Different Present Space Debris Removal Methods

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1 author:

Prachi Singh
Indian Institute of Engineering Science and Technology, Shibpur
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Abstract

Around 23,000 space debris are orbiting the Earth at speeds up to 17,500 mph. This velocity is strong enough to impact any satellite or spaceship. There are many proposed methods and ongoing research projects for landing on a solution for this issue. This paper will cover the capturing methods which are either proposed or still in work to combat the difficulty of space debris.

By **Prachi Singh**

INTRODUCTION

Any man-made objects which are no longer in service and are in orbit about the Earth are termed as space or orbital debris. The nonfunctional spacecraft, abandoned launch vehicle stages form space debris. Approximately, there is around 23,000 space debris orbiting the Earth. They are traveling at speeds up to 17,500 mph, which is fairly strong enough to damage any satellite or spaceship. The size of debris varies from few millimeters to several inches. But, in space tiny paint flecks can damage spacecraft at these velocities.

In 1996, a French satellite was hit and damaged by the debris of a French rocket. On Feb. 10, 2009, a no longer operating Russian spacecraft collided with a working U.S. Iridium commercial spacecraft. This destroyed the latter and additionally added more

than 2,300 pieces of debris in space.

In 2007, China tested an anti-satellite missile to destroy one of the non-functioning weather satellites. This test added around 3,500 pieces of debris to space.

According to Ref 2, the figures of space debris are as follows:

- 3,000 dead satellites in Earth's orbit
- 34,000 pieces of space debris larger than 10 centimeters
- 128 million pieces of space debris larger than 1 millimeter
- There have been 25 debris avoidance maneuvers performed by the ISS since 1999.

KESSLER SYNDROME

In 1978, NASA scientist Donald Kessler presented the idea that too much space debris in the Earth's orbit will create a chain reaction, leading to more and more space debris to the point that the Earth's orbit becomes useless.

SPACE DEBRIS IN EARTH'S VARIOUS ORBITS

The Low Earth Orbit (LEO), (the altitude close to 800 km) is the most crowded. The orbit with altitudes close to 600, 800, and 1000 km have the most space debris in terms of mass. In these orbits, most space debris' mass goes over 50 kg.

Objects of around 5 cm to 10 cm lie in low Earth orbit (LEO) while 30 cm to 1 m lies in the geostationary altitudes (GEO).

CAPTURING METHODS

The capturing method for space debris removal contains the following phases:

- Launch and Early Orbit Phase (LEOP),
- far-range rendezvous phase,
- close-range rendezvous phase,
- capturing phase, and
- removal phase

Some of the proposed methods are:

1. Tentacles capturing

In this method, the debris is captured using tentacles either with or without a robotic arm. With a robotic arm, capturing embraces the space debris through a clamping mechanism. Then a velocity increment will be given by the chaser to deorbit the combination.

For capturing without a robotic arm, the tentacles embrace the target before physical contact with the debris. Bouncing of chaser satellite is avoided during the process.

This technique is easy to test on the ground and has a higher technology readiness level(TRL). At the same time, it is complicated, and more accurate relative positioning and velocity are needed.

Currently, ESA, Aviospace, and Japan are researching this technique.

2. Single robotic arm capturing

The missions of JAXA, Canadarm2, DARPA, and many others have used Robotic arm technology.

As we know that space debris is non-operational and thus cannot provide any information to the chaser satellite. Plus, they are sometimes in even tumbling condition. That is why it is a bit challenging to apply robotic arms in space to achieve the mission target.

To combat this problem, DLR has been developing robotic technologies in a mission named Deutsche Orbital Servicing Mission (DEOS). DLR has developed a simulator called European Proximity Operations Simulator (EPOS) to simulate the behavior during capturing and docking.

But, the problem that remains is the high probability of collision that might result in even more debris.

3. Multiple arms capturing

Advanced Telerobotic Actuation System (ATLAS), a program from the UK, consists of two robotic arms telerobotically controlled from the ground [5]. Multiple arms will be used in the space debris removal.

But since this method requires two arms to be in coordination with each other. Thus, it will be a more complex control system. Additionally, it will be much costly.

4. Net capturing

This method involves deploying the onboard net (in the spacecraft)

in space, which will then capture the nearby target probe. After capturing the debris, the debris will be thrown back to the Earth's atmosphere.

Since the Earth's ground or atmospheric conditions are different from that of space, it is so hard to test the technique on the ground. Plus, the size of the net poses a risk of even greater collision.

5. Tether gripper capturing

The principle of the tether–gripper mechanism is similar to that of the net capturing. The end-effector in the tether–gripper mechanism is shot as a 3-finger gripper to capture a target.

This technique is tough to test on the ground as well as has lower reliability.

6. Harpoon capturing

The principle of Harpoon capturing involves shooting barbs from the chaser satellite which will be penetrated a large space debris object. The chaser satellite will then pull the debris re-enter or to a graveyard orbit. It is an attractive capturing method because of its compatibility with different shaped targets and no grappling point requirement.

But, because of the penetrating process, the risk of generating new space debris is relatively high. Moreover, it is not capable to treat a target with a high tumbling rate.

CONCLUSION

Researches are being carried out to get rid of space debris from the Earth's orbit, All the methods are still in the conceptual phase. Before actual implementation, it has to be made sure that the execution of any plans does not result in the addition of debris in Earth's orbit.

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