Establishing ways to prevent the Kessler Syndrome

Committee: OOSA

Student Officer: Diederik Vroom

Forum: The Office of Outer Space Affairs (OOSA)

Issue: Establishing ways to prevent the Kessler Syndrome

Name: Diederik Vroom

Position: Main Chair

Introduction

The Kessler Syndrome is a theoretical scenario that highlights the potential dangers posed by the exponential growth of debris in low Earth orbit (LEO). First proposed by Donald J. Kessler in 1978, this concept raises serious concerns about the long-term effects of a cascade of collisions between objects in LEO, which could render the region increasingly hazardous for the launch and operation of satellites. Given the increasing reliance on satellite technology in many areas of our daily lives, the Kessler Syndrome is a serious issue that demands attention and action.

One of the main implications of the Kessler Syndrome is that once a cascade of collisions begins, it could create more and more debris, making it even more likely that further collisions would occur. This could result in a self-sustaining chain reaction that would severely limit, or even eliminate, the use of LEO for human activities. To mitigate the potential impact of the Kessler Syndrome, it is crucial for the international community to take preventative measures.

This can include responsible and sustainable practices in space operations, such as proper disposal of satellites and other objects at the end of their life cycle, as well as implementing measures to reduce the likelihood of collisions. Additionally, active debris removal, in which objects are actively removed from LEO to reduce the overall density of objects, could play a key role in mitigating the potential impact of the Kessler Syndrome.

To address the Kessler Syndrome effectively, it is also important for the international community to increase collaboration and cooperation. This could include the sharing of best practices, the development of international guidelines and regulations to govern space activities, and the creation of an international framework for the responsible use of space. By working together, the international community can help to ensure that LEO remains a safe and viable environment for human activities in the future.

Definition of key terms

low Earth orbit (LEO)

> The low Earth orbit (LEO) is, as the name suggests**,** an orbit that is relatively close to Earth's surface. It is normally at an altitude of less than 1000 km but could be as low as 160 km above Earth.

The Kessler Syndrome

The Kessler syndrome (also called the Kessler effect**,** collisional cascading, or ablation cascade) 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.

Cascade of Collisions

Is a series of collisions between objects in LEO, which could result in the exponential growth of debris in the region.

Self-sustaining Chain Reaction

Is a chain reaction that perpetuates itself, leading to an exponential increase in the amount of debris in LEO.

General Overview

History

In 1960, Willy Ley predicted that as manned space flights become more prevalent, a considerable number of space debris resulting from accidental events will have to be removed. This prediction was made after the launch of Sputnik 1 in 1957 and in response to the increasing accumulation of space debris. In response to this, the North American Aerospace Defence Command (NORAD) established the Space Object Catalog, a database that gathers information on all known rocket launches and objects that have reached LEO. This database was later modified and published by NASA and the CelesTrak bulletin board system.

In the 1970s, the NORAD database became publicly available, and NASA scientist Donald J. Kessler applied the techniques developed for the asteroid-belt study to this database of known objects. Kessler and Burton Cour-Palais co-authored a paper in June 1978, which demonstrated that the accumulation of space debris would result in a collision process in Low Earth Orbit (LEO) within decades, rather than billions of years.

At the time, it was widely believed that drag from the upper atmosphere would de-orbit debris faster than it was created. However, John Gabbard was aware of the limitations of the NORAD data and was familiar with the behaviour of space debris. He coined the term Kessler syndrome, which referred to the accumulation of debris in space.

Sources of space debris

There are many reasons why space junk occurs. The primary causes include destroyed spacecraft, explosions, crashes, rockets, natural erosion, and misplaced equipment. These sources can produce space debris of various sizes. When seeking to reduce future space debris, these sources must be taken into account.

In the last 60 years of space activity more than 6050 launches have occurred, resulting in about 56450 tracked objects in orbit, of which about 28160 are still in orbit and are continuously tracked by the US Space Surveillance Network, which includes objects larger than roughly 5-10 cm in low-Earth orbit (LEO). Today, just about 4000 of them are satellites that are still intact and work well.

One of the sources of space debris is a spaceship that is no longer in use, a dead spacecraft. About 24% of the catalogued objects are satellites, only a third is still operational Some of them are programmed to expel themselves into a cemetery orbit at the end of their lives. This is currently a requirement for all new spacecraft. There isn't much room in these cemeteries, though.

Another source of space debris is collisions. When two spacecraft, two pieces of space junk, or a spacecraft and a substantial amount of space debris come into contact, bits of the objects may break off and enter space. More space junk could be created if these space junk bits crash with other spacecraft. Therefore, when there is more, more space debris will grow faster. This is a downward spiral.

Also, spaceships must also be launched using boosters. They raise the spacecraft into orbit until it can depend on its own fuel. At this point, the booster is discarded, keeping it in LEO indefinitely. There, a spacecraft can function for about 25 years. It slowly deteriorates over time as its constituent parts, like the paint, do. This produces minuscule pieces of space junk floating about in space. They don't currently pose a significant problem, but if their population increases, they will.

One can expect to find anywhere in the neighbourhood of 900000 debris larger than 1 cm as a result of satellite and rocket body explosions. It's likely that the flux of man-made debris particles between 0.1 and 1 mm in size will surpass the sporadic flux of naturally occurring meteoroids. The leading cause of in-orbit explosions include any remaining fuel in tanks or fuel lines, as well as any other lingering energy sources, after a rocket stage or satellite has been destroyed in Earth orbit. Over time, the harsh space environment may impair the mechanical integrity of external and internal components, which could lead to leaks or the mixing of fuel components, which could result in self-ignition. The resulting explosion has the ability to shatter the target into several pieces with various masses and imparted velocity, shattering it into pieces.

Dangers of space debris

Space debris, pose's a significant threat to the functioning of the space environment. These fragments of old satellites discarded rocket stages, and other human-made objects can travel at speeds of up to 17,500 miles per hour. This presents a hazard to both human spacecraft and the operations of satellites that support critical communication and navigation systems on Earth.

The accumulation of space debris increases the risk of collisions in orbit. These collisions can generate even more debris, leading to a vicious cycle known as the Kessler Syndrome. This phenomenon could eventually render certain orbits around the Earth unsuitable for human-made objects, affecting the use of space for critical functions such as satellite communications and navigation.

Furthermore, the presence of space debris can also pose a risk to human space missions. Spacecraft are vulnerable to collision with even small fragments of debris, which can cause significant damage or even result in the loss of the mission. The International Space Station, for example, has had to perform several evasive manoeuvres to avoid potential collisions with space debris.

The accumulation of space debris represents, therefore, a significant hazard to the safe and effective use of space. It is crucial that the international community works together to address this issue and implement measures to prevent the creation of new debris while also developing ways to remove existing debris. This will ensure the preservation of the space environment for future generations to explore and utilize.

Timeline of key events

1978 - Donald J. Kessler, a scientist at NASA's Johnson Space Center, first proposed the idea of the Kessler Syndrome in a paper he wrote on the topic.

1993- The United Nations launches the Joint Secretariat for the Inter-Agency Space Debris Coordination Committee (IADC) to coordinate international efforts to address space debris.

July 24, 1996 - The first satellite collision occurred in space between a French satellite and a discarded rocket body. This event highlighted the need for better tracking of space debris and the potential for collisions in orbit.

1997 - The United States government establishes the Joint Space Operations Center (JSpOC) to monitor and track space debris.

2007 - China intentionally destroyed one of its satellites in a missile test, resulting in the creation of thousands of new pieces of space debris.

2009 - The Iridium 33 and Kosmos 2251 satellites collided in orbit, it was the first collision that destroyed an operational satellite

2009 - The European Space Agency launches the Clean Space initiative to address the issue of space debris and its impact on the environment.

2010 - The International Cooperation for the Space Debris Mitigation Guidelines is established to develop standards for the responsible use of space.

2018-The British satellite RemoveDEBRIS, which was launched and deployed from the ISS, tested two different technologies for removing space debris: capture with a net and capture with a harpoon. RemoveDEBRIS also attempted to test a dragsail to slow down the satellite so that it could reenter the atmosphere, but the sail failed to deploy.

Major parties involved

USA, China, Russia India- play a critical role in regulating the use of space and promoting the responsible deployment of satellites and other space-related assets. Governments also provide funding for research and development of space debris mitigation techniques.

ESA- The European Space Agency, an intergovernmental organisation, has 20 members as of the present (ESA). ESA's main headquarters is located in Paris, France, and it was established in 1975. The group is committed to space exploration and works. Fully behind NASA Today, the ESA is continuously engaged in space research and is working on several projects. ESA strives to keep space as free of debris as it can while carrying out its operations there.

NASA- The National Aeronautics and Space Administration (NASA) of the United States of America is a federal agency. The organization is responsible for managing all aspect of American space missions. They are in charge of keeping track of space debris and doing study on the subject. They also offer advice and suggestions to the world community on how to stop the production of space debris.

International Organizations- International organizations, such as the United Nations and the International Association for the Advancement of Space Safety (IAASS), are involved in coordinating international efforts to prevent space debris. These organizations develop standards and guidelines for the responsible use of space, as well as promote collaboration among various stakeholders.

Commercial Space Companies- Commercial space companies, such as SpaceX and Iridium, have a role to play in preventing space debris by designing and deploying their satellites and other assets in a responsible manner.

Possible solution

There are many methods for resolving this issue. In order for all parties to work closely together, certain treaties must first be created and approved. Second, greater funding for research is needed to create debris-emitting spacecraft and equipment to clear space trash. Another option is to mandate that companies and space organisations plan and fund the evacuation of their crashed spacecraft. In general, the problem's roots should be cut out in order to solve the problem itself.

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