Executive Summary

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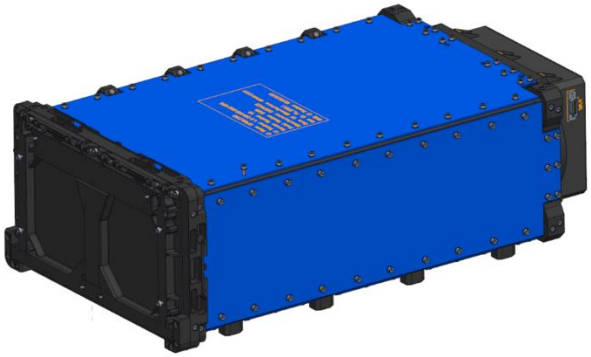

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Change Log

Version	Date	Affects	Description
1.0	2023-04-19	All	First version.

1 Executive Summary

This executive summary provides an overview of the Deep Space Deployer project, which was undertaken by our team at ISISPACE for the European Space Agency. The project involved the design, development, testing and delivery of a deployer that could be used for the release of small satellites into deep space.

The deployer underwent a rigorous qualification campaign, which included a series of tests to verify its performance in extreme mechanical and thermal conditions. The campaign was successfully completed, demonstrating the deployer's ability to meet the demanding requirements of deep space missions.

The purpose of this report is to summarize the entire project, from initial design concepts to the final delivery of the deployer. The report provides an overview of the project timeline, the design and development process, the testing and qualification campaign, and the final delivery of the engineering qualification model deployer to the European Space Agency. It is important to note that this report does not contain any proprietary or confidential information. Its aim is to provide a high-level summary of the project for the benefit of stakeholders and other interested parties. We hope that this executive summary provides a clear and concise overview of the Deep Space Deployer project and its successful outcome.

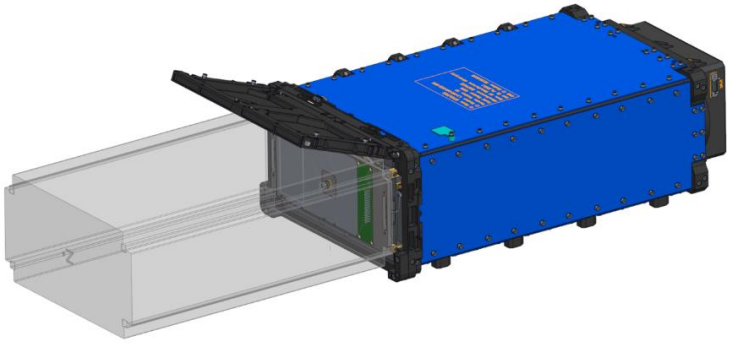

Figure 1: Deep Space Deployer in Deployed Configuration.

The objective of the project was to design an engineering and qualification model of a deployer that allows for a low-velocity deployment from the Hera spacecraft to deploy its 6U CubeSats close to the binary asteroid system for scientific measurements. The Hera spacecraft is planned to launch in 2024 and rendezvous with binary asteroid Didymos, and its moon Dimorphos, in December 2026. The mission will also have two CubeSats on board, Milani & Juventas, which are to be launched by the Deep Space Deployer, each, at a speed of 3 ± 1.0 [cm/s]. The Deep Space Deployer has been designed to accommodate a CubeSat of up to 12.5kg and 6U size. The deployer is integrated into the Hera platform and acts as a "safety box", where it in essence protects the Hera spacecraft from any potential issues that could arise from the malfunction of the onboard CubeSats while in transit to Didymos.

The Deep Space Deployer is based on ISISPACE' DuoPack deployer which has flown on previous missions. The deployer acts as an interface between the host spacecraft and the CubeSats using two special systems designed for this mission – the CubeSat Release System (CRS) and the Umbilical Disconnect System (UDS). The system overview can be found in Figure 2.

In order, to ensure the low-velocity speed of 3 ± 1.0 [cm/s] the CubeSat needs to be disconnected from the Hera spacecraft prior to release using the Umbilical Disconnect System. The system rotates away from the CubeSat using a rotating lug. After that, the CubeSat Release System can deploy the CubeSat(s) into deep space. The CubeSat Release System has three tasks:

1. Fix the position of the CubeSat on the pusher plate outside of the Deep Space Deployer,
2. Hold on to the CubeSat when outside of the Deep Space Deployer,
3. Release the CubeSat with a precise low velocity and a limited rotation rate.

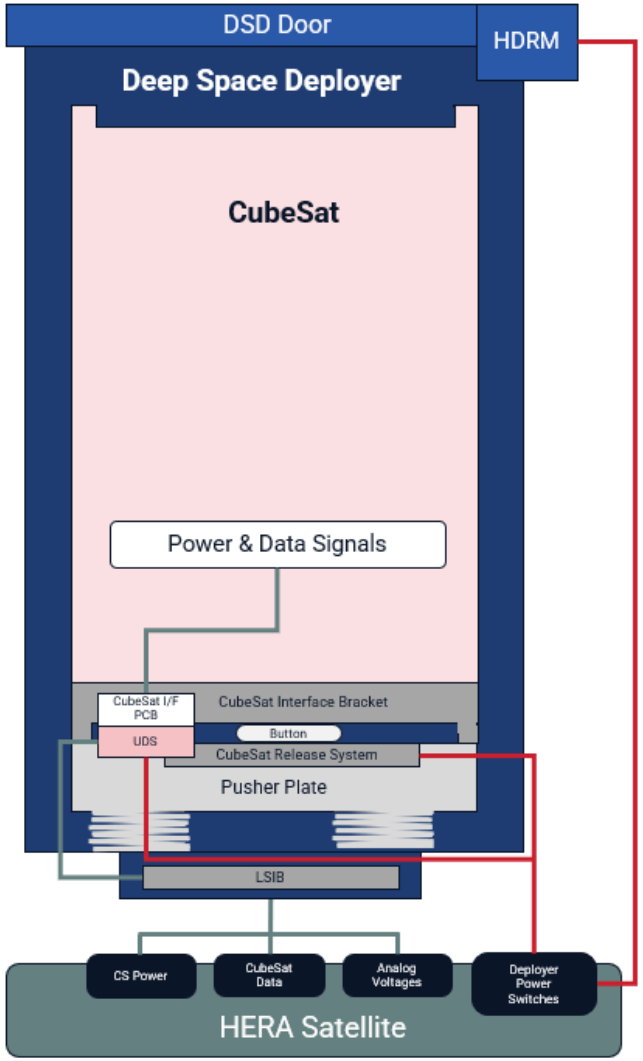

Figure 3: System Overview.

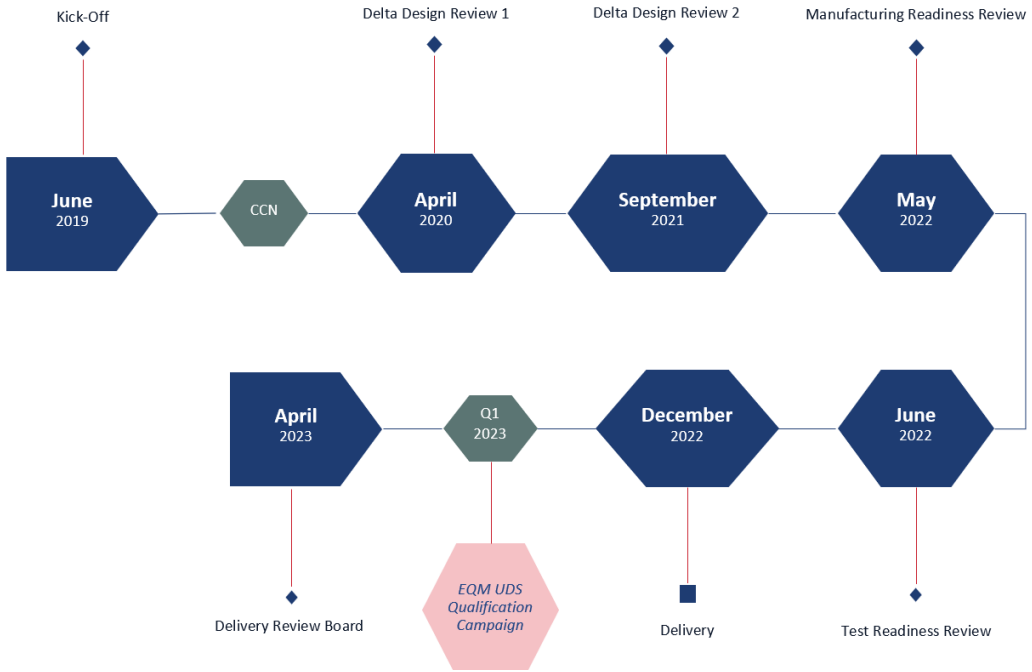

Figure 2: Project Timeline.

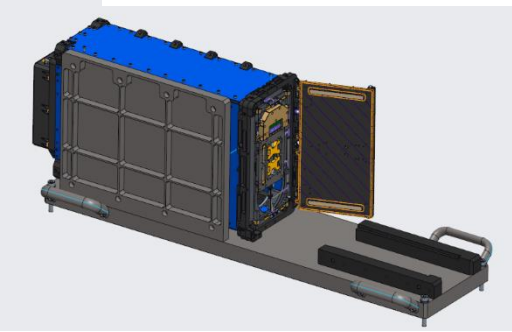

Figure 5: Mass Dummy on Wheels.

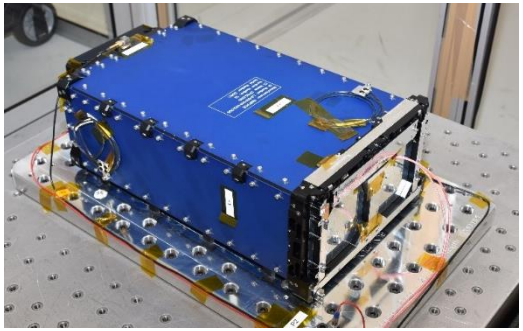

Figure 4: Deep Space Deployer on Vibrations Shaker.

The timeline of the project can be found in Figure 2. Original delivery date of the project was set September 2021. Due the introduction of additional requirements after the first design review, the deadline was pushed to Summer 2022. However, due to design mistakes the qualification campaign had to be stopped twice.

First Qualification Campaign started in June 2022 and ended after the vibrations test, Figure 4 depicts the Deep Space Deployer during the vibrations test. The position of the dynamic rail was moved, however, the door was not updated accordingly. Therefore, the dynamic rail was not clamped and the door had to be redesigned to ensure correct clamping. Dynamic rail ensures the CubeSat is safely *clamped* in the deployer and lowers the vibrations experienced by the CubeSat.

Figure 6: First Qualification Campaign.

Throughout the qualification campaign, several functional tests have been performed. With the exception of post-vibe & post-shock functional tests, all functional tests, have been carried out using mass dummies on wheels, see Figure 5. The dummy has special bearings that mimic zero gravity and allow for a functional evaluation of the CubeSat Release System as well as the Umbilical Disconnect System.

The second qualification campaign started in September 2022. The qualification saw a successful release velocity test and a thermal qualification test only to fail during the vibrations test. The redesign of the door was successful however, the CubeSat release system failed. During the design review, it was discovered the motorization margins applied during the design were not strict enough. Therefore, in cooperation with ESA mechanical expert, the system was redesigned using stronger springs. Moreover, in order to avoid a potential risk found during the design review of the new system, the clamps of the CubeSat Release System were made out of Beryllium Copper.

Figure 7: Second Qualification Campaign.

The third qualification campaign started in October 2022. It was a semi-successful qualification campaign for the deployer and the CubeSat Release System functioned flawlessly. The Umbilical Disconnect System, which ensures communication with Hera spacecraft, unfortunately, experienced some issues. The system worked reliably during previous functional campaigns but during the third qualification campaign, it began experiencing reliability issues. A detailed investigation was carried out, with the support of ESA, and it was discovered the system was designed without necessary margins. The main design update resulted in the main motorization spring of the locking lug being changed from tension to a torsion spring.

Figure 8: Third Qualification Campaign.

A delta-qualification had to be carried out in order to qualify the umbilical release system. The qualification campaign had the flow depicted below. The delta – qualification was successful and concluded in the winter of 2023. The Deep Space Deployer was delivered to ESA in December 2022 and used by the Milani & Juventas teams during their qualifications.

Figure 9: Umbilical Disconnect System Qualification Campaign.

In order to increase surface treatment resilience and de-risk outgassing, a change of material and surface treatment specification allowed for improved surface treatment quality, this can be seen in the DSD showing a

new golden colour in contrast to the traditional blue colour of ISISPACE Deployers. To adhere to thermal needs of the door of the deployer is covered in a Secondary Surface Mirror tape. In addition, aluminium tape has been applied on connector wires that are exposed to the environment during the journey to Didymos.

The project has resulted in a successful qualification of a Deep Space Deployer for use in deep space. ISISPACE has delivered two flight models to the Hera mission as well as a flight spare model. The final version of the Deep Space Deployer can be seen in Figure 10.

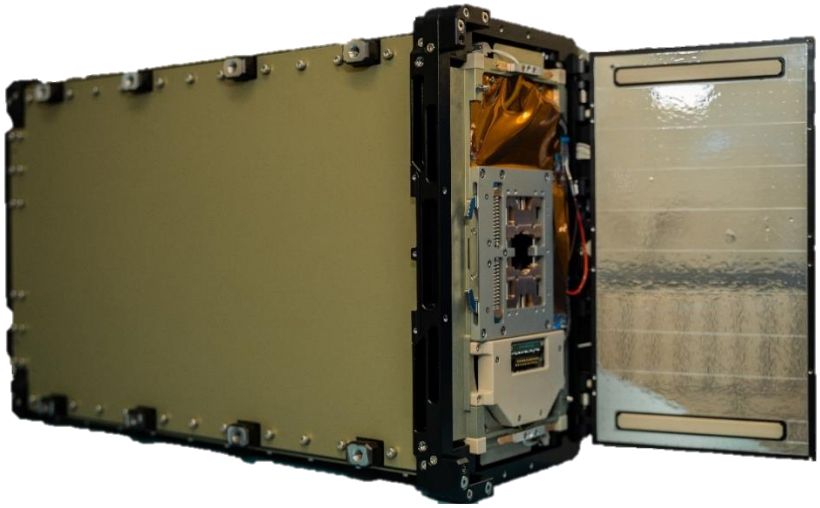

Figure 10: Flight Model of Deep Space Deployer.