GOVERNMENT DEGREE COLLEGE BEGUMPET, HYDERABAD-500 016 TELANGANA

CERTIFICATE

This is to certify that the project titled **SWACHCH ANTARIKSH** submitted to Commissioner of collegiate Education, Telangana, Hyderabad by the students **GAYATRI MOKASHI(108519441012), TRIPTI TIWARI(108519441041), SHAIK ASRA(108519441034), DUMPALI DHARANI(108519441009), B. SIRISHA(108519441006)** during the academic year 2021-22 under the guidance of mentor **Dr. Ch. Kanchana Latha**, Assistant Professor of Physics Department, Government Degree College, Begumpet, Hyderabad.

Signature of Head Organizatiion / Institution

Name and Designation:

STUDENTS FINAL REPORT OF JIGNASA RESEARCH PROJECT IN PHYSICS

A study Research project

SWACHCH ANTARIKSH

Submitted

By

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AND

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PRINCIPAL MENTOR &ASST.PROF OF PHYSICS

GOVERNMENT DEGREE COLLEGE, BEGUMPET TELANGANA

Submitted to

COMMISSIONER OF COLLEGIATE EDUCATION

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Acknowledgements

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GOVERNMENT DEGREE COLLEGE BEGUMPET, HYDERABAD-500016

TELANGANA

DECLARATION

We hereby declare that Jignasa Students Study Project titled **SWACHCH ANTARIKSH** is a bonafide record of research work carried out by us under the guidance of mentor Dr.Ch.Kanchana Latha, Assistant Professor of Physics & Faculty of Physics Department, Government Degree College, Begumpet, Hyderabad and submitted to Commissioner of Collegiate Education, Telangana, Hyderabad-1 by the students **GAYATRI MOKASHI (108519441012), B. SAI PRIYA (2011085468009), M. ANKITHA (2011085468087), Ch. RUCHITHA (2011085468023), M. AMULYA (2011085468081)** during the academic year 2021-22

Signature of the Mentor & Faculty

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Abstract

Space exploration activities since the past 60 years have resulted in collection of garbage orbiting around the orbit. These debris further collide with functional spacecrafts and damage them. Anti-satellite missions and collisions have sent pieces of debris orbiting the Earth. At present 9300 tons of debris is orbiting around the earth.

Majority of the debris are aluminum alloys, paint flecks and steel from the destroyed/old spacecrafts. Artificial space debris along with micrometeoroids (MMOD- micrometeoroids and orbital debris) are responsible for the damage of other satellites. The removal of the magnetic debris using an electromagnet powered by solar energy could lessen the space debris by almost 12 per cent. Low Earth Orbit (LEO) is the orbit in which most satellites orbit. The debris is to be collected from the LEO. This is collected in an aluminum alloy net and can be either sent to the graveyard orbit or the South Pacific Ocean for disposal. The Swachch Antariksh has structures to prevent the debris from leaking. MMOD analysis evidence suggests that even paint flecks can be removed using this method. Removal of space debris has been the focus of Space technology giants across the world. Future space programs can be affected adversely if no action is taken against this. Previous attempts at cleaning the space debris by Japan Space Exploration Agency (JAXA)-Kounotori 6 has been a failure. China has recently launched a debris mitigation technology satellite, Shijian-21 on 24 October 2021. The said classified project aims to test the actual debris mitigation technology. The Indian Space Research Organization (ISRO) is building up its orbital debris tracking capability by deploying new radars and optical telescopes under the Network for Space Objects Tracking and Analysis (NETRA) project in 2022. Swachch Antariksh is a holistic approach to the removal and disposal of space debris; The fraction of the debris it can remove could be helpful in removing the clutter in the space without adding any more junk to it.

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Contents

1.Introduction

1.1 What is space debris?

The advancement in space technology from the past 60 years of human space pursuit has been an adventurous one. This has been successful at providing us weather reports, GPS services, Internet services among many other benefits. These benefits come at a price. Accumulation of useless objects in space has led to an unexpected increase in junk orbiting in the space. The space environment of objects represents more than half a century of space activities following the launch of Sputnik-1 on October 4, 1957. There have been some thousands of launches since then. These launches have resulted in the accumulation of both working and non-working objects. The non-working objects create a clutter in the Lower Earth Orbit (LEO).

The debris present in space includes (but are not limited to) payloads, upper stages and mission related objects (launch adapters, lens covers, etc.). Many items were released unintentionally, such as screwdrivers or protective gloves during extra vehicular activities of astronauts, slag particles produced during solid rocket motor burns, cooling liquids released from satellites or chipped paint flecks.

The most important source of space debris is on-orbit explosions of space objects. For example, in February 2009, a Russian satellite smashed into a U.S. one, creating thousands of chunks of orbital shrapnel. Collisions are prevalent in space, owing to high density of objects present in the orbit.

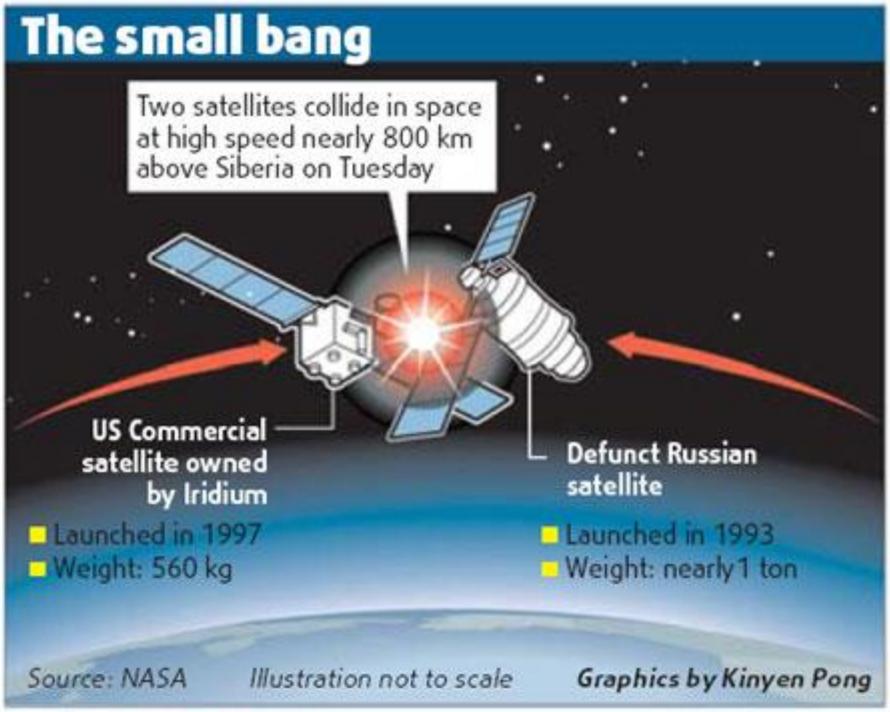


Fig. 1.1 Illustration of the 2009 collision

Furthermore, Anti-Satellite (ASAT) weapons testing have contributed to the space debris in a large scale. The testing of anti-satellite weapons (ASATs) by the U.S. and Soviet Union began during the 1960s and 1970s. North American Aerospace Defense Command (NORAD) files only contained data for Soviet tests, and debris from U.S. tests were only identified later. By the time the debris problem was understood, widespread ASAT testing had ended; the U.S ASAT Program was shut down in 1975.

The U.S. restarted their ASAT programs in the 1980s with the Vought ASM-135 ASAT. A 1985 test destroyed a satellite orbiting at 525 km, creating thousands of debris larger than 1 cm. Due to the altitude, atmospheric drag decayed the orbit of most debris within a decade. A *de facto* moratorium followed the test. China tested the ASAT technology in 2007, shattering Fengyun-1C into 2,000 pieces of trackable debris. On 27 March 2019, Indian Prime Minister Narendra Modi announced that India shot down one of its own satellites with a ground-based missile. The operation is named *Mission Shakti*.

1.2 Damages caused by space debris

A century ago, pollution wasn't a problem on earth. But now it has proven to be threat that could even destroy the earth as we know it. An early diagnosis of the problem can help avoid the consequences. Similarly, space debris is increasingly damaging satellites. The cost and manpower incurred in launching and maintaining the satellites are huge. Such accidents can be avoided by clearing the space debris between the sizes of 5-10cm which damage solar panels and optics.

Data released by the ISRO in 2022 point to an increasingly grim scenario. For protecting its space assets, the ISRO was forced to perform 19 collision avoidance maneuvers (CAM) in 2021, of which 14 were in Low Earth Orbit (LEO) and 5 in the geostationary orbit, according to ISRO's Space Situational Assessment for the year. The number of CAMs jumped from just three in 2015 to 12 in 2020 and 19 in 2021.

Year	Number of CAM performed
2015	3
2020	12
2021	19

Number of Collision Avoidance Manoeuvres (CAM) carried out for Indian Operational assets during last 7 years.

Fig. 1.2 Credit: ISRO Space Situational Awareness Assessment 2021

Due to these collisions great harm is caused not only to the satellites but also the International Space Station (ISS). Damage sustained by NASA's Hubble telescope is a textbook example of harm done by space debris.

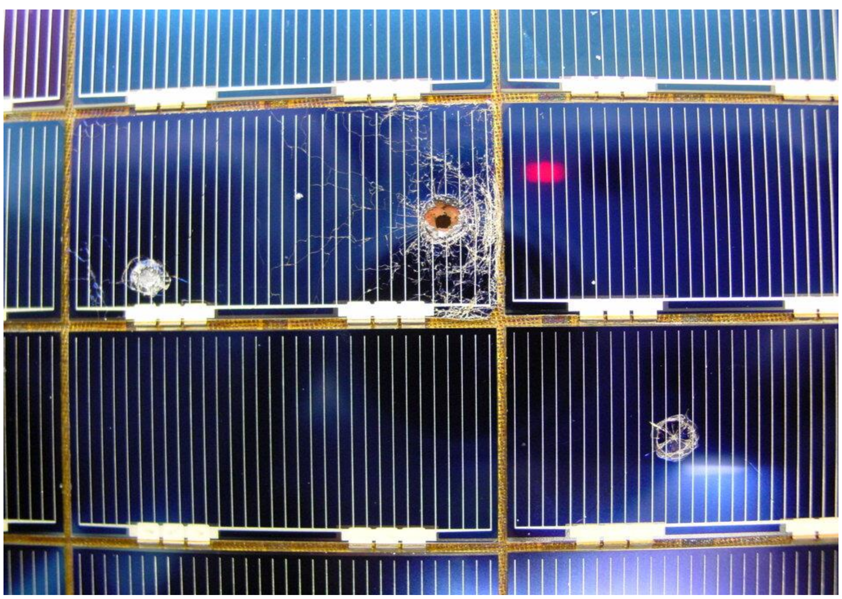


Fig. 1.3 ESA built-solar cells retrieved from the Hubble Space Telescope in 2002, *Credit: ESA*

2. Motivation

The main theme of this project is eliminating the space debris. Presently, the environment around the earth, i.e., the lower earth orbit [LEO] is covered with unwanted pieces of junk. The LEO is cluttered with space junk. If this junk is not removed, we face the threat of being cut away from the outer space. This will have massive impending consequences.

- The future generations will not be able to launch space shuttles/satellites, etc.
- This might even block rays of sun from reaching the earth. This will have an effect on the balance of the ecosystems on earth. The whole community of living organisms on earth is dependent on the energy received from the sun. This will eventually lead to the death of all the living organisms on the earth as we know it.
- The collision avoidance maneuvers made to avoid the debris damages require energy and manual attention. A lot of money and time is required to send the spacecrafts to LEO. All this will be a waste if the satellites are damaged by the garbage.

3. Space Debris Analysis

3.1 Space Debris distribution

1. By altitude and source

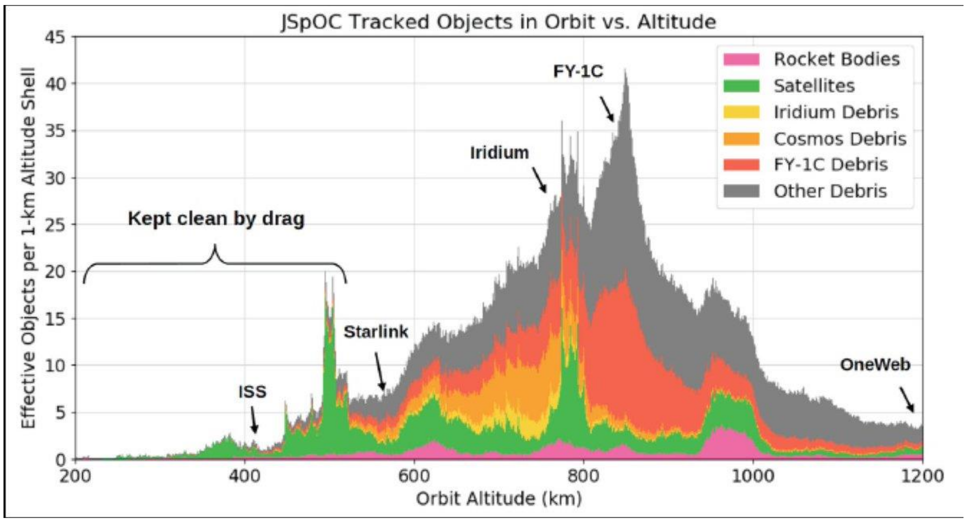


Fig. 3.1 Debris Distribution by orbital altitude *credit: JSpOC*

2. By material type

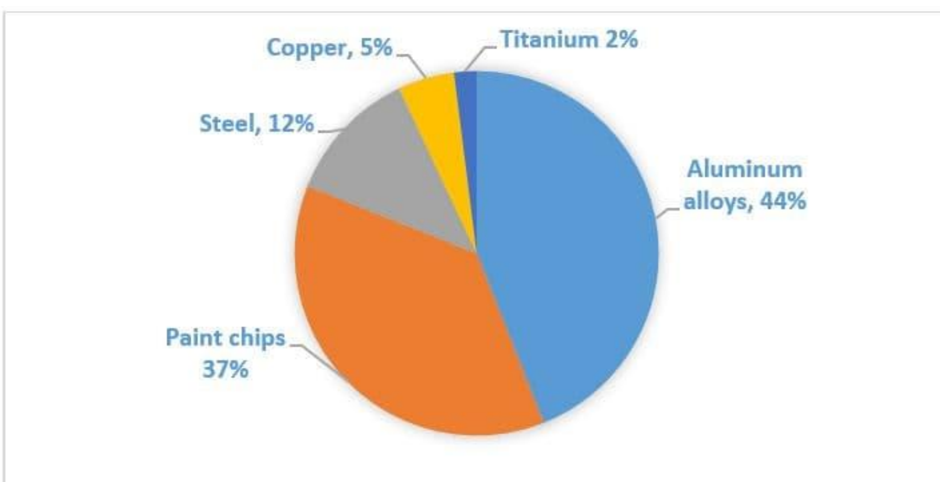
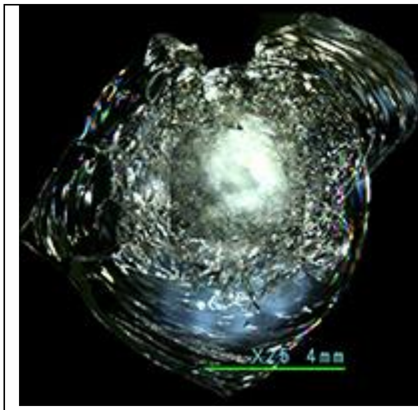
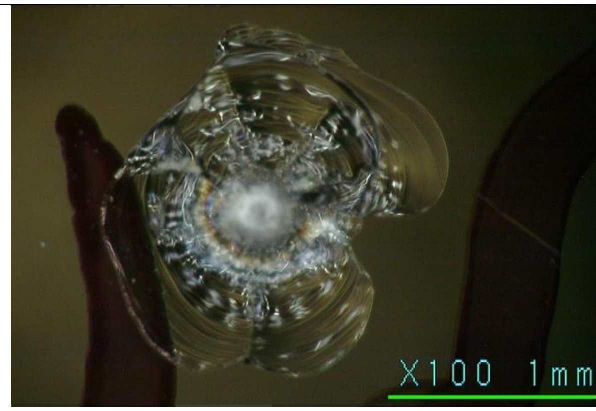
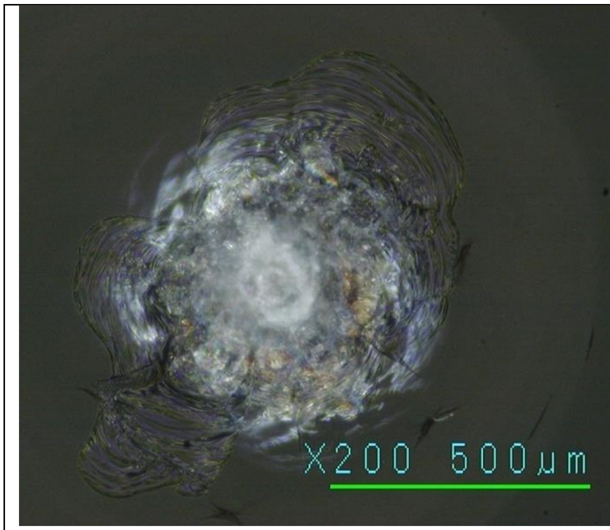
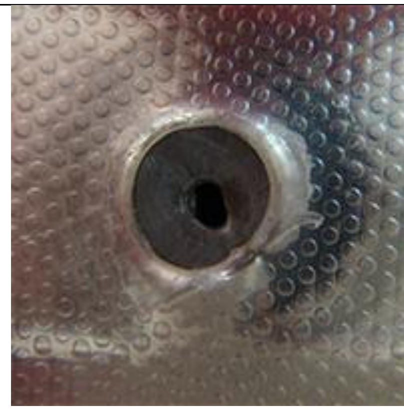


Fig. 3.2 Debris percentage by type of material *credit: space techie*

3.2 Experimental Evidence of Damage Caused

 **Fig. 3.3 STS-126 Window No.2**	 **Fig. 3.4 STS-130 Window No. 7, Index No. 14**
• Size: 1.56mm x 1.08mm • Depth: 0.23mm • Evaluated Particle Type: orbital debris • Particle Elements: plutonium, iron near central crater, zinc near margin • Estimated Particle Size: 0.05mm. • Estimated Velocity: 10 kilometers per second	• Size: 1.76mm x 1.64mm • Depth: 0.11mm • Evaluated Particle Type: orbital debris • Particle Elements: iron, titanium, zinc, chromium. • Estimated Particle Size: 0.05mm • Estimated Velocity: 10 kilometers per second

 **Fig. 3.5 STS-130 Window No. 11, Index No. 15**	 **Fig. 3.6 STS 122**
• Size: 1.02mm x 0.64mm • Depth: 0.08mm • Evaluated Particle Type: orbital debris • Particle Elements: iron (steel) • Estimated Particle Size: 0.03mm • Estimated Velocity: 10 kilometers per second Note: damage photographed by crew on orbit	 **Fig. 3.6 STS 128**

3.3 Some catalogued space debris

NAME	***ALTITUDE***	***VELOCITY***	***PERIOD***
COSMOS2251	100	100	100.37
IRIDIUM33	100	100	99.27
COSMOS2251	100	100	101.76
COSMOS2251	100	100	99.24
COSMOS2251	100	100	102.56
COSMOS2251	100	100	98.63
COSMOS2251	100	100	100.73
COSMOS2251	100	100	98.63
COSMOS2251	100	100	100.53
COSMOS2251	100	100	97.64
COSMOS2251	100	100	97.33
IRIDUM33	100	100	98.44
COSMOS2251	100	100	104.41
COSMOS2251	100	100	95.11
COSMOS2251	100	100	100.53
COSMOS2251	100	100	98.81
COSMOS2251	100	100	99.26
COSMOS2251	100	100	99.89
COSMOS2251	100	100	103.27
COSMOS2251	100	100	95.57

IRIDIUM33	100	100	96.17
IRIDIUM33	100	100	100.68
IRIDIUM33	100	100	97.29
COSMOS2251	100	100	102.67
COSMOS2251	100	100	100.56
COSMOS2251	100	100	99.07
COSMOS2251	100	100	99.43
COSMOS2251	100	100	99.26
IRIDIUM33	100	100	99.33
COSMOS2251	100	100	99.96
IRIDIUM33	100	100	100.56
IRIDIUM33	100	100	103.69
COSMOS2251	100	100	102.29
IRIDIUM33	100	100	98.18
COSMOS2251	100	100	103.31
COSMOS2251	100	100	97.81
IRIDIUM33	100	100	96.9
COSMOS2251	100	100	100.34
COSMOS2251	100	100	100.32
COSMOS2251	100	100	99.52
COSMOS2251	100	100	98.44
COSMOS2251	100	100	104.35

COSMOS2251	100	100	99.99
IRIDIUM33	100	100	99.34
COSMOS2251	100	100	99.6
COSMOS2251	100	100	98.45
COSMOS2251	100	100	96.25
COSMOS2251	100	100	103.36

COSMOS2251	100	100	103.39
COSMOS2251	100	100	98.93
COSMOS2251	100	100	100.19
COSMOS2251	100	100	100.08
COSMOS2251	100	100	100.12
COSMOS2251	100	100	95.7
COSMOS2251	100	100	95.39
COSMOS2251	100	100	99.71
COSMOS2251	100	100	100.3
COSMOS2251	100	100	99.33
COSMOS2251	100	100	100.28
COSMOS2251	100	100	96.64
COSMOS2251	100	100	101.57
COSMOS2251	100	100	98.15

COSMOS2251	100	100	99.75
COSMOS2251	100	100	99.02
COSMOS2251	100	100	101.3
COSMOS2251	100	100	98.34
COSMOS2251	100	100	98.17
COSMOS2251	100	100	98.31
COSMOS2251	100	100	97.49
COSMOS2251	100	100	100.63
COSMOS2251	100	100	99.39
COSMOS2251	100	100	98.07
COSMOS2251	100	100	100.12
COSMOS2251	100	100	101.27
COSMOS2251	100	100	99.06
COSMOS2251	100	100	98.74
COSMOS2251	100	100	99.84
COSMOS2251	100	100	98.84
COSMOS2251	100	100	98.74
COSMOS2251	100	100	98.4
COSMOS2251	100	100	98.19
COSMOS2251	100	100	100.21
COSMOS2251	100	100	98.98
COSMOS2251	100	100	106.55

COSMOS2251	100	100	104.77
COSMOS2251	100	100	98.34
COSMOS2251	100	100	100.31
COSMOS2251	100	100	100.35
COSMOS2251	100	100	97.6
COSMOS2251	100	100	100.02
COSMOS2251	100	100	97.84
COSMOS2251	100	100	99.6
COSMOS2251	100	100	405.8
COSMOS2251	100	100	100.79
COSMOS2251	100	100	100.69
COSMOS2251	100	100	95.14
COSMOS2251	100	100	98.4
IRIDIUM33	100	100	96.17
IRIDIUM33	100	100	100.68
IRIDIUM33	100	100	97.29
COSMOS2251	100	100	102.67
COSMOS2251	100	100	100.56
COSMOS2251	100	100	99.07
COSMOS2251	100	100	99.43
COSMOS2251	100	100	99.26
IRIDIUM33	100	100	100.56

IRIDIUM33	100	100	103.69
COSMOS2251	100	100	102.29
IRIDIUM33	100	100	98.18
IRIDIUM33	100	100	103.31
COSMOS2251	100	100	100.32
COSMOS2251	100	100	99.52
COSMOS2251	100	100	98.44
COSMOS2251	100	100	104.35
COSMOS2251	100	100	99.99
IRIDIUM33	100	100	99.34
COSMOS2251	100	100	99.6
COSMOS2251	100	100	98.45
COSMOS2251	100	100	96.25
COSMOS2251	100	100	103.36

4. Swachch Antariksh

4.1. Introduction

The advancement in space technology has led to an unexpected increase in space debris. Project 'SWACHCH ANTARIKSH' is aimed at eliminating the space debris in an efficient way. It uses the concept of electromagnetism to clean small sized space debris.

4.2. 3-Dimensional model

Fig. 4.1

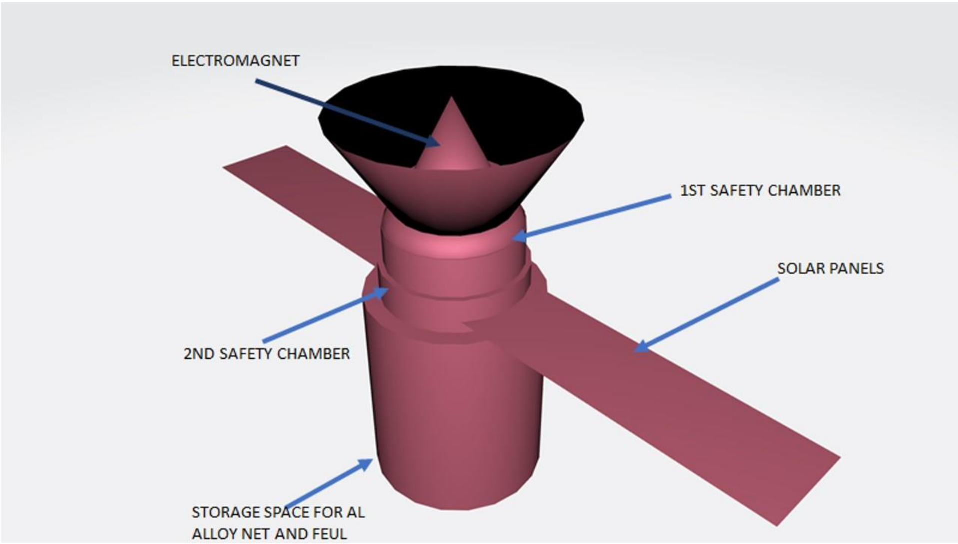


Fig. 4.2 Labelled diagram of Swachch Antariksh

4.3. Collection

As soon as the electromagnet is turned on it attracts the magnetic elements of the debris. The satellite will orbit around the earth collecting the waste and depositing it in the closed lightweight aluminum alloy (AA6061-T6) bin made of net. This process will be continuous throughout the journey of the satellite in the earth's orbit. Periodically the electromagnet will be switched on and off. It serves two purposes.

1. When the first safety chamber hits the saturation amount of material it can collect, it will simply deposit it in the 'bin'. The frequency of the emptying of the electromagnet will be set according to the number of debris present in the space it is traversing.

2. The control over switching on and off would also help in using the energy sustainably.

• The closing of the bin so that the debris doesn't escape back into the space is crucial. SWACHCH ANTARIKSH takes in debris stage by stage, so that the debris doesn't escape back into the space. We can make an analogy using the jungle safari method. There are three gates in order to prevent wild animals from exiting the wildlife safari park. This measure is absolutely crucial as failure to contain the debris would make the debris cleaner redundant.

• The aluminum net would unfurl from its storage unit like a parachute(analogy). It would then store all the debris collected till its disposal.

https://drive.google.com/file/d/15kiOnbDKKdn69pftL4HSobhAnlMH61z4/view?usp=drivesdk

4.4 Disposal

4.4.1 DISPOSAL TO THE GRAVEYARD ORBIT

- After the collection of the debris, the satellite will be propelled farther off the earth's orbit using a minimal amount of fuel into an orbit known as the graveyard orbit.
- A graveyard orbit, also called a junk orbit or disposal orbit, is an orbit that lies away from common operational orbits. One significant graveyard orbit is a super synchronous orbit well above geosynchronous orbit. Some satellites are moved into such orbits at the end of their operational life to reduce the probability of colliding with operational spacecraft and generating space debris.

Fig. 4.3 Graveyard orbit illustration

4.4.2 DISPOSAL TO THE SOUTH PACIFIC OCEAN

- The region of Pacific Ocean between Chile and New Zealand is a region where there is no human habitation. This region is currently being used as space trash disposal patch.
- The collected debris can be directed to the ocean safely.
- This would require more fuel than sending away the debris to the graveyard orbit.

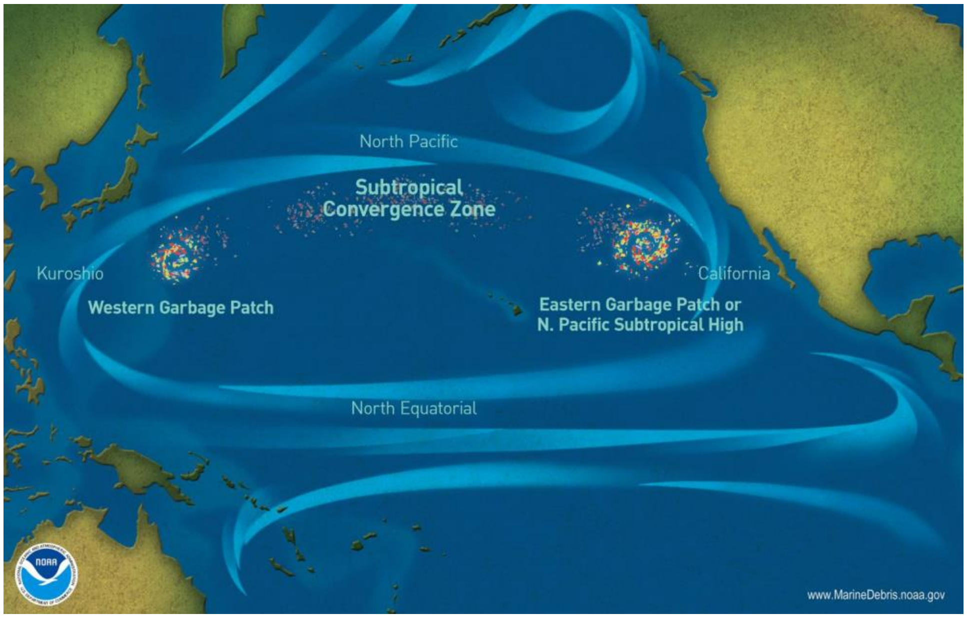


Fig. 4.4 Space trash disposal patch in Pacific Ocean

5. Advantages and Applications of the Model

5.1 Why is it better?

- It deals with a large number of small sized debris. Collection of such debris is a long and tedious task otherwise. This could save many satellites from being destroyed. Hence it will not only be beneficial of the country's space program but it could solve the world's future space prospects. Also, the efforts put in by the humankind to send satellites up to the space would go to waste if the important parts of satellites are damaged.
- This would eradicate the total 5-10cm sized magnetic debris and also some of the paint chips as well.
- It won't be interfering with the normal functioning of the satellites as it has very weak field which is capable of only attracting small pieces of junk. Moreover, if any problems persist, it can be turned off.

5.2 Energy Requirements

The energy requirements of the S.A is fulfilled by fuel storage unit. The solar panels also help in providing unlimited energy until sunlight is available. The electromagnet can be switched off whenever energy needs to be conserved until the satellite starts receiving sunlight again.

5.3 Anti-Leaking Mechanisms

The space has no gravity. It becomes crucial to put in safety mechanisms to prevent the garbage from leaking. The S.A has apparatus to accomplish this. The first safety chamber and the second safety chamber are installed for this very purpose. They prevent the backflow of the garbage into the open space.

5.4 Interference with Normal Activity of other Satellites

The interaction of a satellite with the magnetic field of the earth and the ionized medium through which it is moving has been investigated. Owing to the differing incident velocities of ions and electrons and therefore differing incident flux intensities, a negative potential will be induced on the satellite, but it is smaller than has previously been believed. Satellite motion across the magnetic lines of the earth will induce a voltage on the satellite of as much as 0.2 volt per meter of satellite size, and this may affect the interpretation of measurements of satellite potential. The magnetic drag resulting from the induced currents is proportional to the cube of the satellite dimensions and may exceed the mass drag for satellites larger than 50 meters in diameter; this can occur only above 1200- km altitude, where the charge density exceeds the neutral density. Thus, the magnetically induced current is an insignificant cause of drag. Although some useful power can be extracted from the induced current, it is not a very promising source of auxiliary power for presently conceived vehicles.

5.5 Materials Suggested

- Nature of magnetic material used

1. Silicon steel is a soft ferromagnetic material which can be used as the electromagnet in the present case as it has less hysteresis loss.

2. This means that the efficiency of the electromagnet will be increased thus consumed relatively lesser fuel.

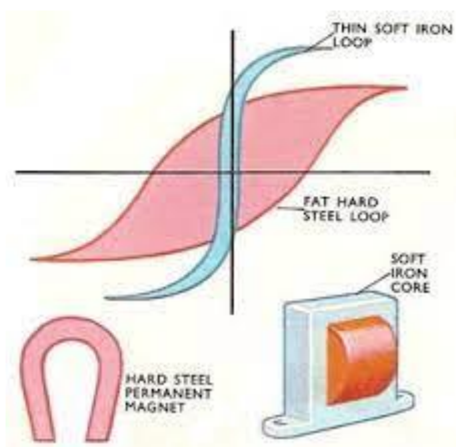


Fig. 5.1 Hysteresis curve for steel vs soft iron

- Material for Net

1. Aluminum alloys are strong, durable and malleable.
2. A storage net made of aluminum would hold the debris together as long as we need. There can be multiple layers of aluminum nets as well to ensure that the debris stays secured.

Material for Net

- Aluminum alloys are strong, durable and malleable.
- A storage net made of aluminum would hold the debris together as long as we need.
- There can be multiple layers of aluminum nets as well to ensure that the debris stays secured.

COMPONENT	STRUCTURE
Material	AA6061-T6
Thermal conductivity[W /(m.K)]	171
Specific heat[J/(kg.K)]	920
Density [kg/m3]	2700

SOURCE OF ALLOY NAMES:Journal of Advanced Research in Applied Sciences and Engineering Technology