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Issues of Space Debris and Sustainable Development Practices

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Abstract

Meteors are probably better known as "shooting stars". They are small pieces of space debris and dust, or fragments from comets. They variety in scope from a grain of sand to around the size of a cricket ball. After they hit the Earth's atmosphere they heat up and glow sendoff a streak crossway the sky. Space junk is a major problem. Some of it is actual large, such as burnt-out skyrocket phases, dead ship and a few tools lost during spacewalks. However, most of it is much smaller. Collisions with large smithereens of junk can incapacitate or even destroy a spacelab. To study the various types of debris on earth and to study the quantity of space debris and removal methods. The real issue of space debris proliferation is to overtake a difficult and complex international legislation but also to create a reaction of the general opinion. Once everybody will be aware of the danger of space debris, governments and companies will be compelled to take proactive steps for cleaning or safe disposal of space debris.

Keyword: Space Debris, Earth Orbit and Collision, Sustainable development, space environment

Introduction

Space is careful as a shared good and is inappropriately overexploited by humans. It is the consequence of what Garrett Hardin called in 1963 the tragedy of the commons, a state of overexploitation due to the impression that the resource is infinite. Space suffers from the tragedy of the commons, a phenomenon that refers -consumption of shared resources when there is no clear

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ownership over it by this sentence, and Megan Ansell means that the natural tendency of space actors in power will likely be to do nothing until they absolutely must. Likewise, to the case of global warming, space establishments tend to wait as much as possible before taking any action, waiting for the situation to become critical.

There are about 23,000 pieces of wreckage larger than a softball orbiting the Earth. They portable at speeds up to 17,500 mph, fast sufficient for a relatively small piece of orbital debris to damage a satellite or a spacecraft. There is partial a million pieces of debris the size of a agate or larger (up to 0.4 inches, or 1 centimeter) or larger, and approximately 100 million pieces of wreckage about .04 inches (or one millimeter) and larger. There is even lesser micro meter-sized (0.000039 of an inch in width) debris.

NASA and the Department of Defense cooperate and share errands for describing the satellite (including orbital debris) environment. Department of Defense Space Shadowing Network tracks discrete substances as small as 2 inches (5 centimeters) in diameter in low-Earth orbit and about 1 yard (1 meter) in geosynchronous orbit. Currently, about 27,000 formally classified objects are still in orbit and most of them are 10 cm and larger. Using singular ground-based devices and inspections of repaid satellite surfaces, NASA statistically determines the extent of the population for objects less than 4 inches (10 centimeters) in diameter.

Collision risks are alienated into three groups contingent upon size of danger. Aimed at substances 4 inches (10 centimeters) and larger, combination estimates and collision evasion maneuvers are effective in countering objects which can be tracked by the Space Surveillance Net. Substances smaller than this typically are too small to track for conjunction assessments and crash evasion. Debris shields can be real in enduring impacts of atoms smaller than half an inch (1 centimeter) for the U.S. modules on the Global Space Position.

Need for the study

Sustainable development practices help countries produce in ways that acclimate to the encounters posed by climate change, which will in turn help to safeguard vital natural resources for ours and future generations. Space sustainability is preservation that all progress can remain to use outer space for peaceable resolutions and socioeconomic benefits now and in the long term. This will need international cooperation, debate, and promises designed to confirm that outer space is safe, secure, and peaceful. Many of these space actions use the same regions of Earth orbit, leading to gathering and possible physical and electromagnetic interference. Uncertainty we do not practice space sustainably, the cost of by space will rise, which might make it too comfortable to continue to use space for National and international security.

The growing population of space debris increases the possible hazard to all space vehicles, including to the International Space Station and other spacecraft with souls aboard, such as SpaceX's Crew Dragon.

NASA receipts the threat of collisions with space debris truly and has a enduring set of guidelines on how to deal with each possible collision threat to the space station. These rules, part of a larger body of decision-making aids known as flight rules, specify when the expected proximity of a piece of debris increases the possibility of a collision enough that indirect action or other precautions to ensure the safety of the aircrew are needed.

Related Studies

Ward Munters (2016) study emphasized the increasing volume of orbital debris threatens the sustainable use of outer space. This paper pulls upon a careful outline of polycentric governance, trust, reciprocity and cooperation for the collective-active problem of space debris in the near-Earth orbits. After analyzing space debris from an international legal and policy viewpoint, a new international organization for the active removal of debris is proposed as a solution to key unified impairments to decisive action by the international community – i.e. the problematic decision-making within the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), the paucity of current international space law on space debris, and international security concerns in the framework of an arms race in outer space.

Megan Ansdell (2019) deliberated the space debris progressively threatens the delivery of satellite services that have developed combined into the operations of the global economy and U.S. military, such as GPS accuracy timing and navigation. Though studies suggest that every year removing as few as five massive pieces of debris in serious orbits could knowingly steady the space debris environment, countries have vacillated to develop space debris elimination systems due to high costs and classic free rider problems. This paper argues that the United States should take the lead in closely developing systems to remove space debris with the utmost possible to contribute to future collisions. Whereas foremost by example will involve certain costs and risks, U.S. leadership in conserving the near-Earth space environment will result in not only long-term welfares for the United States, but also the satisfaction of U.S. national space policy and wider U.S. foreign policy purposes.

Amrith Mariappan et.al., (2020) study explained the space debris administration and alleviation in the microgravity environment is a vigorous research theme of current attention. It delivers theoretical evidence of the concept of a worthwhile energy conversion system that is talented of altering the space debris into useful powders in the International Space Station (ISS) for various bids. A specially designed broom is changed to collect the space debris of various sizes. A visual categorization method is proposed for the debris segregation in the ISS by creating an artificial gravitational field. It could be done by via the frame-dragging effect or gravitomagnetism. An induction furnace is helped for converting the segregated metal-scrap into liquid metal. A fuel-cell aided water atomization method is projected for transforming the liquid debris into metal powder. The high-energetic metal ashes obtained from the space debris could be employed for creating propellants for useful aerospace applications, and the silicon powder obtained could be used for making soil for advancement the pharmaceutical-flora in the space lab in the forthcoming aiming for the scarce-drug discoveries for high-endurance health care management. The projected energy conversion system is a conceivable substitute for the space debris extenuation and its real applications in orbiting laboratories through the international collaboration for the welfares to humanity

Afshaan sheikh et.al (2021) study specified the technology has many pros and cons. But we have also polluted space as we yield contaminated our mother Earth. So far, we were not seeing this as a key and direct problem but now the time has come that we look into this matter deeply and come to a proper solution to remove slowly and gradually as many Debris from space as possible. To abolish a space debris object from its orbit, many techniques have been proposed. This paper summary the different proposed methods of vacuuming space junk like. It also proposes that a special satellite is to be built which can have more than one technique to remove debris from space having generation of more than 30-35 years which can reduce the cost of the task along with space junk.

Effects of the Space Debris on Environment

Four factors determine as how the space debris environment affects space systems operations. These are stage in orbit, predictable area, orbital altitude and orbital inclination of these, time in orbit, projected area and orbital altitude are the principal factors.

Environmental Impacts

The properties of debris on other spacecraft range from surface abrasion due to repeated small particle impact to a catastrophic fragmentation due to a collision with a large object. The comparative velocities of orbital objects (10 kilometers per second [km/s] on average, but ranging from meters per second up to 15.5 km/s) allow even very small objects such as a paint flake to damage spacecraft components and surfaces. For instance, a 3-millimeter (mm) aluminum particle roaming at 10 km/s is equivalent in energy to a bowling ball traveling at 60 miles per hour (or 27 m/s). In this case, all the energy would be distributed in an area of the same size as the particle, causing catering or penetration, depending on the thickness and material properties of the surface being impacted. There has been one unplanned collision amongst characterized objects to date, but surfaces returned from space and examined in the laboratory confirm a regular bombardment by small particles. Space Shuttle vehicle machineries, including windows, are frequently replaced due to such damage acquired while in orbit. Debris also postures a hazard to the surface of the earth. High-melting-point resources such as titanium, steel, ceramics, or large or densely built objects can survive atmospheric reentry to strike the earth's surface. Although there have been no recognized loss of life or severe injuries due to debris, reentering objects are frequently observed and sometimes found.

Debris Collection Method

The Dual-Head Electromagnetic device (DHEM) space broom proposed by Kumar et. al[6] is chosen as a profitable method for the collection of space debris to the ISS. The feedback-controlled adjustable comprehensive speed DHEM space broom will be capable of capturing all the space debris nearing to the ISS including the nonfunctional substances having an average size between 1 and 10 cm, which are moving with different speeds and directions and polluting the space environment and creating risk to operational satellites and space vehicles. Note that the debris capturing net made of Graphene material, and the bidirectional plasma thruster[7], could be other options for space debris collection for the operational protection redundancy. The technology of the net proposed by European Space Agency (ESA) [8] in this regard could be used for capturing the debris after decelerating it using plasma Thrusters.

Space Debris Removal

Space debris can be categorized into three main groups, based on size and the damage it may cause in case of a collision: it could be minor damage, major damage, end of mission, or total destruction. If an accident happens between a space object and a piece of debris larger than 10, and there is a high probability of total destruction of both. The accident is likely to increase the amount of orbital litter by thousands of new units. When objects crash with debris between 1 and 10 cm in size, the consequences could be lethal to the spacecraft, but there is a smaller possibility of debris generation. If objects of less than 1 cm crash into a spacecraft, the object could be shielded and the accident is unlikely to create a significant amount of debris.

Active Space Debris Removal Methods

There are several space debris removal concepts such as ESA's drag augmentation method, (Japan Aerospace Exploration Agency) JAXA's electro-dynamic tether method, and solar sail propulsion method, and Texas A.M University's slingshot method, which motivated this research[9].Active removal are often additional efficient in terms of the amount of collisions prevented versus objects removed, once the subsequent principles are applied for the choice of removal targets[10], which may be used to generate a criticality index and therefore listed, accordingly

Space Debris Removal General Methods

I. Space Environment Based Methods

A) Drug Augmentation System

i. Foam Based
ii. Inflated Method
iii. Fiber Based

B) Electro Dynamic Tether Drag Augmentation

II. Non-Space Environment Based Methods

A) Contact Based Removal Method

i. Slingshot Method
ii. Adhesive Method

B) Contactless Removal Methods Contacts

i. Artificial Atmosphere Influence
ii. Laser Satellite
iii. Ion Beam Shepherd

Problems of Orbital Debris

Space debris can severely damage or destroy a spacecraft. Due to their high average speed, there are 22,000 pieces of debris large enough to track from the ground, but smaller objects could still cause serious damage. This debris is dangerous for future rocket launches.

Objective

This study attempt to analyse the space debris and removal methods.

Materials and Methods

Methodology

The present study is based on secondary data. The data for the study has been gathered from several sources. The secondary tool for data gathering was library research, several legal databases, publications on the Internet sources were books on international legislation and the history of space issues, journal articles, statistics and report. The most recent data was compiled from online sources, such as international space agencies (ESA, NASA, ISRO, ROSCOSMOS, etc.) and international organizations (Inter-Agency Space Debris Coordination Committee, United Nations Office for Outer Space Affairs, United Nations Committee of the Peaceful Uses of Outer Space, etc.).

Limitations

The study focused fragmentation of debris, year wise debris in India and country wise debris on earth. The study based on secondary data only.

Table 1: Size, Measurement and Effect of Space Debris in Earth Orbit

Size (cm)	Number of objects (pieces)	Measurements	Effect
> 10	> 9000	Radar	Can break up a satellite
1-10	>1 e 5	Optical telescope	Penetrate satellite walls
0.1 – 1	> 3 e 7	Statistical Estimate	Surface or component Damage
< 0.1	10 e 9 – 10 e 14	Long Duration Exposure Facility (LDEF)	Sensor interference

Source: Space Debris in Earth Orbit, 2001

Table 1 shows the estimated number of space debris, objects, ranging in size and possible impact of collides with spacecraft or rockets. Space debris models play a vital part in assessing the number of orbital junks.

The artificial component of the overall space environment is typically characterized into five types of objects, and as well by the object's active or inactive status. The five types are spacecraft or payloads, rocket bodies or rocket rooters, operational debris, breakup debris, and anomalous debris. Table 2 shows the fragmentation of the debris on the orbit.

Table 2: Fragmentation Debris

	Payloads	Rocket Bodies	Operational Debris	Breakup Debris	Anomalous Debris	Total
LEO	1,612	758	651	3,232	119	6,372
MEO	126	28	2	0	0	156
GEO	587	116	1	2	0	706
ELLIPTICAL	249	515	135	167	0	1,066
UNKNOWN	171	120	185	0	0	476
TOTAL	**2,745**	**1537**	**974**	**3,401**	**119**	**8,776**

Source: anz-meador, p.d., "history of on-orbit satellite fragmentations", 12th ed., Nasa Johnson space center report jsc-29517, 31 July 2001

Characterization of the Debris on Environment

The orbital debris catalog baseline for extrapolation into the future is growth rate of 240 objects per year. Some specialists expect the growth rate to rise as the number of space activities increases. The increasing numbers of spacecraft placed in high, long-lived orbits are particularly worrisome. If launch and breakup rates 113 increase during the coming period of low solar activity, when the "wash out" effect will below, the debris growth rate may approach 5 or 10 percent per year. For example, preliminary analysis has shown that deterioration of certain types of satellites may produce numerous tractable objects over time. This type of breakup may prove to be a significant source of debris as more satellites linger in orbit after their operational lifetime**.**

Table 3: Characteristics of debris and its impact in case of collision

Size	**Lethal to Operational Spacecraft**	**Number in Orbit**	**Traceable**	**Leftover Lethal Fragments**
Small< 5 mm	Not	Millions	No	No
Medium 5 mm - 10cm	Sometimes	~ 500 000 in LEO	No	Maybe
Large> 10 cm	Yes	~ 21 000	Yes	Yes 10 - 100 000

Source: https://www.researchgate.net/publication/293481473

Space debris with the biggest mass should be on the top of the priority list for removal (Weeden, 2010). Since the biggest objects might create the most debris in the future, removing them will reduce the possibility of generation of large quantities of space junk. The bigger the object, the greater amount of debris it can generate in a possible collision. In this regard, space debris specialists suggest that the mass times collision probability (M x Pc) is the best metric when deciding which large debris should be removed first (Liou, 2010).

Table 4: Country wise Debris in Orbits

Country/ Organization	Payloads	Rocket Bodies & Debris	Total
China	215	3564	3779
Cis	1509	4809	6318
Esa	69	53	122
France	62	467	529
India	70	112	182
Japan	154	90	244
Usa	1384	4279	5663
Other	779	113	892
Total	4242	13487	17729

Source: Satellite Box Score (as of 5 July 2016, cataloged by the U.S. Space surveillance network)

Table 4 shows the country wise debris in orbits. According to CIS (The Common wealth of Independent States) ranking first followed by USA and China ranked third place in orbital space pollution. The major sources are the payloads and rocket bodies and debris. The ensemble of payloads and rocket bodies near number, mass GEO (Geosynchronous Equatorial Orbit) was characterized by number, mass, longitude at epoch and longitude drift rate /day.

Table 5: Orbital Box Score in India

Year	Payloads	Rocket Bodies	Total	CAGR
2000	79	16	95	-
2001	81	22	103	-98.9952
2002	65	400	465	-99.7344
2004	109	431	540	-99.9317
2005	116	430	546	-99.9405
2006	124	437	561	-99.9396
2007	128	423	551	-99.9422
2008	140	428	568	-99.9394
2009	152	490	641	-99.9336
2010	158	527	685	-99.9371
2011	171	522	693	-99.9405
2012	189	512	701	-99.9405
2013	200	490	690	-99.9421
2014	219	478	697	-99.9406
2015	234	435	669	-99.9435
2016	205	338	543	-
Total	**2370**	**6379**	**8748**	**-99.0523**

Source: Satellite Box Score by the U.S. Space surveillance network)

Table 5 indicated that the orbital score level in India. It shows the spatial density weighted area and mass distribution over the decade. The table includes only payloads and associated rocket bodies. The physical appearance of operative and breaking up debris are not well characterized. Orbital score value is calculated with help Compound Annual Growth Rate Formula.

Space junk can impact operational spacecraft, yielding even more debris of all sizes, further increasing the impact risk. This is known as “the Kessler syndrome,” named for NASA scientist Donald J. Kessler, who imagined spacecraft and orbital debris could reach a solidity such that each impact generates more debris and a greater likelihood of colliding with other objects – rendering the use of LEO impossible for decades.

Current Scenario: Historical Growth of Space Debris

The first-ever launch to orbit, Sputnik 1 happed on 4th October 1957. Thousands of satellites have been sent to space[11] and opened the field to all the space applications and eased livelihood. Our daily survives depend more and more on such uses which rotated out to be compulsory and strategically for climate, telecommunications, localization, security and defense, science. As a result, more than 65 years different space agencies are launching spacecraft into Low Earth orbit (LEO); this becomes a quite serious problem.

Figure 1: Space junk is growing up from 1957 to 2018

Conclusion

The space environment is on the brink of suffering from the “Tragedy of the Commons”, due to the overexploitation of its resources, as legislation lacks control, clear regulation and provisions on liability and responsibility. All this advantages many experts to the assumptions that those in power are or likely to take any measures in the directions space debris remediation, not until there is an absolute must. The condition with orbital debris is often associated to that of climate change: the failure of government to take responsibility and act swiftly and preemptively is now putting in jeopardy the future of human life on Earth. Therefore, policymakers must take necessary actions and prevent the possible catastrophic effects on Earth orbit while there is still a possibility for something to be done.

The study offers the direct overview about the current situation and most used removal methods of active space debris. Numerous studies have shown that the level of compliance with the mitigation rules should be higher than 90 percent to frontier the growth of space debris in Earth orbit the last past two decades. Almost all removal methods are found to be compatible with unlike shapes, sizes, types, and orbits of space debris.

Space debris is the pollution of space. This pollution effects the space and earth environment. The small debris in space can damage the satellites due to their high speed. Some defund satellites stay in the orbit for centuries but some which could be falls to earth can be dangerous for people. The growing space debris problem can also be dangerous for future space rocket or satellite missions. It's an international issue and this problem need to be given some attention and start to work as soon as possible.

Suggestions:

A. Reducing the amount of mission-related debris released in spacecraft deployment and operations may be one of the easier ways of decreasing the future debris hazard to space operations.
B. Practice effective machinery to remove an existing piece of debris can also be recycled as an antisatellite weapon.
C. Non-natural satellites, asteroid, comets and other delightful bodies need for its management because our outer atmosphere get over Crowder and the waste continue cause hindrance in further useful products.

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