D-ORBIT

NEW SPACE SOLUTIONS

Designing the Deorbit Kit for scalability and future use

23 Sep 2021- ESA Clean Space Industry Days

Diego Garcés de Marcilla

D-ORBIT'S BUSINESS

LEADER IN SPACE TRANSPORTATION MARKET – MOVING TOWARDS IN-ORBIT SERVICING

2021 TODAY

LAST-MILE DELIVERY SOLUTION FOR SATELLITES

- World's first in-space last mile delivery service, proven in space with paying customers
- Provides correctly spaced satellite delivery; orbital plane changing; and orbit raising
- Building block to enable future in-orbit services tomorrow

2021 TODAY

ADDITIONAL SERVICES: IN-ORBIT SERVICES

- The second life of ION: there are a range of Advanced Services D-ORBIT can provide with IONs in-orbit:

➢ In-orbit validation & demonstration
➢ Backup satellite service to a constellation
➢ Payload hosting and satellite as-a-service
➢ Satellite communication hub services

2021-2026 TOMORROW

IN-ORBIT SERVICING

- The combination of existing technology, the scalability of the ION platform and advanced robotics will enable D-ORBIT to provide in-orbit servicing to satellite operators
- In–orbit Servicing includes: Extending the life of satellites; moving satellites to new orbits; and end of life disposal of satellites

D-ORBIT'S in A GLANCE

135 people (and growing)

D-ORBIT UK

ION Advanced Services
Harwell, UK

D-ORBIT

Headquarters
Production venue, mission control
(2,500m²)

D-ORBIT USA

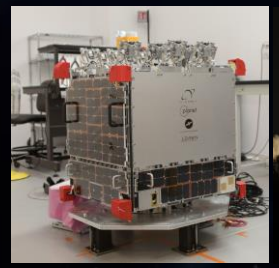
Commercial subsidiary, Washington DC

D-ORBIT PT

Critical software and AURORA mission control software,
Lisbon, Portugal

ION SWIFT (R)EVOLUTION

Three Missions in Nine Months and a Growing Degree of Complexity

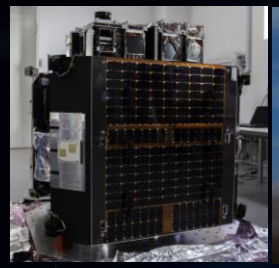



FIRST MISSION
Mission Name: **ORIGIN**
Carrier Name: **ION SCV 001 Lucas**
Date: **September 2020**
Status: **Ended successfully in Oct.'20**

Launch site: Guyana Space Center
Launcher: Vega
Mission: SSMS POC Flight

Satellites onboard: 12
Client: Planet Labs

Validation in space of AURORA, D-Orbit's proprietary cloud-based mission control software.




SECOND MISSION
Mission Name: **PULSE**
Carrier Name: **ION SCV 002 Laurentius**
Date: **January 2021**
Status: **Ongoing**

Launch site: Cape Canaveral
Launcher: SpaceX
Mission: Transporter-1

Satellites onboard: 20
Clients: Planet Labs and one undisclosed US customer

Hosted payloads onboard: 2
Clients: EICAS Automazione, IAC

Validation in space of ION Hosted Payload Service, D-Orbit's innovative plug-and-play technology for in-orbit experiments

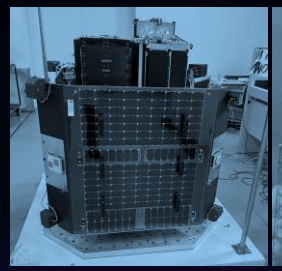

THIRD MISSION
Mission Name: **WILD RIDE**
Carrier Name: **ION SCV 003 Dauntless David**
Date: **June 2021**
Status: **Ongoing**

Launch site: Cape Canaveral
Launcher: SpaceX
Mission: Transporter-2

Satellites onboard: 9
Clients: Deimos Space, Endurosat, Orbital Space, ISISPACE, Reaktor Space Lab, Marshall Intech Technologies, Royal Thai Airforce.

Hosted payloads onboard: 3
Clients: Stellar Project, Unibap, HPS

Testing of Nebula, an on-demand, on-orbit cloud computing and data storage service at the core of D-Orbit's future services




FOURTH MISSION
Mission Name: **DASHING THROUGH THE STARS**
Carrier Name: **ION SCV 004 Elysian Eleonora**
Date: **December 2021**
Status: **Waiting to launch**

Launch site: Cape Canaveral
Launcher: SpaceX
Mission: Transporter-3

Satellites onboard: Not-disclosable yet
Clients: Not-disclosable yet

Hosted payloads onboard: Not-disclosable yet
Clients: Not-disclosable yet

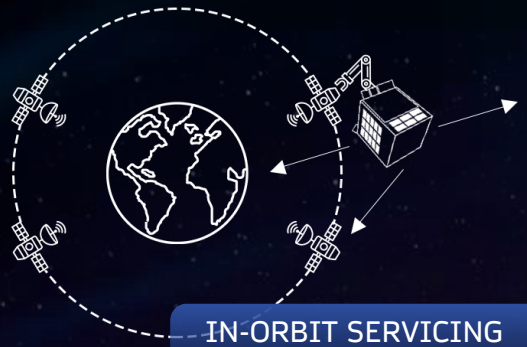
TOMORROW

IN-ORBIT SERVICING

ENABLING TARGETED OBSERVATIONS

The combination of **existing D-ORBIT technology**, the scalability of the **ION platform** and **advanced robotics** will enable D-ORBIT to provide in-orbit servicing to satellite operators

SCALABLE AND MODULAR



IN-ORBIT SERVICING
ACTIVE DEBRIS REMOVAL

TRANSPORTATION	REFUELING	PHASING
MAINTENANCE	EMERGENCY	DISPOSAL

01	Move existing satellites from one orbit to another new orbit	03	Rescue satellites launched or drifting to the wrong orbit
02	Extend the life of satellites	04	Dispose of satellites properly at the end of their life (active debris removal)

PROGRAM INTRODUCTION

CLEANSPACE DEORBITING KIT DEVELOPMENT AND IN-ORBIT DEMONSTRATION

D-Orbit has been selected 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 of the Space Safety Programme (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.

DEORBIT KIT

END OF LIFE DISPOSAL SOLUTION

01 WILL PERFORM A DIRECT RE-ENTRY OVER DESERTED AREAS

02 CAN DEORBIT TARGETS UP TO 2000KM ALTITUDE

03 COMPLETELY AUTONOMOUS FROM TARGET

04 3-AXIS DETUMBLING CAPABILITIES

05 MODULAR AND SCALABLE

DEORBIT KIT HERITAGE

LEADER IN SPACE TRANSPORTATION MARKET – MOVING TOWARDS IN-ORBIT SERVICING

D3 DECOMMISSIONING DEVICE

independent, smart propulsive device available for all satellite platforms operating in LEO, MEO, GEO,

SIMBA
ON BOARD COMPUTER

A lightweight, cost-effective, and versatile onboard computer for platform management or general-purpose applications

SimON
Electro-Explosive System

Used for the remote safe ignition of pyrotechnical chains. The system is particularly indicated for solid rocket motor ignition.

KEY TECHNOLOGIES TESTED IN ORBIT IN 2013 (ALICE 2) AND 2017 (D-SAT)

PROGRAM OBJECTIVES

CLEANSPACE DEORBITING KIT DEVELOPMENT AND IN-ORBIT DEMONSTRATION

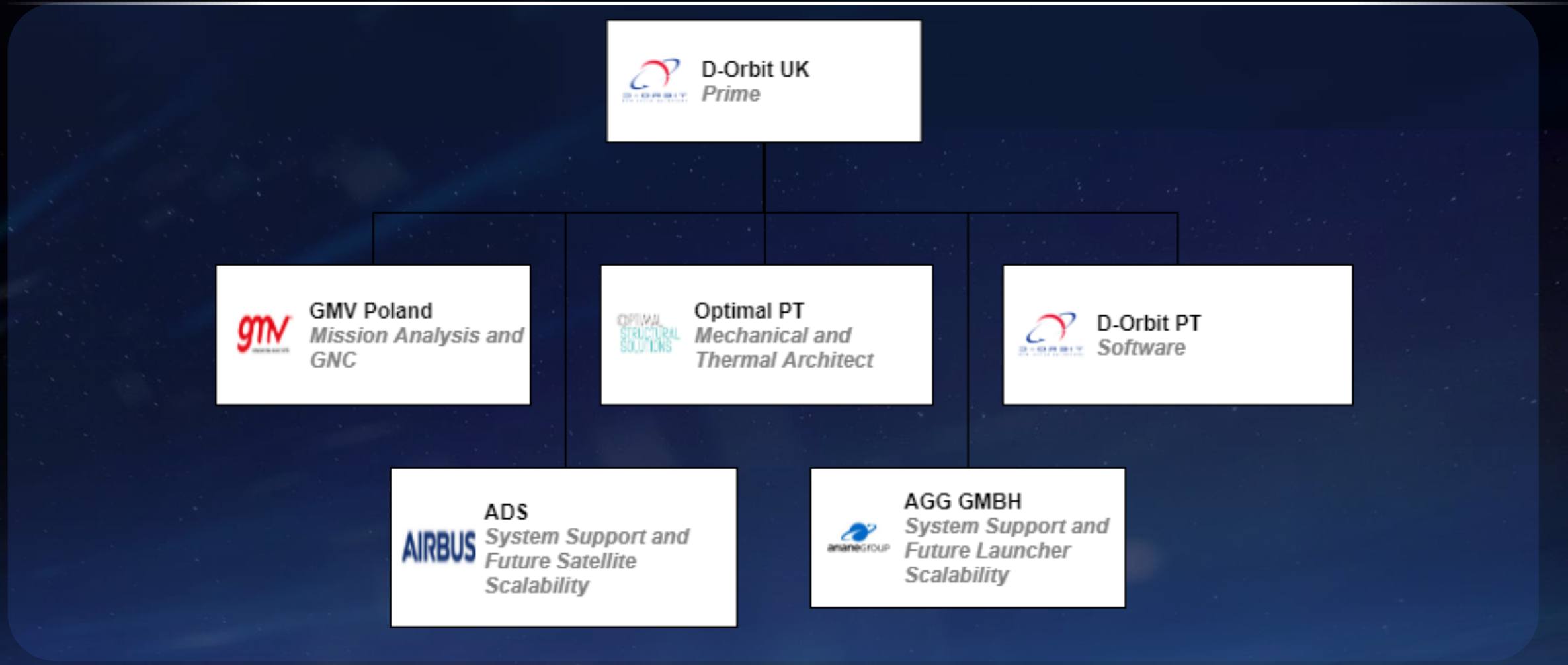
- ClearSpace will launch the first active debris removal mission, ClearSpace-1, which will rendezvous, capture and de-orbit for re-entry the upper part of a Vespa (Vega Secondary Payload Adapter) used with Europe's Vega launcher. This object was left in a 'gradual disposal' orbit (approximately altitude 801 km by 664 km), complying with space debris mitigation regulations, following the second flight of Vega in 2013.

- The Clearspace-1 deployment will be performed by a VEGA launcher with its own VESPA.

This second VESPA is the preliminary target of the deorbit kit

PROGRAM TEAM

CLEANSPACE DEORBITING KIT DEVELOPMENT AND IN-ORBIT DEMONSTRATION



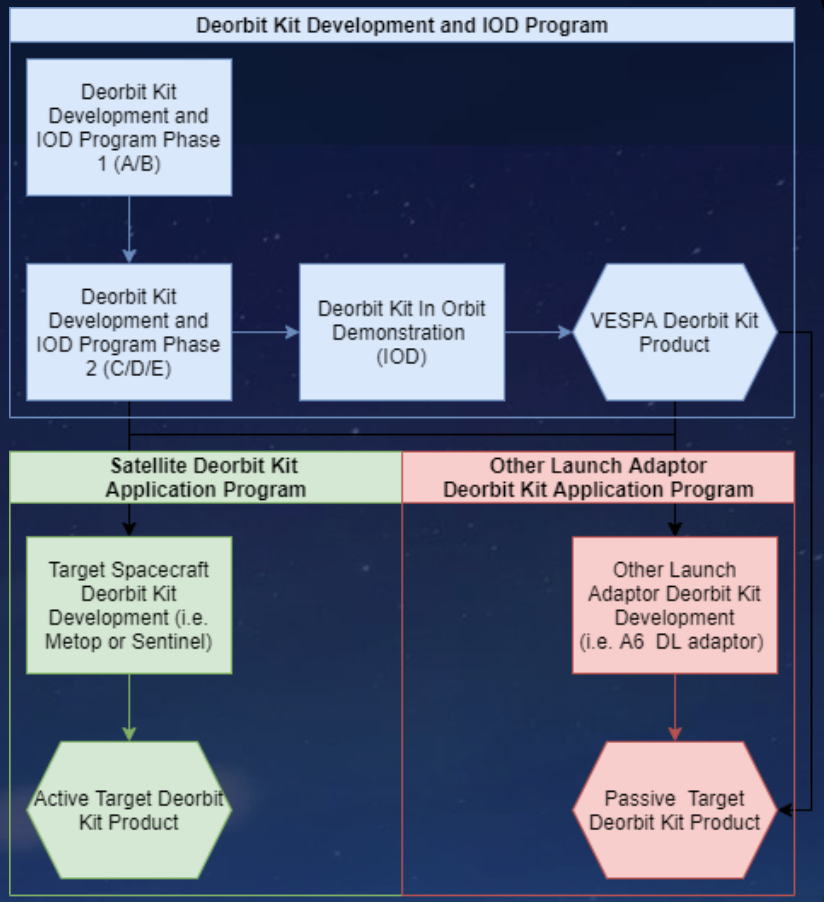
VISION

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.



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.

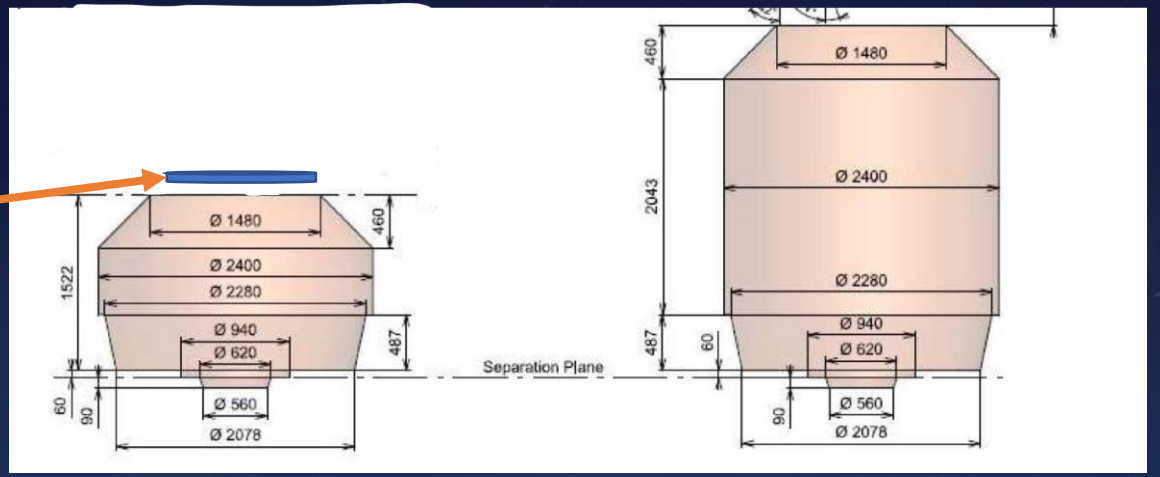
The DOK is meant to be as self-contained as possible, with the notable exception of:

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

MECHANICAL INTERFACE

DEORBIT KIT DESIGN

The DorbitKit is designed as a short circular disk to enable accommodation within a common feature between all spacecraft and launch adaptors that usually is aligned with their COG: the ring interface.



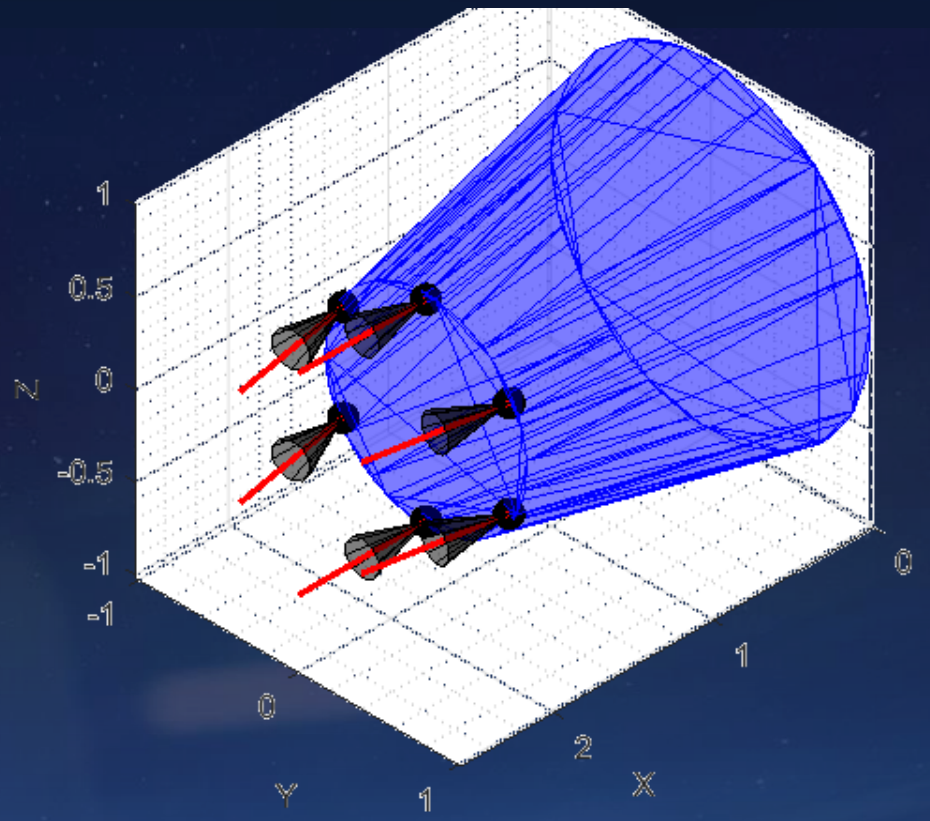
For this reason, a single circular mechanical interface is foreseen to accommodate a maximum number of already developed and future spacecraft and launch adaptors.

MECHANICAL INTERFACE

DEORBIT KIT DESIGN

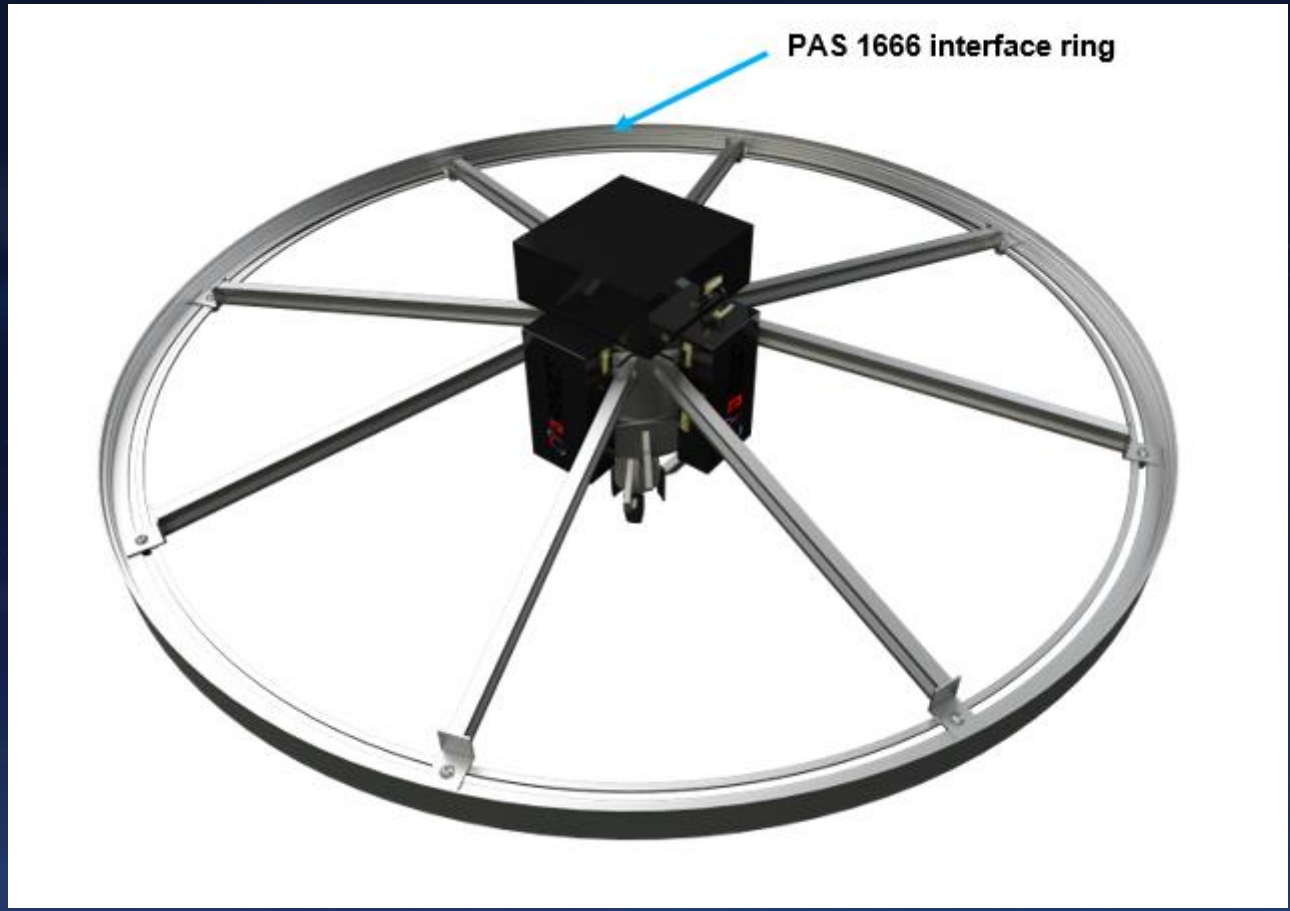
A circular interface is:

- 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



D3 INTERFACE

DEORBIT KIT DESIGN



POWER AND DATA INTERFACE

DEORBIT KIT DESIGN

The current design for the IOD of the DOK includes a nominal and a redundant OBC, and primary batteries. The active version of the DOK also includes secondary batteries.

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

For each of the two OBCs, the following data interfaces are foreseen:

- Data connections to nominal and redounded host platform buses, **MIL-STD-1553B standard;**
- **A low-level Low-Power Command (LPC)** line to issue on/off commands from the host to the kit,
- **A low-level High-Power Command (HPC)** line to issue the batteries arm/disarm status to the Power Distribution Unit

The DOK accepts two independent 28V DC connections, one for each OBC, connected respectively to the nominal and redundant 28V bus to power the watchdog function (~1W), the health checks on the DOK that the host spacecraft may want to perform regularly, and the secondary batteries.

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 standardisation effort is essential to the success of the deorbiting kit as a viable IOS solution in the coming years.

Future developments to make the system suitable for being installed in space on existing space assets to provide services such as:

- Orbital Relocation
- Life Extension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