INSIDER CONCEPT: INNOVATIVE NET & SPACE INFLATABLE STRUCTURE FOR ACTIVE DEBRIS REMOVAL

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ABSTRACT

This paper intends to describe Bertin Technologies' INSIDeR concept. INSIDeR is a patented concept associating two key technologies, net capture and inflatable structures. Net capture is a particularly interested solution to have a concept adaptable to debris morphology and tumbling rate. Inflatable structures are a good mean for deployment, easy control and damping of the movement.

1 INTRODUCTION

Hundreds of thousands of debris are currently orbiting around Earth and their number is growing day by day because of scientific and commercial exploitation of space. The most of orbital debris is in Low Earth Orbit (LEO) posing a danger to users of the orbital environment, such as satellites, as well as for humans or manmade structures on ground could be impacted when objects reenter Earth's atmosphere. Therefore, "space junk" is a real concern and several studies carried out by national and international space agencies in the world, such as NASA and ESA, have shown the need to perform active debris removal (ADR) to stabilize the environmental effect and mitigate risks.

There are a large number of potential solutions to deorbit space debris, from classical robotic arm to space laser technologies, but none of them has already been neither employed nor even space qualified.

The idea proposed by Bertin Technologies is a new solution to safely deorbit space debris of various sizes using a new capture system named INSIDeR, Innovative Net & Space Inflatable structure for active Debris Removal.

2 PRESENTATION OF THE CONCEPT

INSIDeR is a concept, patented in Europe by Bertin Technologies, combining two key technologies. Firstly, high-strength flexible net will act as capture system able to cope with large objects and to fit with different debris morphology and tumbling rate. Then, inflatable structures will act as deployment system ensuring control and damping of debris movement.

A system based on the above mentioned key technologies offers technical and operational advantages. Concerning the mission, INSIDeR can be used as capture kit able to fit on different ADR chaser concepts (mono-mission or multi-mission) enabling high controllability during capture and dumping sequence (coupling sequence in attached files) which will ensure full compatibility with a wide range of mission scenarios. Concerning the debris targeted, INSIDeR is scalable and adaptable to both small and large debris and robust to any object shape and attitude tumbling rate. Concerning the system development and qualification, INSIDeR is a simple, reliable and cost-effective solution which relies on an innovative combination of technologies relatively mature ensuring a limited qualification effort. This last point represents one of the main advantages of INSIDeR. Actually, the deployment and capture system can be almost entirely qualified on ground leading to a considerable reduction of validation costs and development risks. Indeed, the main design and functional parameter for inflatable systems is the difference of pressure between the inside and the outside of the structure, condition which will be easily reproduced on ground to test deployment and capture sequence.

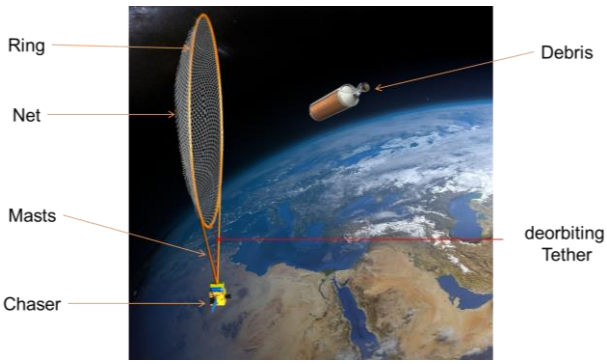

Figure 1. Presentation of INSIDeR

In stowed configuration, INSIDeR consists, in an early preliminary approach, in a 50cm-box that can be plugged on any ADR chaser or on space multi-mission bus, such as the Myriade or Proteus platforms. This box acts as main mechanical interface with the platform and it hosts deployable and non-deployable components.

Operationally, INSIDeR leaves enough time to operate the system in a space environment giving the opportunity to have many Go/No-Go points. This will

improve reliability and limit potential failure causes. Finally, this system is space-saving, that means that in case of aborted mission no further space debris will be generated.

3 MAIN CHARACTERISTICS

INSIDeR capture system consists in the following deployable elements:

- Inflatable ring,
- Deployable net fixed on the ring (opportunely folded when the system is in stowed configuration),
- Several inflatable masts linked to the ring and the box in order to produce a semi-rigid link between the platform and the capture system,
- One or several tethers that goes around the ring and that are linked to the chaser
- A snap link to lock the net by pulling on the cable.

Non-deployable items, accommodated close to the chaser interface, are:

- The deploying mechanisms such as the inflating/deflating device and the cable winding/unwinding device
- The detection subsystem consisting in a dedicated sensors and cameras to detect the target and follow the coupling sequence.
- The electronic system providing the control functions and the power generation and distribution

Different capture operation approaches exist. One of the options is illustrated in the following figures and described hereinafter.

After separation from launch vehicle, the chaser performs the required manoeuvers to synchronize itself with the target and join an orbit slightly higher than that of the object as shown in Fig. 2. There, the deployment of the capture system is carried out keeping a safety distance (few hundreds of meters) from the debris. Then, a complete check-up of all the systems is performed and the sensor target acquisition procedure starts.

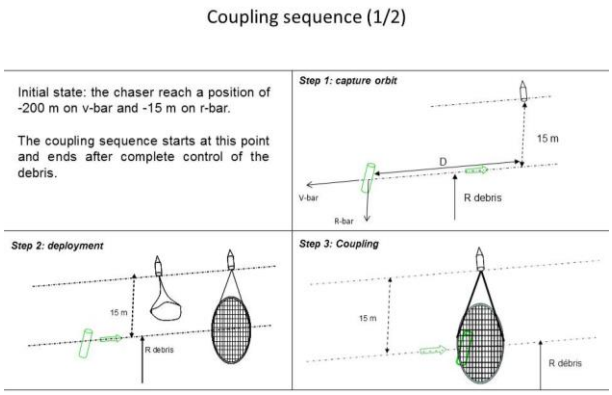

Figure 2. First part of the coupling sequence

Once acquisition is carried out and the system is ready, a small impulsion is given to the chaser in order to approach the target with a relative velocity of less than 2 m/s. This sequence is presented on Fig. 3. It shall be noted that, if a problem is detected, the system can be stopped and switched in safe mode at any time during the approach phase. In nominal operation, the irreversible capture sequence is engaged when the debris enters in the ring and the masts are deflated. Thanks to the difference of velocity between the chaser and target, the debris continue to push on the net stretching its surface and, at the same time, tightening the tethers connected with the chaser. This induces the shrinking of the net edges trapping the object.

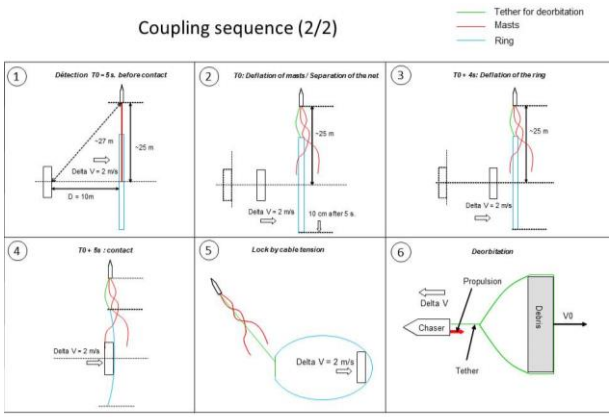

Figure 3. Second part of the coupling sequence

Once the object is captured, a stabilization procedure starts giving a small acceleration to the chaser. Once the system stabilizes, the final controlled deorbitation is engaged by a controlled manoeuver carried out by the chaser which injects both the spacecraft and the debris in a safe reentry trajectory to ensure atmospheric disintegration without possibility to impact residential area on ground.

4 CONCLUSION

INSIDeR is a subsystem for active debris removal application. It is intended to be implemented on any ADR chaser that will perform the final approach and the deorbitation. This system will provide a simple, reliable and cost-effective capture solution in order to limit development costs and risks and finally boost activities to fight space debris proliferation.

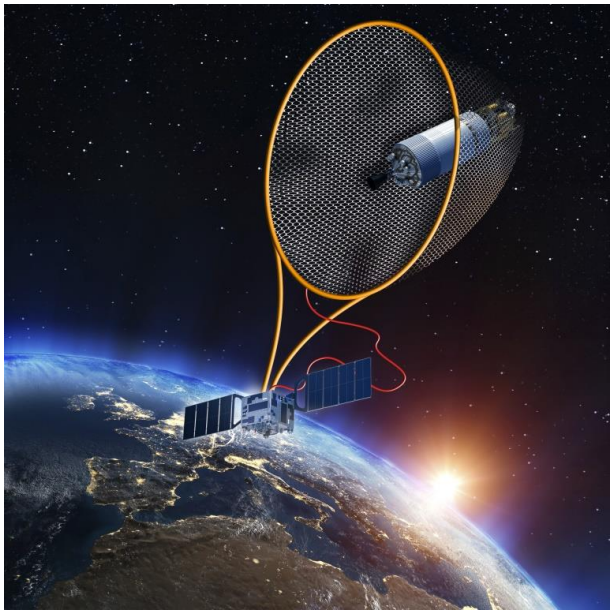

Figure 4. Artist view of INSIDeR Concept