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Ion truster and solar sail propulsion-Enabling the new capabilities to space technology by removing Space Debris

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Abstract: **In this a concept aimed on the removal of inactive satellite (debris) from outer space based on a mechanism propelled using an ion thruster with a solar sail combination. There is a lot of space junk surrounding the earth. This junk can be harmful for other satellites and future manned missions to space. Hence, clearing this space junk is necessary.**

The mechanism will be launched from earth and can be monitored and controlled from earth. It will have a robotic arm, that will be used to lock on to a decommissioned satellite or some other space junk and it will be hurled into the earth's atmosphere, where it will burn up. This mechanism will be propelled by an ion thruster in combination with a solar sail. This will be helpful in removing debris from outer space.

Keywords: **solar sail, satellites, earth's atmosphere.**

1. INTRODUCTION

There are basically two kinds of satellite, active satellites and inactive satellites.

Satellites help us in many ways like communication, remote sensing, navigation, weather prediction and monitoring etc. the satellites whose lifetime is over are known are as inactive satellites. They do not function after this lifetime and become a danger to the other satellites.

There are totally four types of orbits, Low Earth Orbit (LEO), Medium Earth Orbit (MEO), Geo – Synchronous Orbit (GEO) and Highly Elliptical Orbit.

Table 1: Types of Orbit in Space

Sl. No	Orbit Type	Altitude (km)
1	Low Earth Orbit (LEO)	100-1,700
2	Medium Earth Orbit (MEO)	1,700-35,700
3	GEO Synchronous Orbit (GEO)	Above 35,700
4	Highly Elliptical Orbit	Very high above 35,700

Low Earth Orbit

Most of the countries launch satellites in the LEO because it is close to Earth and easier to monitor.LEO has numerous orbits inclined to Orbiteach other and the potential for collision is very high.The satellites in this orbit rotate at the speed of 7 – 8 km/sec and take about 1 ½ to 3 Hours to complete one rotation.

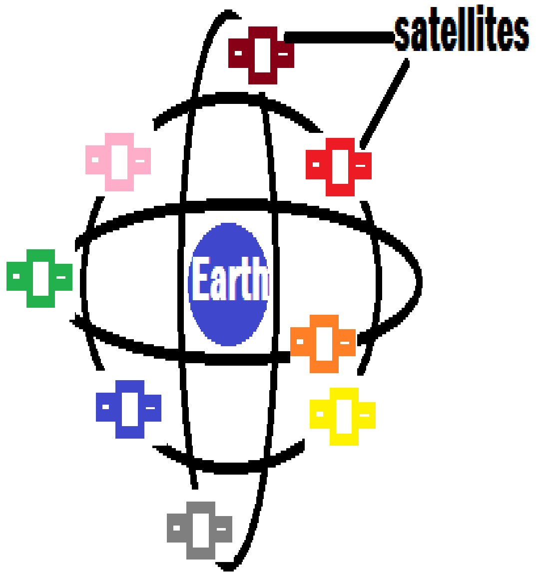


Figure 1: Satellites Present in The Low Earth

Totally 48,165 satellites are present in the outer space and 60 % of the active satellites are present in the LEO and the total no. of inactive satellites present in the outer space is 28,672 and 98 % of them are in the LEO.

Satellite and Debris by Countries

In LEO, more than 16,000 satellites belong to the CIS (former states of USSR), USA and China and also a small no. of satellites are also launched by France, India, Japan and others.

95 % of the inactive satellites (debris) belong to the CIS, USA and China.

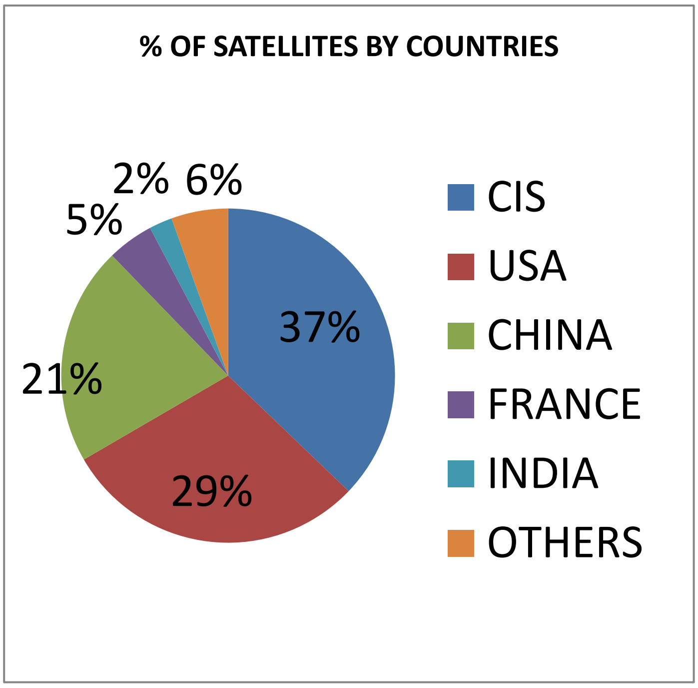


Figure 2: Number of Satellites in Leo

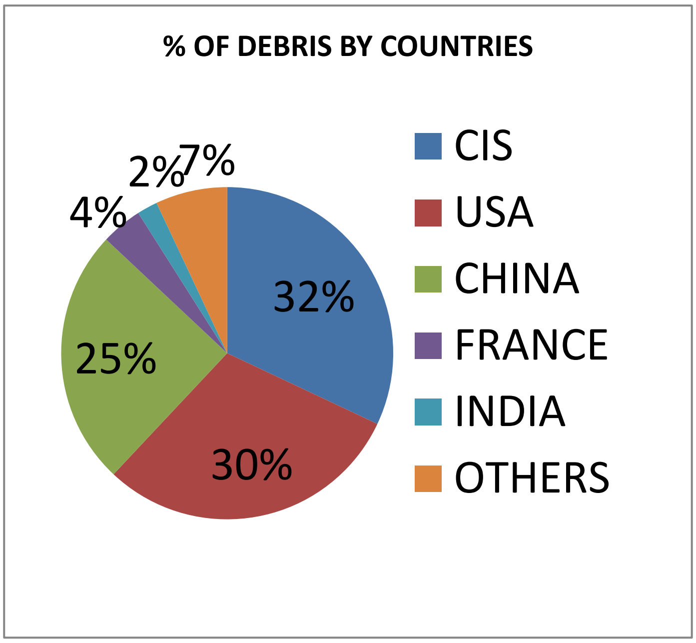


Figure 3: Number of Debris by Countries

Debris from destruction of satellite in LEO

In low earth orbit (LEO) inclined orbits are present due to which there can be a large number of collisions.

A collision might take place between two inactive satellites or between an active and an inactive satellite which results in a cloud of debris made of the destroyed parts of the satellite.

This cloud will then start to spread over the orbit of the satellite and in a few months, it will cover the entire planet. Further collisions will keep on reducing the average size of the debris which further increases the harmful potential against other active satellites.

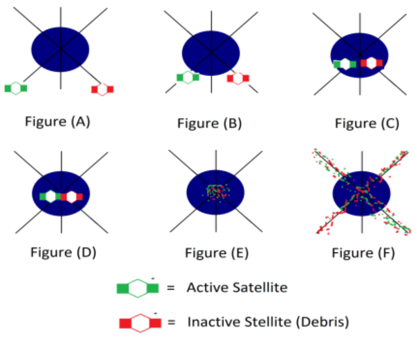


Figure 4: Accidental Breakup of Satellites

Table 2: Debris list in Space

Sl. No.	Description	DEBRIS SIZE		
		0.1 to 1 cm	1 to 10 cm	> 10 cm
1	Total debris in space	145 million	780,000	42,000
2	Debris in low earth orbit	18million	375,000	16,000
3	Debris from the destruction of a 10-ton satellite	6-16 million	255,000-755,000	6,000-14,000
4	Debris from Chinese ASAT test	2.5 million	250,000	3,500

2. COLLECTION OF DEBRIS IN SPACE

In this concept of removing debris in space, we are using Ion thruster and the solar sail and by this type of mechanism we will be able to remove two debris from space. Ion thruster belongs to the electric propulsion category. The setup will consist of two mechanisms for debris retrieval. One will be propelled by an Ion thruster while the other will propelled by the solar sail.

A. In case of the mechanism propelled by solar sail, the mechanism will attach onto the debris and then the solar sail will be deployed. By the action of solar wind on the solar sail, the mechanism will be propelledtowardsthe Earth's atmosphere. Eventually, it will enter into the atmosphere and will burn up.

Figure 5: solar sail mechanism

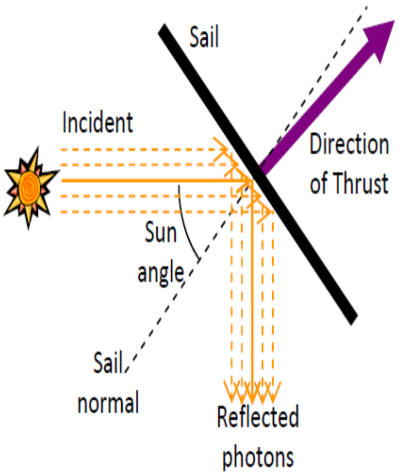


Table 3: No. of days required by a solar sail of given size to enter into the Earth's atmosphere

Solar Sail Size	No of Days till Entry
5 m X 5m	1,267 days
10m X 10m	980 days
20m X 20m	630 days
25m X 25m	519 days
30m X 30m	338 days

B. In case of the Ion thruster propelled mechanism, after linking on to the debris, the Ion thruster will generate the thrust necessary to change the direction of the mechanism and to propel it towards the earth's atmosphere. A sample specification of the Ion Propulsion system is as follows,

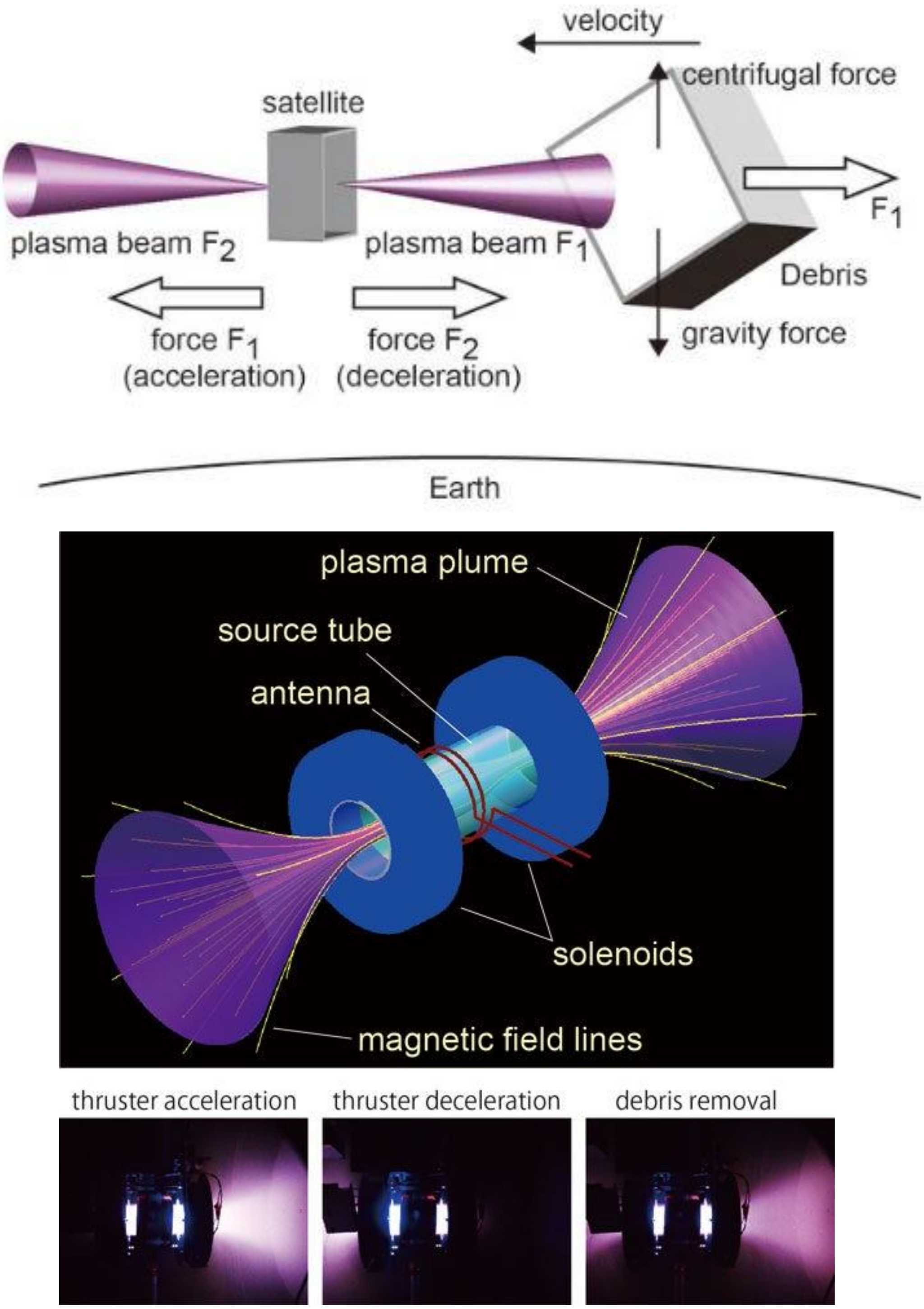


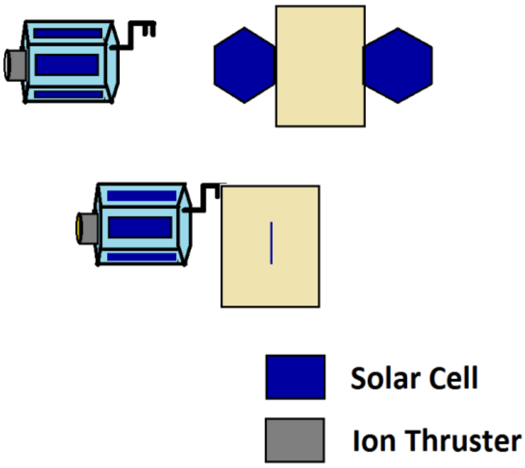
Figure 6: A Simple Depiction of Debris Retrieval

- **Low Thrust, High Efficiency**

@ 0.5 N of Thrust

@ 200,000 mph top speed

> 18,000 mph in Space Shuttle



3. ENTRY OF DEBRIS RETRIEVER IN TO THE EARTH'S ATMOSPHERE

In space there are innumerous paths in the Low Earth Orbit. After debris retrieval, initially, the solar sail or ion thruster will bring the debris to the parking orbit and then it will be hurled towards the Earth in a specific path such thateven if it does not completely break up in the Earth's atmosphere, it will fall into the sea.

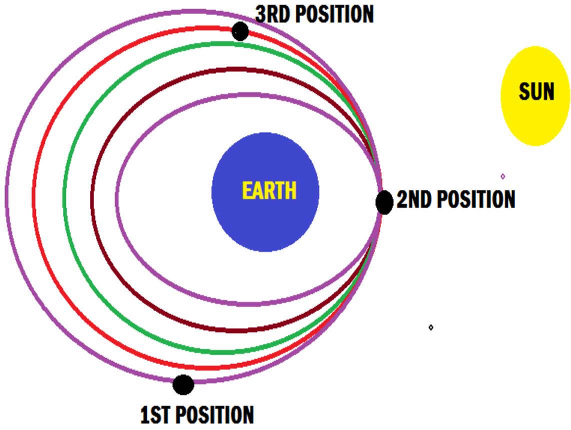


Figure 7: Entry of debris into Earth's atmosphere

4. CONCLUSION

A new concept for active removal of space debris has been presented, in which a space debris shepherd uses the momentum transmitted by a low-divergence accelerated ion beam in order to achieve contactless debris removal. A preliminary analysis of the concept has been conducted highlighting the key aspects of the system design and its performance. Ion thrusters with low beam divergence (1 ton) debris has been evaluated analytically in the hypothesis of quasi-circular orbit evolution. As a numerical example, a very large (5 tons) space debris can be deorbited in about 7 months with a total IBS mass of less than 300 kg assuming, as a very preliminary value, a structural mass of 150 kg. Although the concept implementation appears to be feasible with state-of-the-art space hardware further analysis will be required to investigate the physical interaction between an orbiting body and an ion beam including sputtering phenomena and possible plasma backflow from the debris surface towards the IBS spacecraft. The control of the relative distance between the IBS and the debris flying in proximity for a large time span.

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