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Space Debris – It's Effect on the Earth

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***Abstract*: Space debris is the space waste or space junk that is created by meteoroids, or unusable satellites, and the parts of the rocket that is just floating in space without any use. Space debris creates many threats to other working satellites or space stations. Increasing space debris creates more space debris, and this is known as Kessler syndrome. It affects the internet, and weather monitoring system. There are more than 9,600 tonnes of objects in earth's orbits according to European Space Agency (ESA). So, this is the main challenge to manage the debris in space.**

***Keywords*: Collision, Kessler syndrome, Satellites, Space debris, Space agency, Rings.**

1. Introduction

Is space debris responsible for making rings around Earth? A recent study shows that the Earth will soon have its ring. If we consider Jupiter many rings formed around it which are formed by natural debris. This debris is formed because Jupiter has its many natural satellites like the moon these satellites collide with each other and create natural debris. This debris creates the ring around Jupiter. So, from distance, it seems like rings that are created on Jupiter. And the same process is with other gigantic planets also. Now there will be possible that the same ring will get around the earth, but when the earth has its rings then it will seem very ugly. Because what going to happen here will be a lot of space debris that humans have made firstly it covers the earth then the remaining debris will make the rings around the earth. US researchers tell that "Earth Is 'On Course' to Have Its Saturn-Like Rings Made of Space Junk," Now the problem of space debris is very genuine today. Because of this, it is possible that we were neither able to launch the satellite nor could we explore anything. And this is not an exaggeration by any means. Now, how is this debris made, this is primarily created when human beings launch satellites and observatories to do various research in space. Now if a satellite is launched, then how much will its life be, on average 6 years or 10 years, after that no work is left for it. It floats in space, and it becomes space junk. Now, in the last 20 years, what happened if you look at it is that it has become very easy to launch a satellite, which has also had its benefits for example Internet is now easily accessible through satellite, even in more remote areas outside the earth, apart from that you can broadcast television in many areas, communication has become easier. Due to this, there are ways on earth, but now a problem has come to the fore that is all together space junk has been collected around the earth, and this space junk is also increasing continuously. Because what happened quite often is that there are countries, they had launch satellites and it's been 10 to 20 years, it's no work, now what happens is that many times these satellites collide with each other or some meteor in space hits these and then the satellite whose weight was around 200kg or 300kg and was a single unit, now there has been a collision over there, thousands of pieces have been created now these 200, 300 pieces are moving in space, and the speed is more than 15000miles per hour that is what NASA said. Now don't assume that this debris is floating comfortably in space it is moving at a very high speed. Suppose in space there is an astronaut and when this space debris, hits then he will get such a feeling that someone shoots him. Based on the theory that space debris creates space debris itself, we call it Kessler's syndrome. Now what is the issue is that the space debris is going to increase day by day, what will happen with this is that there will be debris around the earth, apart from that an additional ring will be formed around the earth due to which it may be in the future that many satellites may also crash back towards the earth and maybe the space missions continuously be failed. This paper discusses space debris.

2. What is Space Debris?

Space debris is often known as space waste or space junk. The term 'junk' in space refers to parts that are no longer in use. Natural meteoroids and artificial (man-made) orbital debris are both included in the space debris. So, space debris is the part of a satellite that has been destroyed or is not really in use anymore and is floating around hundreds of miles above the earth. Meteoroids orbit the sun, whereas most manufactured debris orbit the Earth. The debris formed when we leave useless satellites in space, or paint flecks, frozen liquid ejected from spacecraft, and components of the rocket that are generated when they clash with other debris. There are about 10 million pieces of space junk that are orbiting the planet, and when they collide, more debris forms that move at high speeds. In 1996, debris from a French rocket that had burst a decade before struck and destroyed a French satellite. This shows that when a spacecraft collided with other debris created hundreds of new fragments that result in more new debris. These pieces contain both small and large debris which pose a threat to human space activities.

"Every satellite that goes into orbit has the potential of becoming space debris, that is said Professor Hugh Lewis, head

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of the Astronautics Research Group at the University of Southampton.

Most of the time the countries, including the United States, China, Russia, and India, have practiced blowing up their satellites with missiles. That also creates more debris. A derelict Russian spacecraft collided with and destroyed a functional US Iridium commercial satellite on February 10, 2009. More than 2,300 pieces of massive, trackable debris and many smaller pieces of debris were added to the inventory of space junk because of the collision. The debris came from the Chinese weather satellite Fengyun-1C, which was launched in 1999 and deactivated in 2002 but remained in orbit. In 2007, China used a ballistic missile launched from the ground to destroy the satellite as part of an anti-satellite test, adding about 3,500 pieces of massive, trackable debris as well as many smaller pieces. According to European Space Agency (ESA), the total mass of all space objects in Earth's orbit weighs more than 9,600 tonnes. NASA says that there are around 23,000 bits of debris orbiting the Earth that are larger than a softball. They fly at 15,700 mph, fast enough for a little piece of orbital debris to cause damage to a satellite or spacecraft. There are around half a million bits of debris the size of a marble or larger (up to 0.4 inches, or 1 cm) and approximately 100 million particles of debris (0.000039 of an inch in diameter) are also present. Objects of all sizes have the potential to crash and impair orbital missions, space flights, and the International Space Station (ISS) in various ways.

3. How Does Space Debris Affect?

Everyone is gone affected by space debris, especially since satellite technology is used practically in every aspect of our modern lives. Because of this, it is possible that we were neither able to launch the satellite nor could we explore anything. The matter is going that people will go to Mars and make colonies. Elon Musk takes us to Mars, but it is not possible if the space debris continues to grow like this. If the debris continues to grow, then human beings trap themselves here on the earth. Because if space debris kills a satellite, it may take years and hundreds of millions of dollars to restore its function, space debris increases the cost of operating satellites. The growing amount of space debris poses a threat to all space vehicles and other human-capable spacecraft like SpaceX's Crew Dragon. Across all satellites, hundreds of collision avoidance maneuvers are performed every year, including by the (ISS), where astronauts live. Even though the debris is far smaller than the initial objects, each new piece of space junk poses a risk of collision. A 1-centimeter paint particle flying at high enough speeds, according to NASA, could wreak the same amount of damage on Earth as a 550-pound object traveling at 60 mph. In low Earth orbit, which is around 1,200 miles in altitude, objects collide at a speed of around 22,000 mph. The most frequent man-made object in Earth's orbit is an LEO satellite. Many current services rely on LEO satellites for their operation. Military and scientific research services, as well as global positioning systems (GPS) and television, are among them. The International Space Station (ISS) and the Hubble Space Telescope are both in low Earth orbit. Human lives would be jeopardized if the ISS collided with space junk. Because both the junk and the spacecraft are moving at such high speeds (about 15,700 mph in low Earth orbit), even a small piece of orbital debris colliding with a spacecraft might cause major problems. Several spaces shuttle windows had to be replaced due to damage caused by a substance that was later identified as paint particles. Millimeter-sized orbital debris poses the greatest threat to most robotic spacecraft in low Earth orbit, posing a mission-ending threat. According to the size of the threat, collision risks are categorized into three categories. Conjunction evaluations and collision avoidance maneuvers are effective in battling objects 4 inches (10 cm) and larger that can be tracked by the Space Surveillance Network. Collision avoidance and conjunction studies are difficult to perform on objects smaller than this. Debris shields on the US modules on the ISS can withstand collisions with particles smaller than half an inch (1cm). According to NASA, trash in orbits less than 600km will fall to Earth in a few years, whereas garbage in orbits greater than 1,000km will circle the Earth for a century or more. There is another problem that is coming, is that Earth may soon have its own set of rings, according to the researchers at the University of Utah, United States. Like Saturn, Earth will also have its rings and these rings will be made because of the space debris. Currently, thousands of derelict pieces of space junk are circling the Earth, these include everything from dead satellites, old rocket bodies, and lost items. But it's not only a problem of space. Any collision has the potential to cause problems with the internet, weather services, imagery, and climate change research. It might also jeopardize multinational eavesdropping efforts. If the problem is not addressed in the next three or four decades, the "Kessler Effect" may occur. Space debris generates more space debris, which increases the chances of collisions. There may eventually be enough debris to cause a cascade of collisions between smaller and smaller pieces of space trash, rendering the Earth's orbit useless. There's also a chance that several companies are working on a big new constellation of satellites to beam the internet down to Earth. SpaceX and Amazon are two companies that want to launch thousands of satellites to give global satellite internet access. A total of 50,000 satellites could be sent into space if the mission is successful. A greater number of collision avoidance movements will be required as a result.

4. Earth also has its Rings

All the Solar System gas giant planets (Jupiter, Saturn, Uranus, and Neptune) have rings, whereas Mercury, Venus, Earth, and Mars do not. There are two ideas about the formation of ring systems. They could have developed from leftover material from the planet's creation, be the remains of a moon that were killed by an impact, or simply have been broken off by its parent's gravitational tugging.

In a geostationary orbit, some of the items that humanity has shot into space can be seen as a ring. Satellites for weather and communications orbit Earth at the same rate as the planet revolves on its axis, ensuring that they constantly pass over the same spot on the surface. When these satellites have outlived their usefulness, they will be relocated to a new orbit, Space

scientists follow larger trash to prevent collision with critical spacecraft like the ISS and Earth-observation satellites. There isn't likely to be enough space junk to form visible rings. Lower-orbit material generally returns to Earth after a few years, whereas stuff in a higher orbit can stay for a century or more. So, what happens is that the space debris firstly covers the earth and then makes a ring around the earth.

Fig. 1.

5. Kessler Syndrome

Proposed by NASA scientists Donald J. Kessler in 1978, in research titled "Collision Frequency of Artificial Satellites: "The Creation of a Debris Belt." is a scenario in which the density of objects in low Earth orbit (LEO) due to space pollution is high enough that collisions between objects could cause a cascade in which each collision generates space debris that increases the likelihood of further collisions.

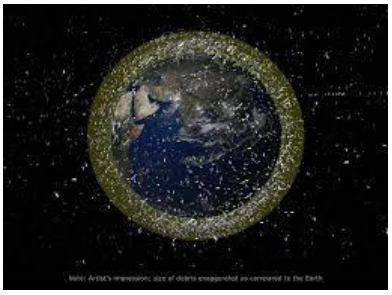

Fig. 2.

Kessler Syndrome is a hypothetical scenario in which the Earth's orbit becomes clogged with items and trash, preventing satellites from reaching certain areas of the orbit. In this scenario, collisions between orbital objects prolong space pollution, resulting in more debris and a cascade of collisions. The idea has gained popularity in recent years because of rising interest in space activities among notable corporations. Several major corporations, including Amazon, SpaceX, OneWeb, and Apple are expected to launch tens of thousands of artificial satellites into orbit during the next decade. As a result, a scenario like the one outlined in Kessler's concept could be triggered. According to the European Space Agency (ESA), humanity has launched approximately 12,170 satellites since the birth of the space age in 1957, and 7,630 of them remain in orbit today but only roughly 4,700 are still operational. These items are more than simply a speculative danger. OneWeb has launched more than half of the satellites that will make up its 648-member constellation, which may grow in the future. Amazon plans to launch its internet-satellite network, which will consist of approximately 3,200 satellites. In November 2021, Astra, a Bay Area company, filed an application with the Federal Communications Commission for its 13,600-satellite broadband network. All these satellites that are presented in space or that are launched in the future will have the probability of Kessler Syndrome.

6. How to Manage Space Debris

According to the United Nations, all firms must remove their satellites from orbit within 25 years of their mission's completion. This is difficult to enforce, though, because satellites can (and do) fail. To solve this problem, several companies around the world have adopted distinct ways. Private firms and national governments, unfortunately, are slow to respond. Most of the operations are geared at decreasing and preventing the first production of space debris. Rockets, for example, must burn all their fuel and reactants to prevent exploding. When satellites reach the end of their useful lives, they can either deorbit and burn up in the atmosphere (ideally) or push themselves into "graveyard orbit," hundreds of miles above anything useful if they're high enough. In the future, we can reduce space debris by ensuring that satellites are removed from orbit in a reasonable amount of time once they are no longer operational. Preventing in-orbit explosions (through passivation of space objects at the end of their operational life) or collisions is the most effective short-term method of lowering the rate of space debris development (via collision avoidance maneuvers while the objects are still active). Proposed solutions have generally been technological or administrative, according to Akhil Rao, assistant professor of economics at Middlebury College and the paper's lead author. Some of the technological solutions for removing space debris from orbit include nets, harpoons, and lasers. Unfortunately, we won't be able to quickly vacuum or sweep space debris into a space garbage truck. To eliminate space garbage, we must approach it closely, especially the larger and more dangerous ones, and maintain the same speed as each object.

Fig. 3.

Then we'll need to link to it in some way and either transfer it to a lower orbit or re-enter it into the atmosphere, where it will burn up. If the device is on a rocket stage with propellant still on board, there is a risk of explosion, which is why astronauts never do the operation. All these options include using a harpoon to capture a satellite, catching it in a large net, using magnets to trap it, or even utilizing lasers to burn the satellite and increase its atmospheric drag, forcing it to fall out of orbit.

"If we want to try and solve the space debris problem, we have to start to remove that type of object," Lewis said.

A maneuver will be undertaken if the danger of colliding with the space station is more than 1 in 100,000 and it will not have a significant impact on mission objectives. If the probability is greater than 1 in 10,000, the maneuver will be carried out unless it provides an additional risk to the crew. Debris avoidance actions are often small and occur one to several hours before the conjunction. Such moves with the space station take around 5 hours to design and execute using the station's Russian thrusters or the propulsion systems on one of the parked spacecraft. The International Space Station has carried out 29 debris avoidance operations since 1999, three of which occurred in 2020. NASA introduced the conjunction assessment and collision avoidance technique for human spaceflight with shuttle mission STS-26 in 1988. All these techniques are used to avoid more collisions or to avoid Kessler syndrome. It also helps manage the space debris. Before the launch of the first piece of the International Space Station in 1998, NASA and the Department of Defense partnered to develop and implement a more sophisticated and high-fidelity conjunction evaluation technique for human spaceflight missions. The Earth Observation System satellites in low-Earth orbit and the Tracking and Data Relay Satellite System in geosynchronous orbit were among the robotic assets that NASA utilized in a similar method in 2005. In 2007, the conjunction evaluation method was used for all NASA maneuverable spacecraft in low-Earth orbit and within 124 miles (200 km) of the geosynchronous orbit. Two major orbit-change maneuvers were implemented in 2015 for ESA's Integral and Cluster-2 missions. Both will safely re-enter Earth's atmosphere during the next decade because of these movements, avoiding long-term interference with the LEO and GEO sectors. All ESA-managed GEO satellites have been re-orbited as well. There is no specific way to manage space debris.

7. What are the Future Projects to Remove Space Debris?

Japan’s Aerospace Exploration Agency (JAXA) and the European Space Agency have 2start-ups to help clear space trash. Competition in the satellite market is heating up as digital businesses such as SpaceX, Amazon, and OneWeb strive to provide global Internet access through the mass deployment of satellites. However, until a way to remove abandoned space debris can be discovered, the satellite company faces an unclear future. The Japan Aerospace Exploration Agency (JAXA) and Astro scale have teamed up to complete the world's first debris clearance mission. To gather a large fuselage from a Japanese rocket, JAXA's Commercial Removal of Debris Demonstration (CRD2) project is separated into two stages. In the first stage, scheduled for 2022, an experimental satellite will be launched to collect data and inspect the fuselage. The company's portfolio also includes the ELSA-d mission, which Astro scale advertises as "the world's first commercial orbital debris clean-up." A series of separation and capture motions will be initiated by the magnetic locking mechanism on the two-part 180-kilogram chaser satellite and 16-kilogram target spacecraft. Astro scale intends to launch a demonstration mission on a Soyuz spacecraft in the first half of 2020, with commercialization following in the fiscal year 2025. "It's the first time Japan will engage in a formal treaty tackling space garbage, which has become a major problem," said Japan's UN Ambassador Kimihiro Ishikane. "Japan will draw on its long experience with space junk and looks forward to cooperating," he said. An additional space agency Clearspace-1, an ESA mission to remove a piece of junk from orbit, is scheduled to fly in 2025. The mission will be funded through a service contract with a commercial consortium led by a start-up to help build a new market for in-orbit servicing and debris removal. "This is the best time for such a project," says Clear Space's founder and CEO, Luc Piquet. "The issue of space junk is more critical than it has ever been. There are around 2000 active satellites in orbit and over 3000 spacecraft that have failed. During Space19+, ESA's Ministerial Council, which took place in Seville, Spain, at the end of November, ministers agreed to place a service contract with a commercial supplier for the safe evacuation of an inactive ESA-owned object from low-Earth orbit.

8. Conclusion

As space debris is increasing day by day. The companies and agencies just launched the satellites and when the satellite is of no use it just floats in the space at a very high speed and makes more space debris. So, there is a need that we must allow those satellites that is having a self-life of 15 to 20 years. And there is a need for an International Law on this issue. Like we have made an International Law that as the 1967 Outer Space Treaty and 1972 Liability Convention, both the Law is adopted by the United Nation, and this would be a government-to-government issue. The treaties declare that states are internationally responsible and liable for any damage caused by a spacecraft even if the damage was caused by a private company from the state. Like this Law, we need another International Law in which the company or the agency that launched a satellite should have accounted for the debris that is caused by those satellites in the future.

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