reflected by the number of relevant regulations that are being proposed and put in place to address these important issues. The deorbit kit has been identified as a potential strategy for achieving compliance with ESA space debris mitigation policy

AUTONOMOUS DEORBITING SYSTEMS FOR FUTURE LEO MISSIONS

The deorbit kit, which is a suite of equipment that is installed on the ground before the launch of the satellite, is intended to carry out the necessary functions to perform controlled re-entry of the satellite at end-of-life or after failure.

DEORBITING KIT USE CASES

ANTICIPATING DEMAND

Thanks to the ESA Zero Debris Policy and new regulations, any new launch will soon have to comply with a 5-year re-entry constraint for any object released during launch. This brings new challenges for dual launches, which would be forced into very inefficient trajectories, having to reduce the release altitude of the dual launch adapter below 500km in between releases.

For example, this could lead to a reduction in payload capacity of up to 300kg for a VEGA-C

The addition of a deorbiting kit would mitigate the impact of the new regulations, allowing to release the launch adapter at any altitude.

Additionally, the requirement for deorbiting reliability is likely to get more stringent, up to 99%/100% likelihood required.
This is unlikely to be achievable without a dedicated system, either fully cross-strapped as part of the spacecraft or as an add-on kit.

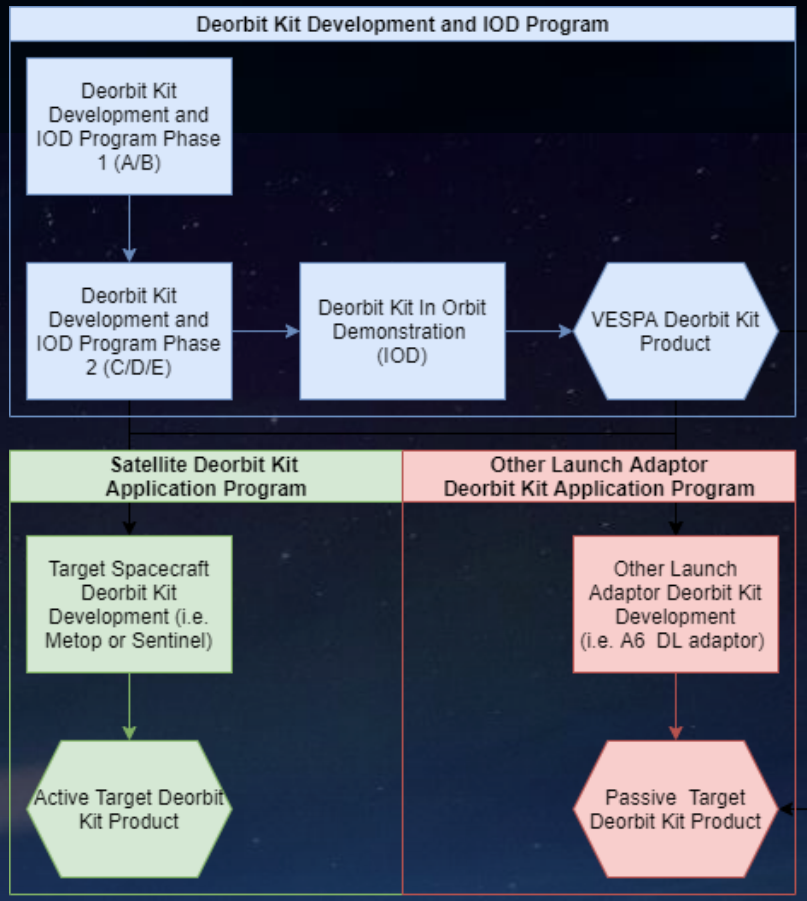
VISION

DEORBIT KIT PRODUCT LINE

The ultimate goal is to develop a modular and scalable concept that would allow the deorbit kit to be accommodated on other hosts (other launch adaptors and satellites).

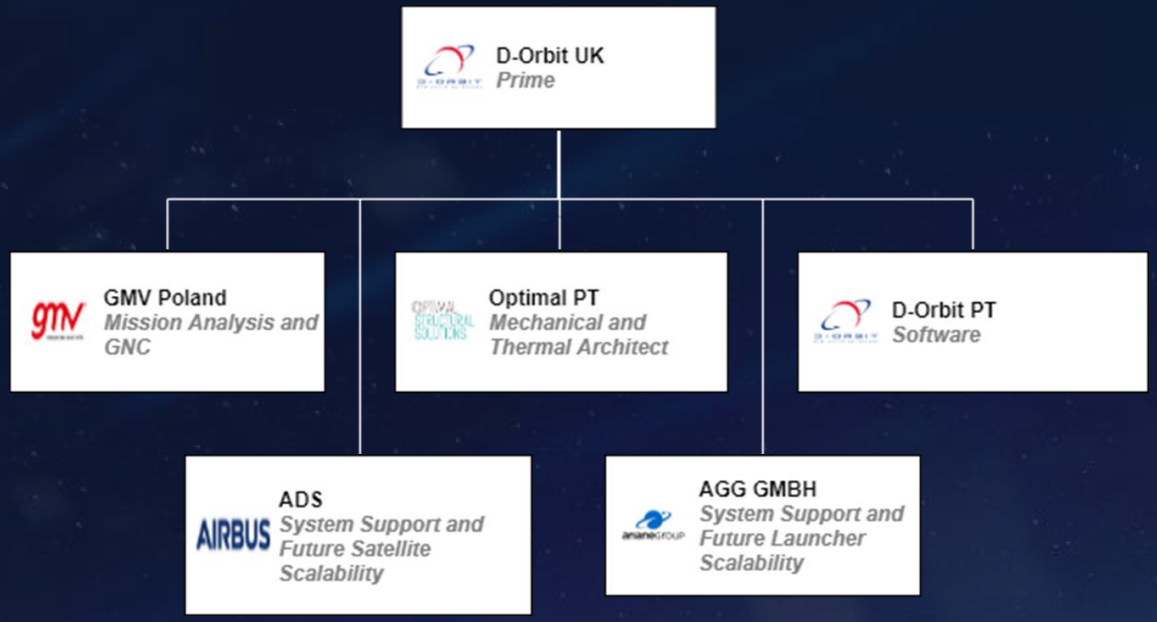
The DOK is being developed in two versions:

- **passive target DOK:** a “fully autonomous” DOK meant to be mounted on passive or non-operational satellites such as launch adaptors, with a short lifespan,
- **active target DOK:** a “connected” DOK, which connects to the host to detect satellite failure before turning ON and establishing communications with ground, with an extended lifespan to envelope longer applications.



PROGRAM TEAM AND OBJECTIVES

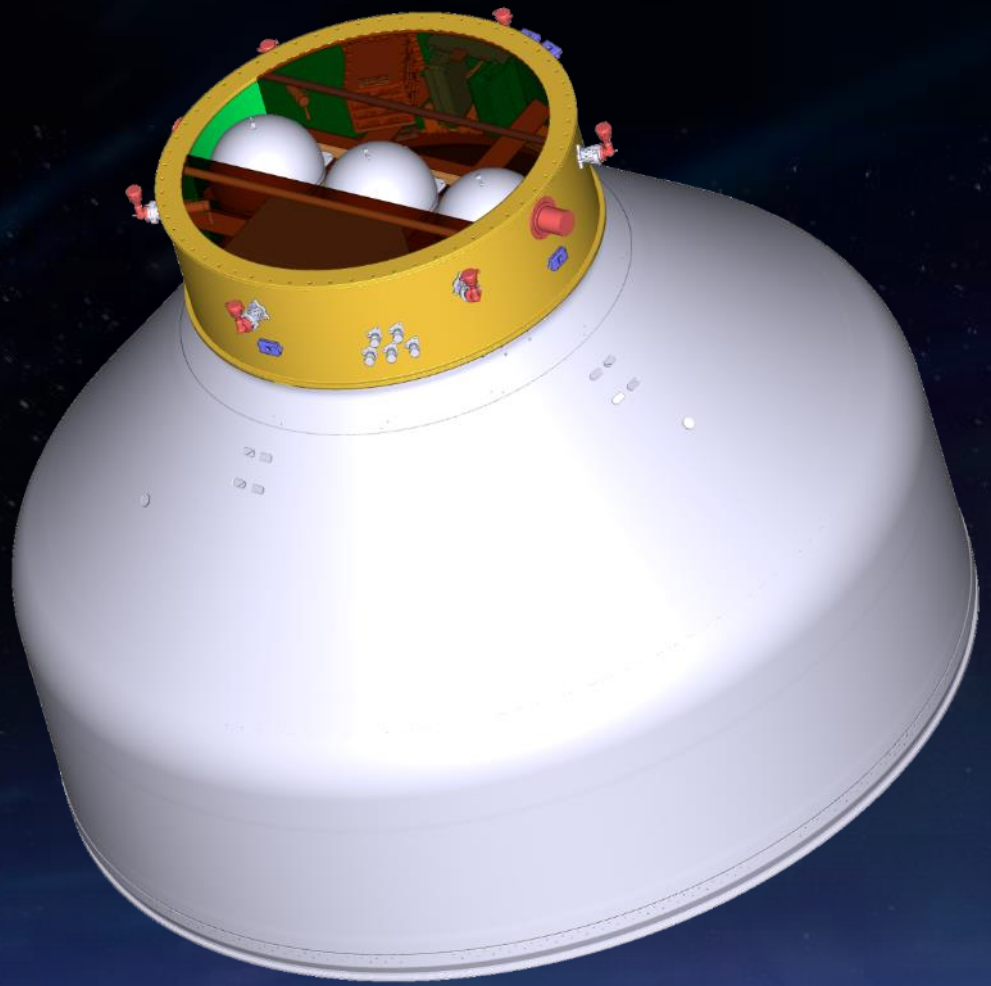
CLEANSPACE DEORBITING KIT DEVELOPMENT AND IN-ORBIT DEMONSTRATION



The Deorbiting Kit is preliminarily foreseen to be launched on the same VEGA launcher, attached on ground to the upper part of the VESPA that will deploy Cleaspace-1 (subject to timing/confirmation).

DESIGN CONCEPT

DEORBIT KIT PRODUCT LINE



The deorbiting kit is a cylinder of customizable diameter and height. The IOD is 1200mm diameter by 300mm height, and only includes:

- Avionics
- Battery
- Communications
- Propulsion System
- Attitude Estimation Sensors
- Thermal Control System

A simple deorbiting kit is essential to **limit wet mass and cost** to enable its commercialization and **keep reliability high**

DESIGN UPDATES

DEORBIT KIT DESIGN

The Deorbiting Kit baseline has undergone two major design changes to better respond to the market needs:

1) <u>New Avionics</u>:

- Previous design was based in more traditional high rel. CCU, ICU and Battery components
- New design benefits from the flexibility of COTS based avionics -> **AVH3**
  - **AVH3** is a complete avionics solution that contains **redundancy** and **modularity** between sub-systems.
  - For Deorbiting Kit **AVH3** includes:
    - OBC Board
    - AOCS Board
    - EPS Board plus Power Distribution Unit and Battery Management System
    - Propulsion avionics: PRO Core Board plus PRO SENSE and ACT Boards.

2) Move to a **<u>Green Propulsion solution</u>** instead of a traditional hydrazine propulsion sub-system.

MECHANICAL CONCEPT

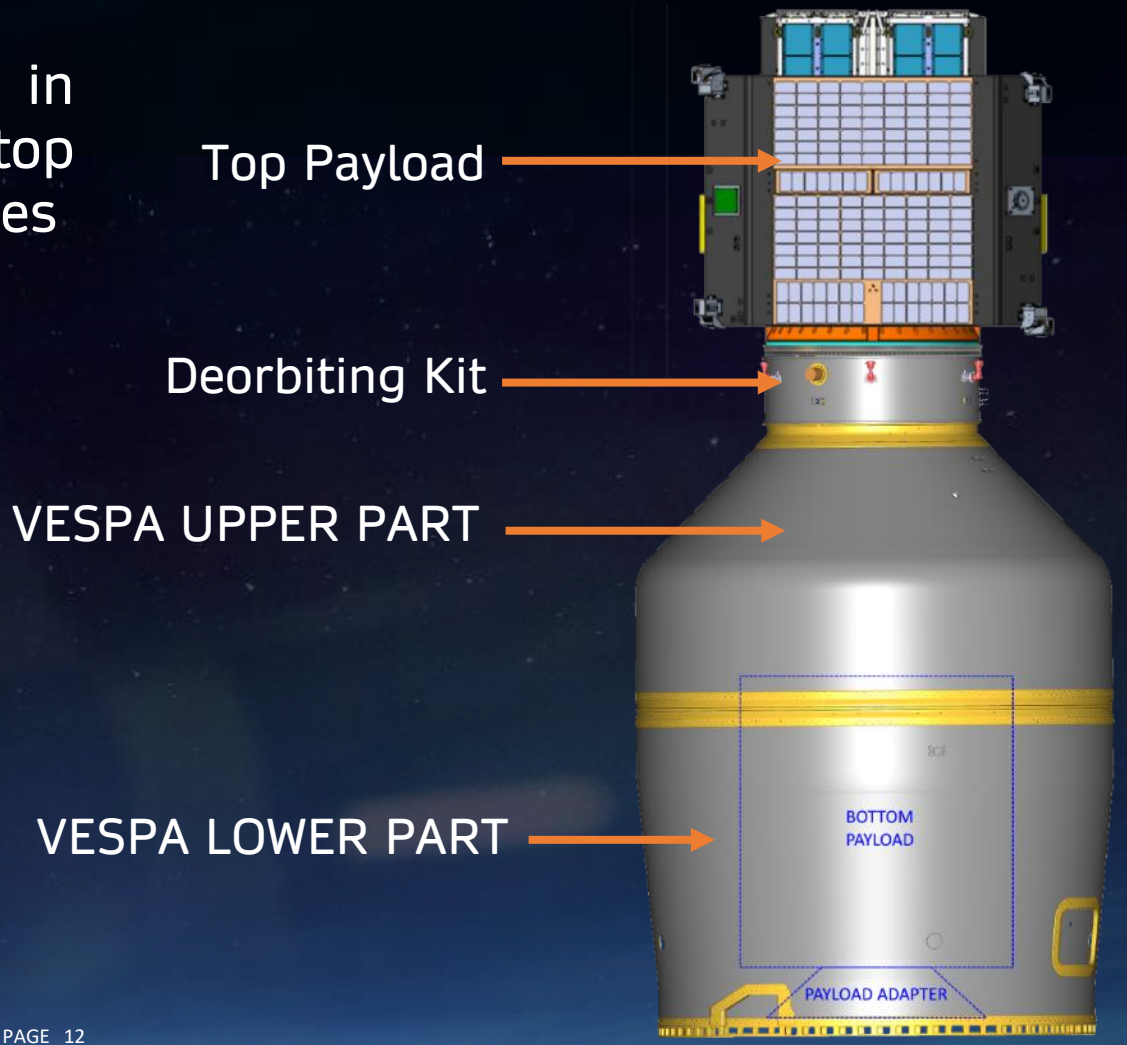
DEORBIT KIT PRODUCT LINE

The Deorbiting Kit IOD will be bolted in between the launch adapter and the top payload's clamp-band with identical interfaces

It can also sit in between the clamp-band and the spacecraft enabling the deorbit kit to deorbit the spacecraft rather than the launch adapter.
This guarantees a standard interface for both the passive and active target deorbiting kits.

A circular interface is:

- Structurally robust, as evidence by its use on all spacecraft-launcher interfaces
- Suited to accommodate chemical propulsion thrusters in a hexagon to allow for 3-axis control.
- Flexible in the attachment location and easily scalable if needed



MISSION PROFILE

DEORBIT KIT DESIGN

SELF CONTAINED

DEORBIT KIT DESIGN

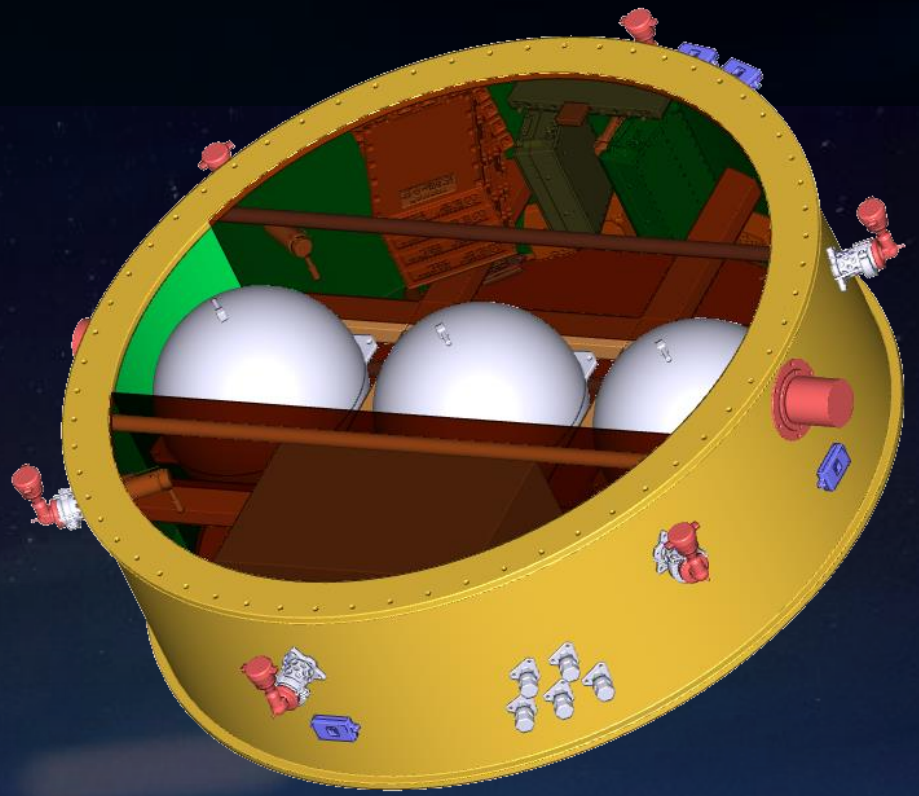
Active host monitoring equipment (host watchdog, host power and data interfaces, etc) do not make sense to have on a passive target deorbiting kit.

Hence:

- Baseline is the configuration to deorbit a passive target (Passive target DOK).
- Hardware needed to make it an Active target DOK is designed as add-ons to ensure future use compatibility.

The DOK is meant to be as self-contained as possible, with the notable exception of:

- The mechanical interface with its host,
- A potential power and data interface with its host, to enable a watchdog function.



POWER AND DATA INTERFACE

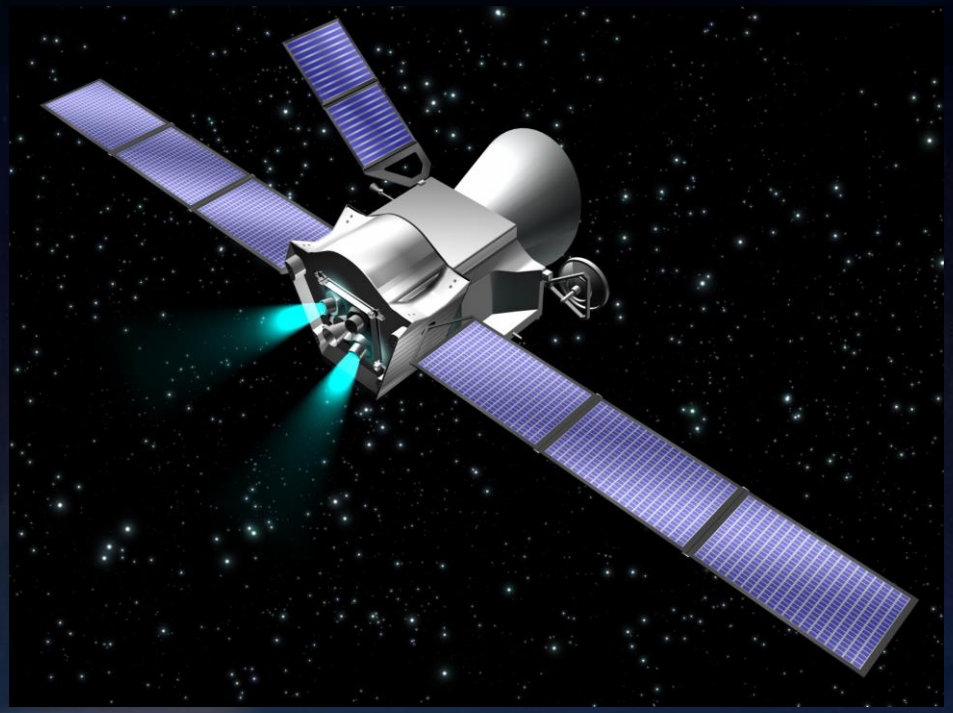
DEORBIT KIT DESIGN

The power and data interfaces are only present on the active target version of the deorbit kit. Both of these are handled on the on-board avionics, which features a watchdog board.

The following data interfaces are foreseen:

- Data connections to nominal and redounded host platform buses;
- **A low-level command** line to issue on/off commands from the host to the kit,
- **A low-level command** line to issue the batteries arm/disarm status to the Power Distribution Unit

The DOK accepts a 36V DC connection to power the watchdog function (~2.8W) during the operational life of the spacecraft, greatly limiting the impact on the host's power budget.



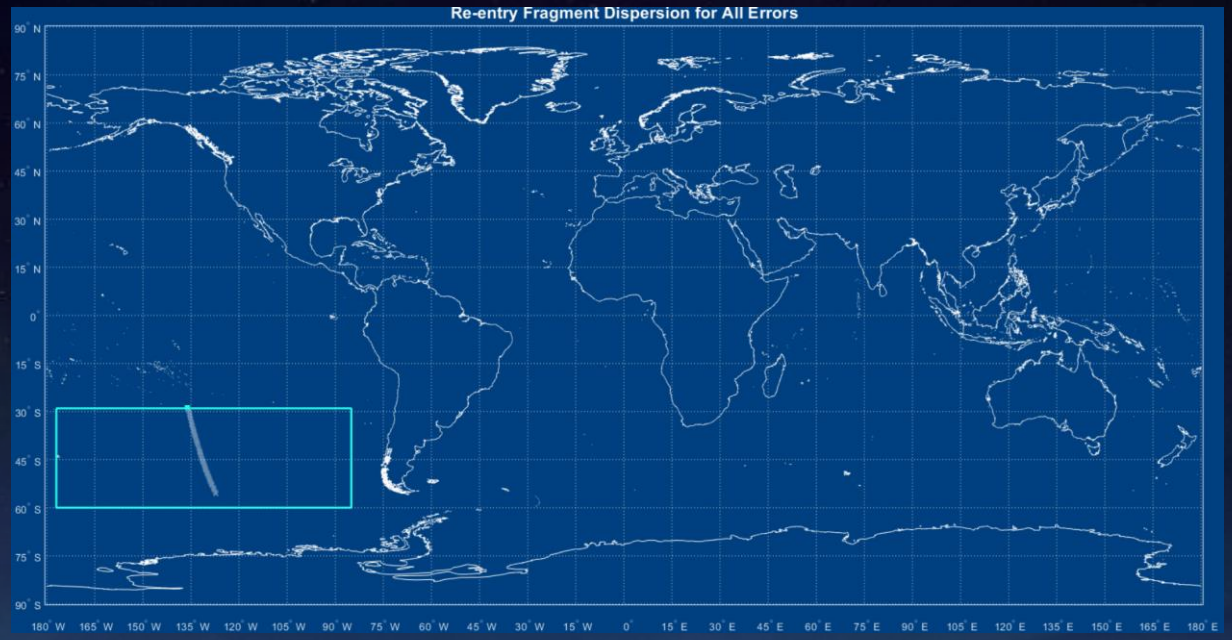
ZERO DEBRIS COMPLIANCE

DEORBIT KIT DESIGN

Technologies like the Deorbiting Kit are necessary for the ESA zero debris policy

The deorbiting kit is compliant with the goals of clean space:

- Probability of successful removal > 0.99, even for long duration missions (>25 years)
- Electric passivation for controlled reentry
- Perigee lowering phase guarantees orbital lifetime of only a few months even if disposal manoeuvre is unsuccessful
- Re-entry in uninhabited area
- Manoeuver fully tracked by ground-based radars and confirmed via ground station contact



CONCLUSION

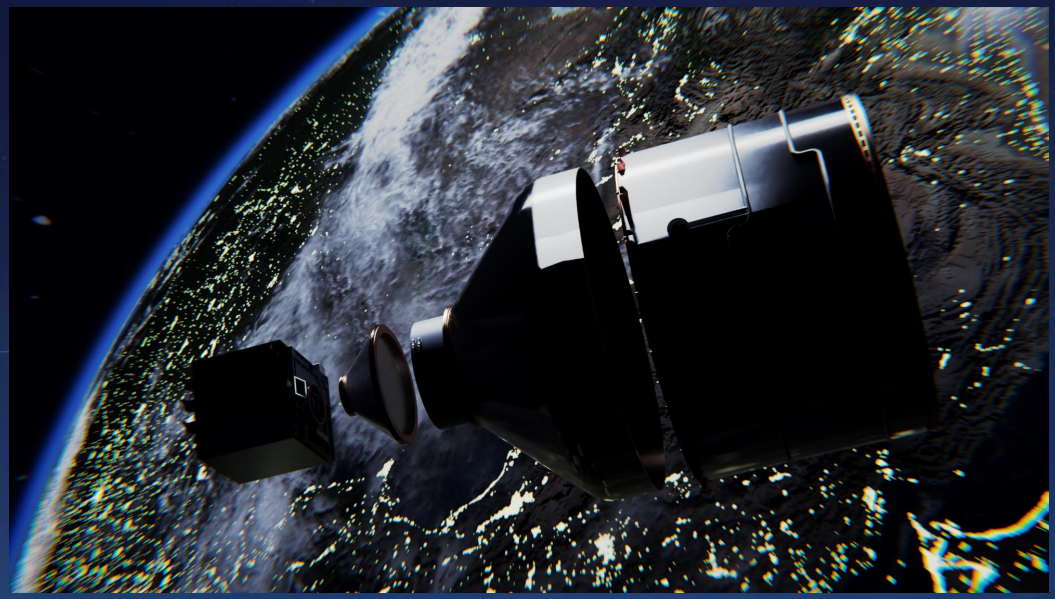
DEORBIT KIT

D-orbiting Kit's plug-in solution is special in its potential to become a self-sustaining product. While the aim of the initial activity addressed within Clean Space is to deorbit a passive launch adaptor (such as a VESPA upper part) as an in-orbit demonstration, the ultimate goal is to develop a modular and scalable concept that would allow the deorbit kit to be accommodated on other hosts (other launch adaptors and satellites). This constraint is fully integrated into the mechanical and electrical architecture of the deorbiting kit.

This effort is essential to the success of the DKIT as a viable IOS solution in the coming years to enable the ZDP

Future use cases:

- Installation in-space for Orbital Relocation, life extension, or removal
- Extension of launcher capabilities



D-ORBIT

NEW SPACE SOLUTIONS