

Space Debris Low Earth Orbit (LEO)

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Abstract: *Humans have created a lot of garbage on earth surface to which we can see, but up in the atmosphere, unbelievably the amount of junk human have created in space is equally colossal. The main topic of this paper is to discuss space debris particularly in LEO orbit. The discussion starts with the satellites basic characteristics and move on to debris history and development. Some previous studies and researches done with regard to the debris conditions are discussed. Statistics on the debris growth and its impact to the active satellite and space craft's located in LEO orbit are presented. Finally, the paper mentioned on space debris removal system. The main question this paper tries to address is why LEO orbit has the most number of debris and the impact of the growth to the future.*

Keywords: Space, Debris, Satellites, LEO (Low Earth Orbit)

1. History and Background of Satellites

The satellite history started in 1957 by the Russian. They launched the first satellite called Sputnik. Since then, different satellites are launched and the numbers grow rapidly around the world. Most of the satellites are launched and owned by The United State of America, China, Russia, United Kingdom, and many others. As there are many satellites, this also translates to an equal number of space debris both from the working and non-working satellites. Let's take Sputnik as an example, it is a tiny spacecraft and lasted only three months in orbit. After that it will be burned up in the earth's atmosphere. Now, earth orbit are layered into three satellite orbits, namely low earth orbit (LEO), Geo-stationary orbit (GEO) and the third one is medium earth orbit (MEO).

2. Orbits Characteristics

LEO: Numbers of satellites are 500+, life span five years (short), Propagations Loss least, latitudes around 500-1500 km,

Types of Satellite launch there are:

- Military
- Surveillance service.
- International Space Station.
- The Hubble Space Telescope.
- Many Earth observation satellites.

MEO: Numbers of satellites are 400+, life span 12-20 years (long), Propagations Loss High, latitudes around 5000-12000 km, Types of Satellite launch there are:

- Navigation
- communications GPS

GEO: Numbers of satellites are 500+, life span 12-20 years (long), Propagations Loss Highest, latitudes around 35.000 km, Types of Satellite launch there are:

- Broadcasting
- Communications Satellites

3. Introduction

Definition: space debris is a man-made objects orbiting in space. There are two types of debris, *natural* and *artificial*.

- Natural space debris consists of small pieces of cometary and a steroidal material called meteoroids. These meteors are visible to the naked eye when they travel through the earth's atmosphere.
- Artificial space debris is any non-functional man-made object in space which usually floats in the earth orbit. Low earth orbit is 500 km above the earth's surface. This is where most of the junk is and also the region where most of manned made spacecraft and many scientific satellites resides.

4. Literature Review

There are quite a number of studies conducted to look at the debris growth and the solution. Mark A.Sturza, stated that a new approach that is currently under implementation is to move the communication satellite that traditionally operated in geo-stationary orbit (GSO) to LEO. In LEO then, it will be further categorized as three different kind of global satellites systems providing different kind of services as described in Table 1[4].

Table 1: New GEO Satellite System that will be soon in LEO [4]

Satellites	Services
Little LEOs	<ul style="list-style-type: none">• Paging• Email• Fax
Big LEOs	<ul style="list-style-type: none">• Voice telephone• Low speed Data
Broadband LEOs	<ul style="list-style-type: none">• Multimedia Conferencing• Internet Access• Video Conferencing• Video-Telephony• High Speed Data

In March 2010, Parliamentary Office of Science and Technology (POSTNOTE), stated that debris poses a

growing treat to satellite that in LEO and could prevent the use of valuable orbits in the future. In the altitude below LEO orbits the object can easily fall to earth atmosphere and will be burnt up. Some of these objects are:

- Defunct space: such commercial satellite with lifespan 15 years.
- Spent rocket bodies that used to launch satellite into orbit.
- Objects released during missions of the satellite.
- Small fragmentation caused by collisions, explosions [2].

Science Museum Learning (SML) mentioned at LEO altitude of about 500 km, it contained the most of manmade space craft and many scientific satellite such as international space station (ISS), and Hubble Space telescope [5]. David Wright, showed that LEO, MEO, GEO are consist of 95% operational satellites. Based on previous studies, LEO has the biggest amount of functional satellites with 46%, MEO with 42%, whereby GEO is 36% [4]. Figure 1 shows the operational satellites percentage in different orbits.

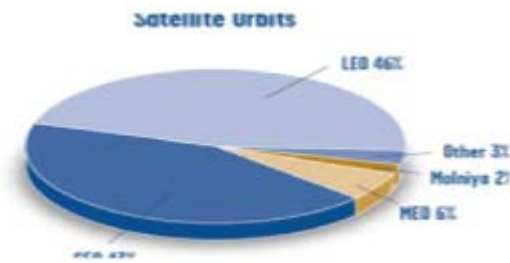


Figure 1: Operational Satellite in the orbits [4].

5. LEO Space Debris

LEO debris move around the planet at 17,000 miles an hour (27,400 kilometers an hour) or more. The orbits of these debris objects are different in direction, orbital plane, and speed. With these conditions, collisions are unavoidable. At this speeds, termed ultrafast, even a tiny piece of junk presents a serious hazard for satellites, spacecraft, and spacewalking astronauts. Gravitational pull will ensure that anything we've ever put in orbit will eventually make its way back to Earth. And though thus far no one has ever been killed by any space debris, NASA estimates on average one piece returns to Earth each day. NASA and other national space agencies have recognized orbital debris as a serious problem and are currently doing preparation plans to mitigate existing space junk and control future debris.

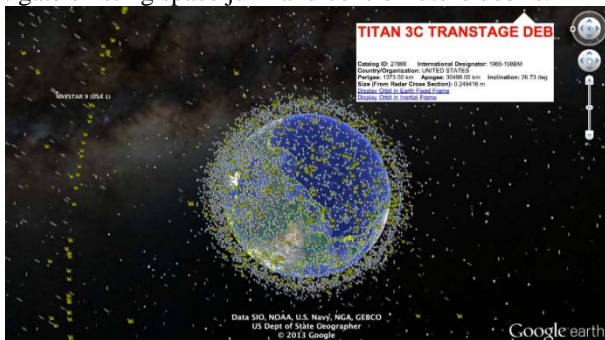


Figure 2: Image Google Earth based interactive showing details about satellites and debris in orbit. (Credit: satellitespy.net)

The green objects in Figure 2, represent the active satellites, and the gray represent the objects which are the debris. As seen in the picture, most of the objects and debris are concentrated at very low altitude. The debris is not distributed equally in all earth orbits, but mostly are in LEO orbit. [4]

LEO has the most space debris among the other orbits MEO or GEO. The simple reason to this is due to LEO characteristics itself where the most number of satellites are in LEO orbit. LEO satellites are at around 500-2000 km latitude, the nearest to earth surface. LEO orbiting satellites are less expensive to launch into orbit. These satellites also do not require high signal strength and give less time delay due to the latitude near to earth.

LEO satellite life span is around 5 years. Once it stops functioning it stays there in the orbits. LEO are mostly used for communication applications. One example of these communication satellites are Iridium phone system. There are also satellites for remote sensing purposes because it uses the sun-synchronous LEO orbit [6]. Others are used for military and surveillance service. International Space Station (ISS) is also in LEO orbit. Others are earth observation satellites and spy satellites. Previously, communication satellites are placed in geo-stationary orbit GSO, but recently there is a new idea to move it to LEO orbit. This is because of GEO signal latency; it takes longer time to traverse if located at GEO compared to LEO. Despite the obvious, LEO facilities and characteristic such as signal strength and less time and latency are too lucrative to ignore making this orbit extremely hazardous, dangerous and congested.

Unavoidable as it is, LEO debris seems to be the severest problem for earth. LEO consists of around 400,000 debris which ranges from 1 to 10cm in size. Small it may be, but it is large enough to cause serious damage [3]. The bigger objects which are greater than 14cm can be summed to about 14,000 objects. In total, there are over 750,000 debris. [6]

Even a small bit of debris could cause major damage to a working satellite when it caused collisions. There has been a steady growth of space debris since the launch of Sputnik in 1957, with a major and sudden increase due to two of the largest debris creating events in history. The first is in 2007 when Chinese anti-satellite (ASAT) test was conducted. This was done intentionally by China where they destroyed its Fengyun-1C satellite in order to test their new ground based ASAT system. This has produced about 150,000 pieces of debris bigger than 1 cm and it was spread at an altitude near the earth polar orbit between 800 – 1000 km. The second event was in 2009, The Iridium-Cosmos collision. It was an accidental collision between a working Iridium satellite and a defunct Russian military satellite. This has added 200,000 pieces of debris greater than 1 cm in size. Though this collision has only caused a temporary service interruption to Iridium due to sufficient space satellite, its impact to space junk cannot be ignored. It has also triggered alarm that this kind of accident collision can happen anytime.

These orbits are known as “critical orbits” due to they are most likely to reach a situation where the growth rate of new debris due to collisions exceeds that of natural removal caused by atmospheric drag. It is becoming critical because several large fragmentation events have occurred in these regions and also debris lifetimes can last up to decades [3].

Table 2: Categories of Leo Debris

Physical Size	Potential Risk to the Satellites	Impact	Numbers of Objects
>10 cm	Can be tracked No effective shielding	Catastrophic Complete destruction	14,000
1-10 cm	Larger objects in this range may be tracked No effective shielding	Severe damage or complete destruction	400,000
< 1cm	Cannot be tracked Effective shielding exists	Damage	>10,000

6. Leo Debris Growths and Impact

Based on the World Market Survey, more than 1,200 satellites will be launched over the next 10 years. A report by *Euro Consult* has also predicted that an estimated 1,220 satellites will be made for launching over the next period. An average of 122 satellites to be launched per year is up significantly from the previous decade annual average of 77 satellites launched. This is a sign showing that government and commercial operators require more satellite capabilities. In Euro Consult’s just-released "Satellites to be Built and Launched by 2019, World Market Survey," the company projected that revenues from the manufacturing and launch of these 1,220 satellites will reach \$194 billion worldwide for the decade (www.spacedaily.com). With revenue figures as stated, satellite business will attract more businesses and government to participate. Our only salvation is that the numbers of objects from LEO that faced frictional drag will increase and re-enter the earth atmosphere, subsequently they will fall back to earth and burn up to clear up some space for future satellites. Figure 3 gives the number of LEO satellites that re-entered earth’s atmosphere, for each year since 1969 until 2004.

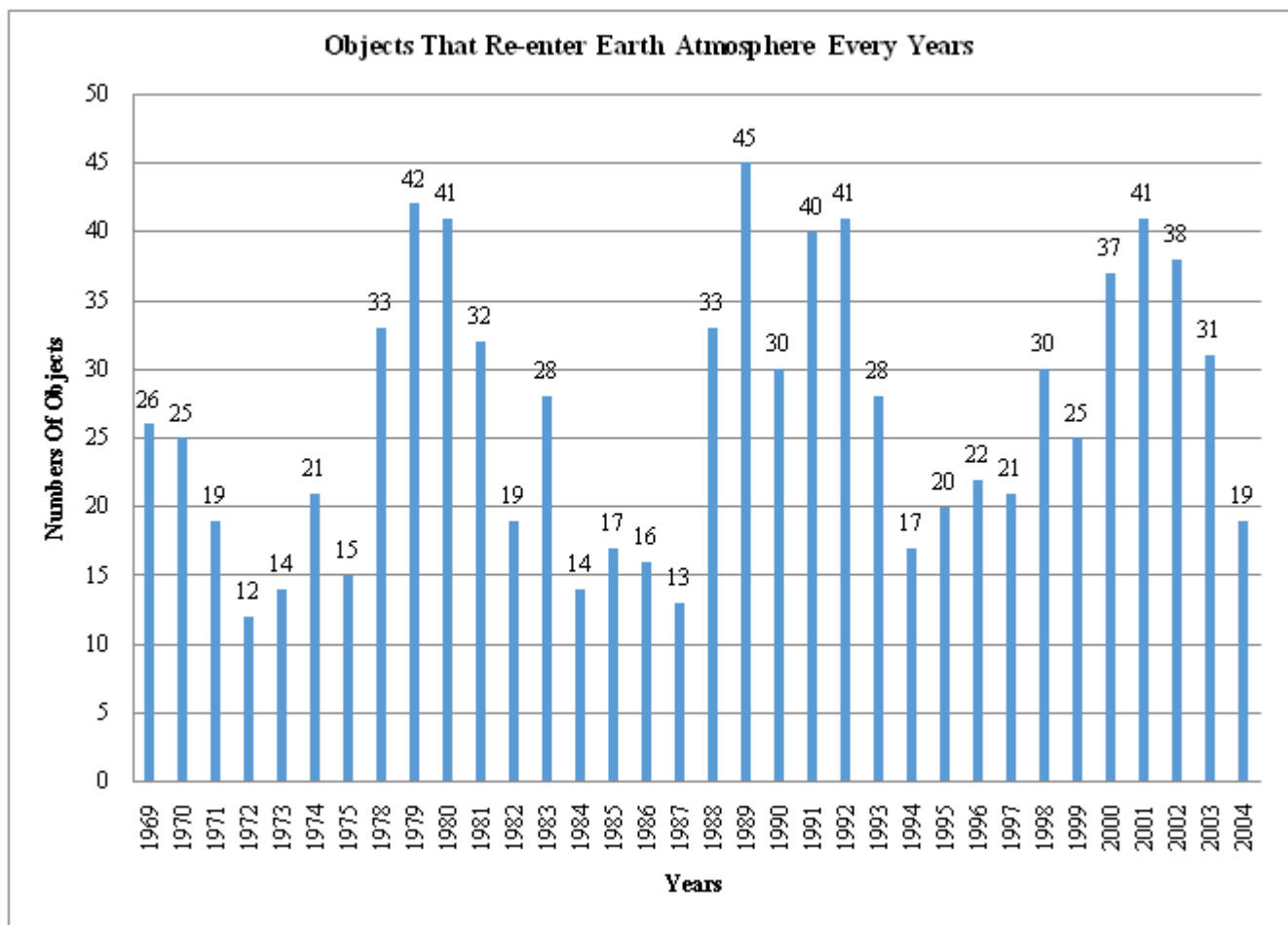


Figure 3: Numbers of objects re-enter the earth atmosphere

7. Conclusion

There are 400,000 LEO debris out there. These objects are different in sizes and every year it is estimated another 120 new satellites will be launch yearly. It is unavoidable with an increase numbers of satellite, there will be a linear increase of collisions. The impact and risk becomes higher

for all satellite and spacecraft located in LEO orbit. What makes it worse; there are no laws, rules and regulation for space debris today. There are no guidelines stating the minimum and maximum number for each country to launch new satellites. The United States of America however has initiated some programs to address this issue. The first is a mitigation program where it refers to reducing the creation of new debris. The second is removal program referring to either natural removal by atmospheric drag or active

removal by human-made systems [3]. To date, there is no space debris removal system in operation. Nevertheless, there are quite a few ideas and concepts proposed on this issue such as the electrodynamic tethers, solar sails, drag augmentation devices, orbital transfer vehicles, and space-based lasers. All of these space debris removal concepts have their own benefits and weaknesses, making it very difficult to find a complete system that fulfills the needs. This is a real grave and serious issue to be addressed by all countries because even if there are no more new satellites launched, the risk is still the same because accidental collisions can always happen at any time.

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