SPACE JUNK: CAN WE REMOVE IT?

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ABSTRACT: It is the legacy of more than half a century of space. Today, it is said there are more than 22,000 objects actively being tracked. These are just the big, easy-to-see items, however. Moving around unseen are an estimated 500,000 particles ranging in size between 1-10cm across, and perhaps tens of millions of other particles smaller than 1cm.All of it is travelling at several kilometers per second - sufficient velocity for even the smallest fragment to do a lot of damage if it strikes an operational space mission .Thus the biggest challenge to the engineers is to remove this junk. Scientists have proposed a viable solution to the growing problem of space junk. The idea involves launching a satellite to rendezvous with the largest space debris, such as spent rocket bodies. UK engineers are developing a system to harpoon rogue or redundant satellites and pull them out of the sky. UK researchers have developed a device to drag space junk out of orbit. They plan to launch a demonstration of their "Cube Sail" next year. So in this paper we will be going through few solutions to remove this junk. Although many theories are been brought into this matter in last decades, we will be going through few of them. We have to come out with a innovative thought to face this engineering problem in the field to space technology

KEYWORDS: **Space Debris, Space harpoon, Cube Sail, Space politics.**

1.0 INTRODUCTION.

Space debris, also known as **orbital debris**, **space junk**, and **space waste**, is the collection of objects in orbit around Earth that were created by humans but no longer serve any useful purpose. These objects consist of everything from spent rocket stages and defunct satellites to erosion, explosion and collision fragments. As the orbits of these objects often overlap the trajectories of newer objects, debris is a potential collision risk to operational spacecraft.

The vast majority of the estimated tens of millions of pieces of space debris are small particles, less than 1 centimeter (0.39 in). These include dust from solid rocket motors, surface degradation products such as paint flakes, and coolant released by RORSAT nuclear powered satellites. Impacts of these particles cause erosive damage, similar to sandblasting. A much smaller number of the debris objects are larger, over 10 centimeters (3.9 in). Against larger debris, the only protection is to maneuver the spacecraft in order to avoid a collision. If a collision with larger debris does occur, many of the resulting fragments from the damaged spacecraft will be in the 1 kilogram (2.2 lb) mass range, and these objects become an additional collision risk. As the chance of collision is a function of the number of objects in space, there is a critical density where the creation of new debris occurs faster than the various natural forces remove these objects from orbit. Beyond this point a runaway chain reaction can occur that reduces all objects in orbit to debris in a period of years or months. This possibility is known as the "Kessler syndrome", and there is debate as to whether or not this critical density has already been reached in certain orbital bands.

1.1 Debris growth in now days.

Faced with this scenario, as early as the 1980s NASA and other groups within the U.S. attempted to limit the growth of debris.

- In 1981 when Schafer's article was published it was placed at 5,000 objects, but a new battery of detectors in the Ground-based Electro-Optical Deep Space Surveillance system quickly found new objects within its resolution.
- By the late 1990s it was thought that the majority of 28,000 launched objects had already decayed and about 8,500 remained in orbit.
- By 2005 this had been adjusted upward to 13,000 objects, and a 2006 study raised this to 19,000 as a result of an ASAT test and a satellite collision.
- Following Kessler's 1991 derivation, and updates from 2001, the LEO environment within the 1,000 kilometers (620 mi) altitude range should now be within the cascading region. However, only one major incident has occurred: the 2009 satellite collision between Iridium 33 and Cosmos 2251.
- A 2006 NASA model suggested that even if no new launches took place, the environment would continue to contain the then-known population until about 2055, at which point it would increase on its own.
- Richard Crowther of Britain's Defense Evaluation and Research Agency stated that he believes the cascade will begin around 2015.

A report in 2011 by the National Research Council in the USA warned NASA that the amount of space debris orbiting the Earth was at critical level. Some computer models revealed that the amount of space debris "has reached a tipping point, with enough currently in orbit to continually collide and create even more debris, raising the risk of spacecraft failures". The report has called for international regulations to limit debris and research into disposing of the debris.

1.2 Characterization

1.2.1 Large vs. small

Any discussion of space debris generally categorizes large and small debris. "Large" is defined not by its size so much as the current ability to detect objects of some lower size limit. Generally, large is taken to be 10 centimeters (3.9 in) across or larger, with typical masses on the order of 1 kilogram (2.2 lb). Logically it would follow that small debris would be anything smaller than that, but in fact the cutoff is normally 1 centimeter (0.39 in) or smaller. Debris between these two limits would normally be considered "large" as well, but goes unmeasured due to our inability to track them. The great majority of debris consists of smaller objects, 1 centimeter (0.39 in) or less. The mid-2009 update to the NASA debris FAQ places the number of large debris items over 10 centimeters (3.9 in) at 19,000, between 1 and 10 centimeters (3.9 in) approximately 500,000, and that debris items smaller than 1 centimeter (0.39 in) exceeds tens of millions. In terms of mass, the vast majority of the overall weight of the debris is concentrated in larger objects, using numbers from 2000, about 1,500 objects weighing more than 100 kilograms (220 lb) each account for over 98% of the 1,900 tons of debris then known in low earth orbit

1.3 Sources of debris

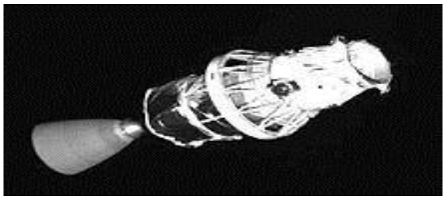
1.3.1Dead spacecraft

Vanguard 1 remains in orbit over 50 years after launch. Communications were lost in 1964, but it will remain in orbit for 240 years. In a catalog listing known launches up to July 2009, the Union of Concerned Scientists listed 902 operational satellites. This is out of a known population of 19,000 large objects and about 30,000 objects ever launched. Thus, operational satellites represent a small minority of the population of man-made objects in space. The rest are, by definition, debris.

1.3.2 Lost equipment

According to Tuft's book *Envisioning Information*, space debris objects have included a glove lost by astronaut Ed White on the first American space-walk (EVA); a camera Michael Collins lost near the spacecraft Gemini 10; garbage bags jettisoned by the Soviet cosmonauts throughout the Mir space station's 15-year life; a wrench and a toothbrush. Sunita Williams of STS-116 lost a camera during EVA.

1.3.3 Boosters



Spent upper stage of a Delta I rocket (photographed by the XSS 10 satellites

Lower stages, like the solid rocket boosters of the Space Shuttle, Boosters that remain on orbit are a serious debris problem, and one of the major known impact events was due to an Ariane booster. During the initial attempts to characterize the space debris problem, it became evident that a good proportion of all debris was due to the breaking up of rocket stages. Although NASA and the USAF quickly made efforts to improve the survivability of their boosters, other launchers did not implement similar changes.

1.4 Tracking and measurement

Tracking from the ground

Radar and optical detectors such as lidar are the main tools used for tracking space debris. However, determining orbits to allow reliable re-acquisition is problematic. Tracking objects smaller than 10 cm (4 in) is difficult due to their small cross-section and reduced orbital stability, though debris as small as 1 cm (0.4 in) can be tracked. NASA Orbital Debris Observatory tracked space debris using a 3 m (10 ft) liquid mirror transit telescope.

Other sources of knowledge on the actual space debris environment include measurement campaigns by the ESA Space Debris Telescope, TIRA (System), Goldstone radar, Haystack radar, the EISCAT radars, and the Cobra Dane phased array radar. The data gathered during these campaigns is used to validate models of the debris environment like ESA-MASTER. Such models are the only means of assessing the impact risk caused by space debris, as only larger objects can be regularly tracked.

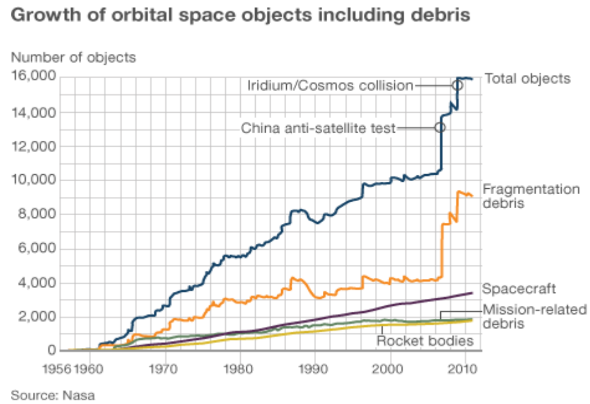
1.5 Measurement in space

The Long Duration Exposure Facility (LDEF) is an important source of information on the small particle space debris environment.

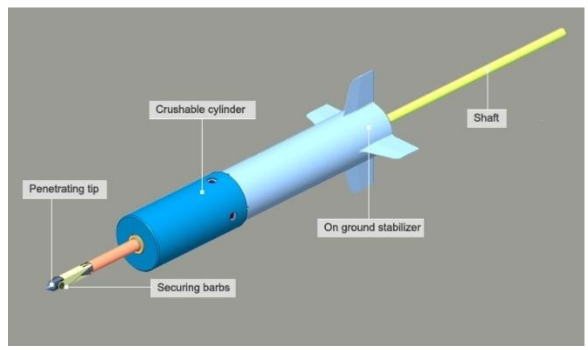
Returned space debris hardware is a valuable source of information on the (sub-millimeter) space debris environment. The LDEF satellite deployed by STS-41-CChallenger and retrieved by STS-32 Columbia spent 68 months in orbit. Close examination of its surfaces allowed an analysis of the directional distribution and composition of the debris flux.

2.0 Space Debris: Time to clean up the sky

A wide range of space agencies and intergovernmental organizations has taken a bite out of this issue down the years. The opinion expressed is always the same: the problem is inescapable and it's getting worse? It's also true the tone of concern is being ratcheted up. There is now a wild jungle of debris overhead - everything from old rocket stages that continue to loop around the Earth decades after they were launched, to the flecks of paint that have lifted off once shiny space vehicles and floated off into the distance. It is the legacy of more than half a century of space activity. Today, it is said there are more than 22,000 pieces of debris actively being tracked. These are just the big, easy-to-see items, however. Moving around unseen are an estimated 500,000 particles ranging in size between 1-10cm across, and perhaps tens of millions of other particles smaller than 1cm.All of this stuff is travelling at several kilometers per second - sufficient velocity for even the smallest fragment to become a damaging projectile if it strikes an operational space mission. Gravity ensures that everything that goes up will eventually come back down, but the bath is currently being filled faster than the plug hole and the overflow pipe can empty it.



2.1 UK design to 'harpoon' old satellites



The on-the-ground test harpoon is about 60cm in total length. A space harpoon would not need the winged stabilizer

UK engineers are developing a system to harpoon rogue or redundant satellites and pull them out of the sky. It is a response to the ever growing problem of orbital junk - old pieces of hardware that continue to circle the Earth and which now pose a collision threat to operational spacecraft. The harpoon would be fired at the hapless satellite from close range. A propulsion pack tethered to the projectile would then pull the junk downwards, to burn up in the atmosphere.

2.1.1Explosive concern

This is research in its very early stages. The BBC has filmed firing tests of a prototype harpoon at Astrium UK's Steven age base. The company, the largest space manufacturer in Europe, is also pursuing other ideas at its centers in France and Germany. These concepts involve nets and robotic grappling devices. All systems have their pros and cons. Harpoons could deal well with a satellite that is tumbling, for example, but the approach has its critics because of the fear it could actually add to our problems in space.

These two incidents produced hundreds of thousands of new fragments, negating all the mitigation gains that had been made over the previous decades.

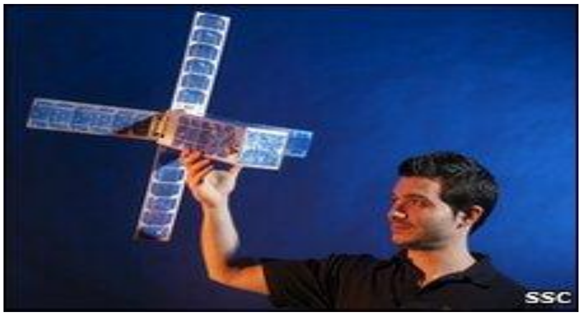
Prof Richard Crowther is the UK Space Agency's chief engineer. He says there is a short window of opportunity to get on top of the issue before the number of collisions starts to increase and the problems associated with junk and debris begin to cascade. But he warns that any proposal for satellite removal requires international agreement because these systems could also be viewed as aggressive developments - as space weapons.

2.2 Swiss to launch space junk cleaning device

Switzerland is well known for being a tidy nation, but now Swiss scientists are using this national instinct to help design a special satellite to scoop up space junk orbiting Earth.Nasa says more than half a million pieces of spent rocket parts, broken satellites and other pieces of debris are orbiting Earth and some satellites have been damaged or destroyed after colliding with space junk. They plan to launch a demonstration of their "CubeSail" next year. It is a small satellite cube that deploys a thin, 25-sq-m plastic sheet.

2.2.1 Simplicity of approach

It is thought more than 5,500 tones of junk now clutters the region of space just a few hundred km above our heads. Last year, two satellites even collided, showering their orbit with tiny fragments that now pose additional risk to operational spacecraft.



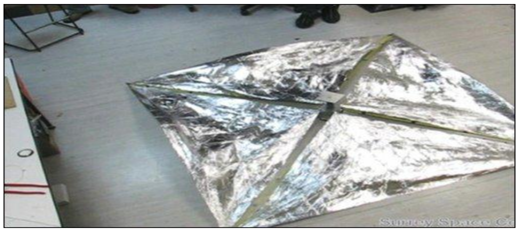
The controlling spacecraft is a box that is 30cm in its longest dimension

CubeSail, unveiled on Friday, is a 3kg (6.6lb), 10cm x 10cm x 30cm (4in x 4in x 12in) nanosatellite. It incorporates within its tiny frame a polymer sheet that is folded for launch to be unfurled once in space. The simple deployment mechanism features four metal strips that are wound under tension and will snap into a straight line when let go, pulling the sheet flat in the process. The team hopes to launch its demonstrator at the end of next year, riding piggy-back on another mission or as part of a cluster of small research satellites that are sometimes lofted en mass atop a single rocket.

2.2.2 Force of sunlight

The nanosat will then circle the Earth, going from pole to pole at an altitude of about 700km (435 miles), testing its systems and assessing the drag principle. If successful, CubeSail could become a regular add-on system to satellites and rocket stages, opening up a new space business akin to the daily refuse services here on Earth.

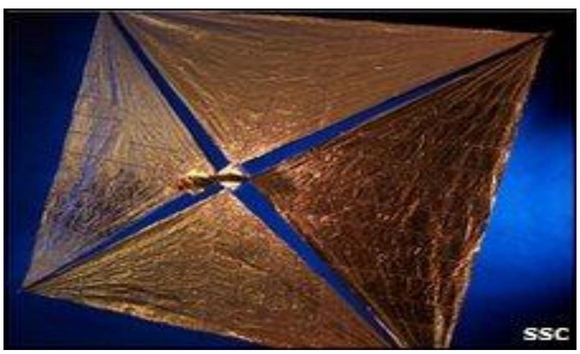
"We would be looking to put it on our own satellites and to put it on other people's spacecraft as well," said Sir Martin Sweeting, the chairman of SSTL, the world-leading small-satellite manufacturer, which is supporting the research.



This "solar sailing" technique has long been touted as a means of moving spacecraft around the Solar System, or even just helping conventional satellites to maintain their orbits more efficiently. Indeed, some of the large geostationary satellites, for example, already use solar-sail flaps to maintain their attitude without firing their thrusters. This saves valuable chemical propellant and extends mission lifetime.

2.2.3 Delicate control

CubeSail will endeavor to demonstrate this "propellant less propulsion" by trying to shift the path it takes across the surface of the Earth by just a few degrees over the course of a year. To do this though, the nanosatellite will have to carefully control the angle of the sail with respect to the Sun, just as an ocean vessel has to play with its sails to



The sail will be made from an extremely fine polymer

catch the wind

Once its mission is complete, CubeSail will be instructed to take itself out of orbit. The project is a private venture within the Surrey Space Centre, which is based at the University of Surrey, Guildford. CubeSail has been funded by Europe's largest space company, EADS Astrium, which is one of the world's biggest manufacturers of satellites. The entire cost of the project is expected to be no more than £1m ($1.5m).Other groups around the world are expected to launch solar sail demonstrators soon. The Japanese, too, have work in progress. And even Astrium is sponsoring other space junk mitigation strategies within its own division.

3.0 Problems in removing space junk

- **Space politics**

  The new research identifies more than 60 objects at a height of about 850km, and two thirds of those weigh more than three tones each - many moving near a speed of 7.5km/s. Most of these largest threats are spent rocket bodies, and it is there that Dr Castronuovo thinks the effort should begin

  "It's difficult from a political point of view; many of these objects belong to nations that are not willing to co-operate or do not allow access to their objects even if they are at the end of their operative life, and there is no international regulation on who should remove the objects that are left in space," he said.

  "If we start concentrating on the spent rocket bodies - which do not have sensitive equipment on board -it should not pose any problem to the owner to give permission to remove them; and there's no doubt they are not operative anymore.

- In 2007, China demonstrated an anti-satellite system, destroying one of its own defunct satellites and creating 2,000 extra bits of debris in the process.
- More recently, a collision between US and Russian satellites. On 10 February this year, a defunct Russian communications satellite crashed into an American commercial spacecraft, generating thousands of pieces of orbiting debris.

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