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Space Debris Elimination Techniques

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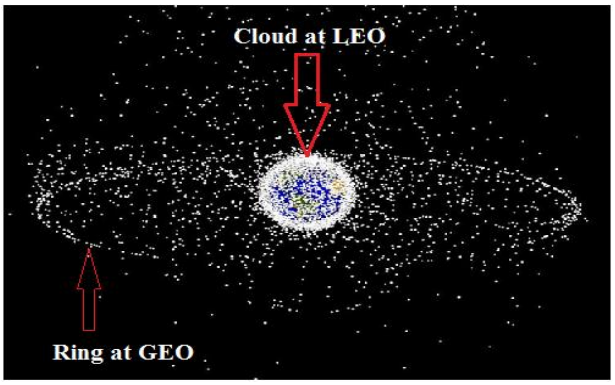
ABSTRACT:

There are numerous satellite missions being launched from the Earth till today. Any launched satellite goes into space and performs its basic operations up to a predefined time limit. But what happens to it after that time? Sometimes it roams around in the same orbit as an waste material or SPACE DEBRIS. This debris has been increasing from the past decades and at present, its amount has reached to a level which is considered as a serious problem for the existing as well as future satellite missions in space. So, to remove the present debris from the outside orbits of earth and to avoid creating more debris in future, there are some techniques proposed from different parts of world. In this paper, some of these techniques will be discussed.

Keywords:
SpaDE, electro dynamic tether, sling-sat

INTRODUCTION:

Space debris, also called orbital debris is the collection of waste and defunct (non functioning) objects in the orbit around the Earth. It basically includes spent rocket stages, old satellites, and the fragments created from collisions of different satellites. Since the new spacecraft mostly follows the orbital path of old satellites (spacecrafts)



there are obvious chances of it colliding with the debris of previous satellites or any other object. From the data available, As many as ten million pieces of human-made debris are estimated to be circulating in space at any one time. In the year 2009, there are about 19000 pieces of debris with size larger than 2 inches are tracked below 200 km altitude. There are two primary debris fields: the ring of objects in GEO (Geosynchronous Earth Orbit) and the cloud of debris in LEO (Lower Earth Orbit).

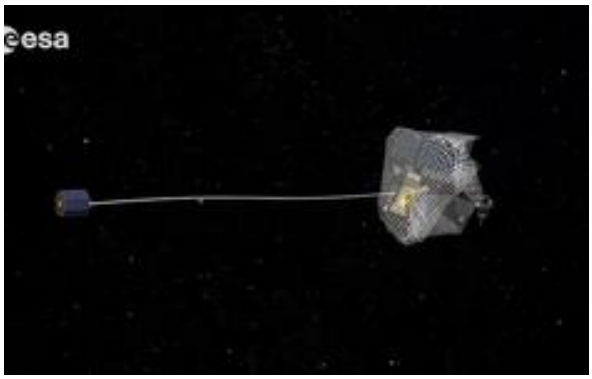
Many times, the debris size is less than 1cm(0.39 inches), but the impact of these type on collision causes severe damage to satellites or spacecrafts. The damage can be reduced by using “whipple shield” which is generally used to protect parts of a space station established in outer space. But it turns out to be not much effective in case of satellite or a spacecraft because they have some outer and comparatively delicate parts

like solar panels or optical devices(like telescopes) and these components are subject to constant wear by debris and micrometeoroids. In order to reduce the amount of debris, there are various techniques proposed, some still hypothetical, some which can be implemented and some which are operational. These techniques are snagging and moving debris, solar sails, electro dynamic tethers etc. These all techniques will be discussed in this paper.

TECHNIQUES TO REMOVE SPACE DEBRIS

1. Snagging or moving space debris:

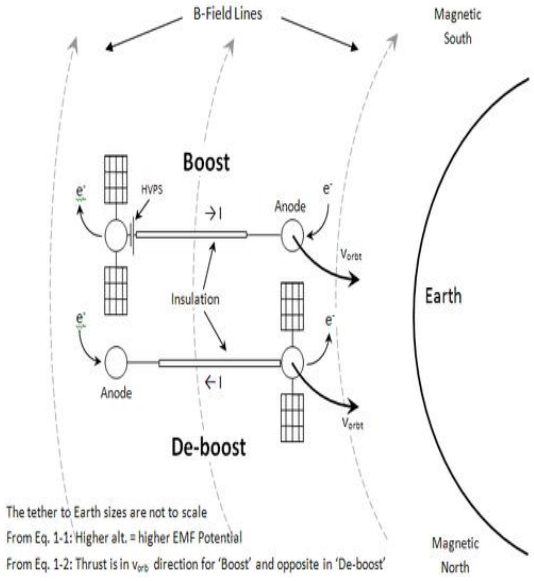
This technique was first proposed in the e. De Orbit mission by ESA (European Space Agency). This mission was proposed in early 2014 and it aims to use a technique to capture or grab the debris and remains from the space using some kind of nets, harpoons, robotic arms or tentacles. It would seek out satellite debris in a polar orbit at an altitude between 800 and 1,000 kilometers (500 to 620 miles). The CLEAN SPACE initiative taken by ESA, is studying the e.DeOrbit mission for removing debris, aiming to reduce the environmental impact of the space industry on Earth and space alike. This mission is designed to target debris items in well-trafficked polar orbits, (800 km-1000 km). The first technical challenge to be faced is to capture a massive, drifting object left in an uncertain state, which may well be tumbling rapidly. To achieve this , a large number of imaging sensors which can react quickly and highly advanced autonomous controlling will be required to assess its condition and then approach it. Then steady station keeping with the target is also hard enough and at the end that is object is being crafted down to burn up in the atmosphere by using some robotic arm or some throw nets.

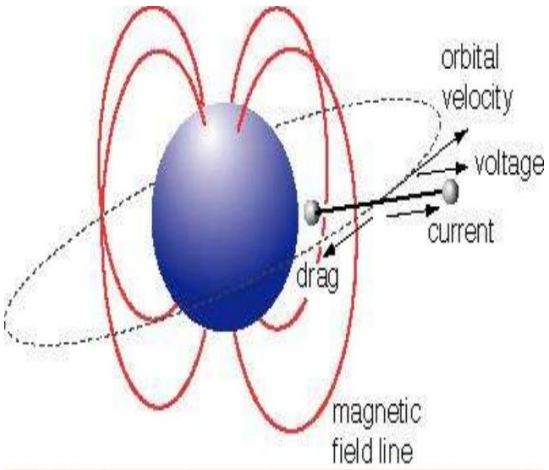


2. ELECTRODYNAMIC TETHER:

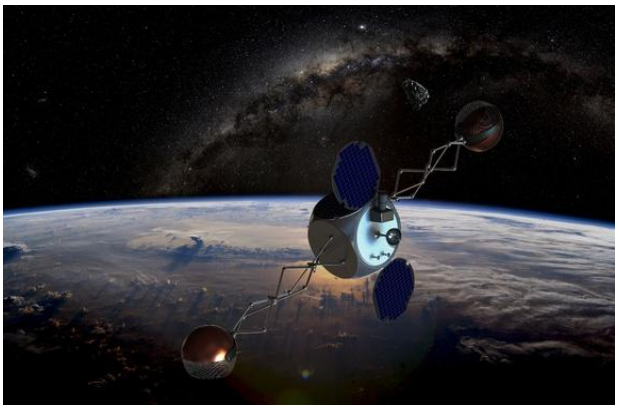
This is the technique which the Japanese are going to use to clean up the space junk. According to the report from agence France presse , Japanese space agency has proposed to use an electrodynamic tether, its current will slow down the speed of the moving satellites or debris to make it to fall on earth where the atmosphere of earth will burn it down. The electrodynamic tether can be used as both the booster as well as breaker for any satellite. It is basically a long conducting wire attached to a satellite which works on the principle of Fleming's left hand rule according to which if the thumb, index finger and middle finger of left hand are perpendicular to each other and the middle finger shows the direction of current, the index finger shows the direction of

magnetic field then the thumb will point towards the direction of motion of the body. The body moves because of a force applied to it which is called Lorentz force. This principle is used to move satellites or to reduce their speed to make them fall on earth. When the charge flows through the conducting wire, the earth's magnetic field acts on it to provide acceleration to the spacecraft or satellite. When the direction of charge is reversed then it can be used to de-orbit the satellite.





3. *TAMU Space Sweeper with Sling-Sat(4S)* :
This technique is also about capturing of space debris but with a very less amount of fuel usage. A university in Texas proposed this idea. The sling sat will work on swinging capturing an object, then swinging it towards Earth's atmosphere to destroy it and then using the momentum to go towards the next piece of debris for same process. By this technique, the fuel consumption will be very less as the sling sat will use the momentum gained by throwing the debris.

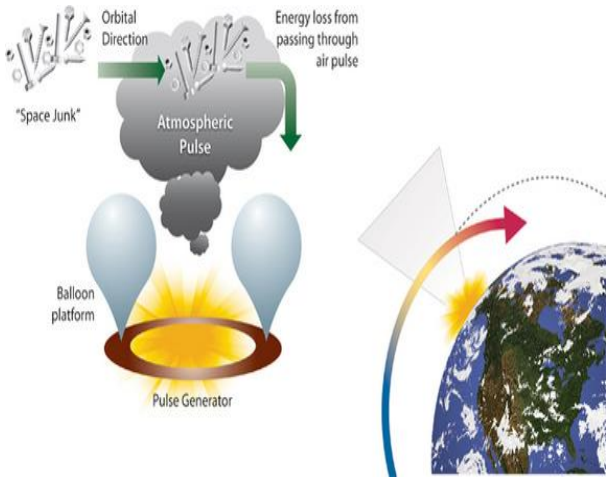


To remove the space debris, many ideas have come up from different parts of the world. But an idea that sounds most technical is to clean the debris object by object. Obviously to travel for each object (and sometimes very widely spaced objects) the spacecraft will require loads of fuel making it a much inefficient project. The 4S system points to correct this flaw. It will trap the debris at the ends of a spinning satellite, and then throw the object down while rotating in Earth's atmosphere in order to destroy it. Then it will make use of the momentum exchanged during the two actions to move towards the next piece to be captured. This will minimize the fuel usage and extend the operational lifetime.

4. SPACE DEBRIS ELIMINATION(SpaDE)

This technique is like huffing and puffing to de orbit the debris. In this technique, the pulses of atmospheric gases are fired in the path (orbit)

of debris. The vertical blasts in the Earth's atmosphere can be directed to the orbiting debris to either make it change its trajectory or to make it fall back on Earth. The preliminary results show that it will affect the low earth orbital debris and it can affect more pieces if they are struck together. Also, with a small change in velocity, the amount of de orbiting debris can be increased to a high value.



According to the early estimate reports, the fuel consumption for this operation i.e. to create an atmospheric pulse is roughly equal to 500 gallons of gasoline, although various tests are being done to reduce this amount to a favorable one.

The most important thing about this technique is that it has promising results as compared to other techniques. The air or gaseous pulses would eventually fall back to atmosphere, leaving no residue or part in orbit to get it interfere with low earth orbital satellites. In other words, it is fail safe as it does not place any solid material that can create new debris in case of failure or malfunctioning. The only parameter to be considered is its cost of fuel. If it is controlled then probably it will be the most promising technique.

Besides these techniques, there are several other techniques like solar sails, an electro dynamic debris eliminator which is a typical net of conducting wires designed to capture the debris and throw it to the earth's atmosphere to destroy it. Some better techniques will be introduced in the coming time.

CONCLUSION:

Space debris imposes serious threat to the existing satellite systems and also to the lives on earth because if the objects falling from space survives the earth's heat then they will come down to cause some serious destruction. There are number of techniques which required to be implemented to remove this space debris but still these are either economically unfeasible or technically undeveloped. This problem should be taken into account seriously and very soon to make these techniques practical to ensure a safe satellite system around our earth.

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