THE CLEARSPACE-1 MISSION: ESA AND CLEARSPACE TEAM UP TO REMOVE DEBRIS

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ABSTRACT

During the 2019 ESA Council at Ministerial Level, Space Safety was adopted as a new basic pillar of ESA's activities, including the first space mission to remove an item of debris from orbit. As a result, ESA has signed an €86 million contract with an industrial European consortium led by Swiss start-up ClearSpace SA to develop this unique debris removal service. The objectives of this mission are to 1) Remove from orbit ESA-owned object(s) with a total mass greater than 100 kg by no later than end 2025, 2) demonstrate the technologies needed for debris removal, and 3) open a new market for in-orbit servicing and debris removal.

The target to be removed is an ESA owned VESPA (VEGA Secondary Payload Adapter) upper part, launched in 2013. It orbits the Earth in a slightly eccentric orbit (664 km x 800 km). VESPA's mass and dimensions, 112 kg, 1.3m height and 2.1m maximum diameter, make it a representative object for possible future debris removals of for example large constellations.

1 A SERVICE ORIENTED APPROACH

ESA's Clean Space Office has studied Active Debris Removal (ADR) missions for several years now, ranging from internal conceptual designs[1] in 2012 up to detailed designs with European large space integrators[2]. While these studies focussed on a classical phased design approach (e.g. phase A/B/C/D), in parallel desire for a more service oriented approach was pushed forward by European industry.

In response to this desire, ESA's Director General gave the go-ahead to release a Request for Information in 2018, where European Industry could submit an outline of an idea for a mission concept to remove a European debris. Several ideas were submitted and evaluated by ESA. The six most promising ideas all received a Service Offer Request in 2019. This time, industry were asked to propose a service to remove their selected debris by 2025. This service would be subjected to funding by ESA member-states at the Ministerial Council, By the end of 2019, Space Safety was adopted during the Ministerial Council as a new basic pillar of ESA's activities, including the first space mission to remove an item of debris from orbit: the ADRIOS (Active Debris Removal and In-Orbit Servicing) program was born, with its first mission: ClearSpace-1.

2 CLEARSPACE-1 IN A NUTSHELL

Eight ESA member states supported the mission during the Ministerial Council, namely Switzerland, Poland, Germany, Czech Republic, Sweden, Portugal, The United Kingdom and Romania, bringing a funding of 86 Million Euro to the mission with the goal of implementing the first space mission to remove an item of debris from orbit. ClearSpace-1's objectives are therefore:

- clean up space by removing from orbit ESA-owned object(s) with a total mass greater than 100 kg by no later than end 2025
- demonstrate the technologies needed for debris removal
- open a new market for in-orbit servicing and debris removal.

The mission budget is estimated at 100 Million Euro plus an additional 10 Million of margin. The prime company of the industrial consortium will need to draw on its network of sponsors and contributors to fund this 24-Million-euro contribution.

3 THE TARGET

The target to be removed is an ESA owned VESPA (VEGA Secondary Payload Adapter) upper part, (NORAD object 39162), launched as part of VEGA's second launch ('VV02') that took place on 7 May 2013. It allowed for three satellites to be launched: ESA's PROBA-V satellite, VNREDSat-1, and ESTCube-1. PROBA-V was mounted on top of the VESPA as it was the first satellite to be deployed, and was injected into a Sun-Synchronous Orbit (SSO) at 820 km and inclination 98.73º.

Following the deployment of PROBA-V, the VESPA Upper Part (VESPUP) was ejected from the VESPA Lower Part (known as 'boat-tail'), which allowed the deployment of the remaining two satellites. Fig. 1 shows the VESPA with PROBA-V mounted on top. One can clearly distinguish the upper part of VESPA from the

boat-tail, with the gold-coloured separation ring in-between. While the VESPUP is mostly dark coloured, it is clear that several light-coloured parts can be distinguished, which could aid in autonomous image recognition.

Figure 1. PROBA-V on VESPA adapter (Credits: ESA/CNES/Arianespace/Optique Video du CSG)

Fig. 2 shows an overview of the VESPUP characteristics.

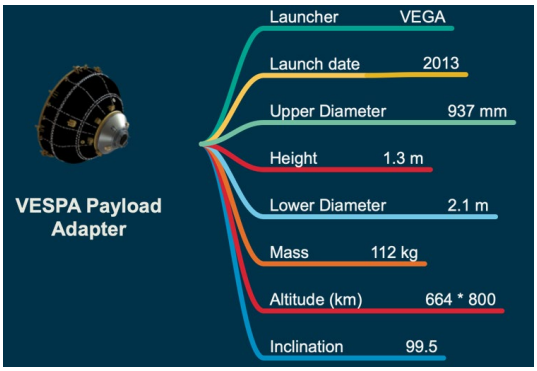

Figure 2. Overview of VESPUP characteristics.

This object's mass and shape are close in size to a typical small satellite. Its relatively simple conical shape and sturdy construction make it a suitable first goal, before progressing to larger, more challenging captures with follow-up missions. It is uncontrolled, and so well represents the technical challenge of rendezvous and capture with an 'uncooperative' target.

4 THE SERVICER

The ClearSpace-1 servicer itself is a medium-sized servicer with payloads for visual navigation and capture system. Designed to fit in a VEGA-C launch configuration shared with other satellites, the platform is based on conventional and mostly off-the-shelf equipment allowing to keep the development cost to a minimum. Several sensors will be present to allow vision-based navigation, such as visual cameras (both far range and for close range) and a radar, see Fig. 3.

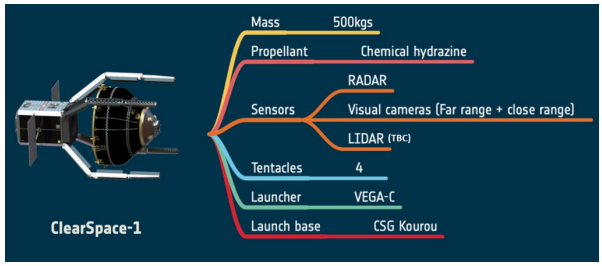

Figure 3. ClearSpace-1 Servicer overview

The dominant feature of this mission is of course the capture system, which consists of 4 tentacles large enough to embrace the target and ensuring a capture even without touching. Once embraced, the arm joints will rotate further in order to achieve a firm grip on the target by pushing it towards the servicer. Fig. 4 shows an animated capture sequence. This method allows to secure the target independently of its attitude, and for a wide range of tumbling rates. Following capture, the servicer-target stack is expected to start rotating and will need to be stabilised.

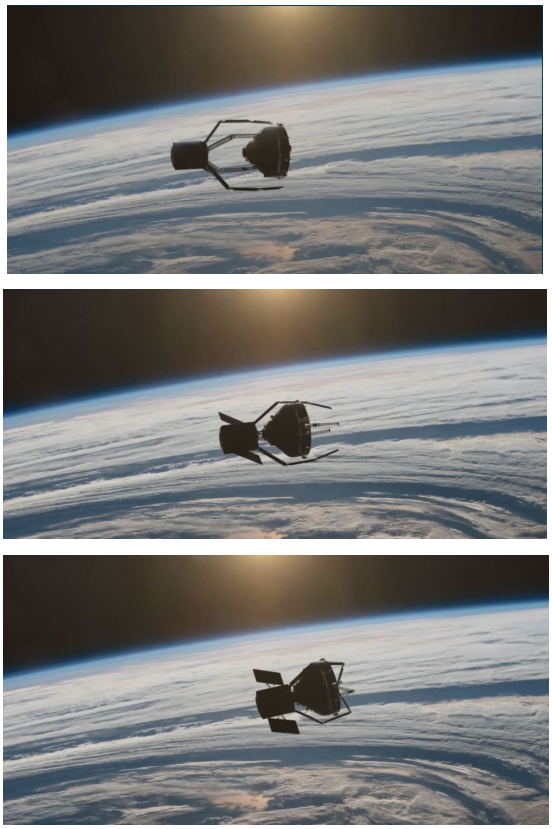

Figure 4. Animated sequence of the servicer capturing the target.

The mission's operational concept includes a launch to a parking orbit, from which not only a commissioning phase but also a targeting phasing time are started, in order match the orbit plane of CleanSpace-1 with that of the VESPA Upper Part. When matched, the satellite changes altitude and performs a Far Range Rendezvous, switching to a Close Range Rendezvous when getting closer to the target, and finally captures it as shown above. Once captured, the now-stack configuration stabilises, turns around and performs a set of de-orbit burns to ensure a re-entry of both ClearSpace-1 and VESPA.

Future plans call for servicing missions that could deorbit multiple objects without also destroying themselves.

5 THE SCHEDULE

The mission design started in late-2020 and is now in preliminary requirements phase to be completed by late 2021. A one-year preliminary design is then followed by a one-year detailed critical design phase. The final design phase, qualification and acceptance, starts in end 2023 and continues to mid-2025 when the satellite is readied for launched. Each design phase ends with Key Performance Gate, where the progress of this service procurement is evaluated by ESA. See Fig. 5 for an overview of the schedule.

This service approach allows the contractor to be responsible not only for the design but also for launcher procurement and operation of the mission, giving ClearSpace SA the foundation to enable future commercial Active Debris Removal and In-Orbit Servicing activities.

Figure 5. ClearSpace-1 Schedule

6 A NEW PLAYER IN TOWN…

Fig 6 shows a draft consortium overview (draft as the consolidation of the consortium is still on-going through competition). ClearSpace SA is leading an industrial team for the mission. ClearSpace will lead the design, while its partners will build the servicer. ClearSpace was founded in 2018 out of the realization that On-Orbit Servicing and Space Debris Removal are vital services for the future of Space exploration and operations.

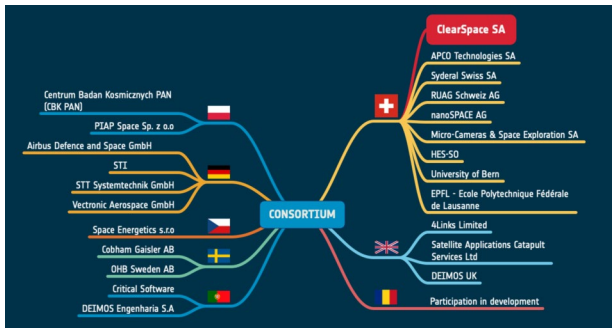

Figure 6. ClearSpace-1 main consortium overview

Since its foundation, ClearSpace SA company staff have grown above 30 members[3].

7 CONCLUSIONS

ESA has signed an €86 million contract with an industrial European consortium led by Swiss start-up ClearSpace SA to develop this unique debris removal service. The target to be removed by 2025 is the uncontrolled VESPA upper part.

The servicer spacecraft called ClearSpace-1 is a medium-sized spacecraft featuring several vision-based navigation sensors, as well as four tentacles in order to capture the target.

This new service, supported by eight ESA member states, allows the contractor to be responsible not only for the design but also for launcher procurement and operation of the mission, giving ClearSpace SA the foundation to enable future commercial Active Debris Removal and In-Orbit Servicing activities..

8 REFERENCES

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3. ClearSpace website, https://clearspace.today/