

Space Debris

Mitigation, Remediation and Sustainability

Space debris

- What is space debris: Nonfunctional, Artificial objects in earth orbit including fragments and remnants of spacecrafts.
- Sources: Defunct Satellites, Rocket stages explosions/collisions, Paint flakes
- Threats: To operational Satellites, Space stations future space missions, Kessler syndrome.
- Impacts: Collisions, Interference with astronomical observations, disrupt communication signals, damage/destroy infra in space

Orbits and Debris

LEO	160 - 2,000 km
MEO	2000 - 35786 km
GEO	35,786 km.

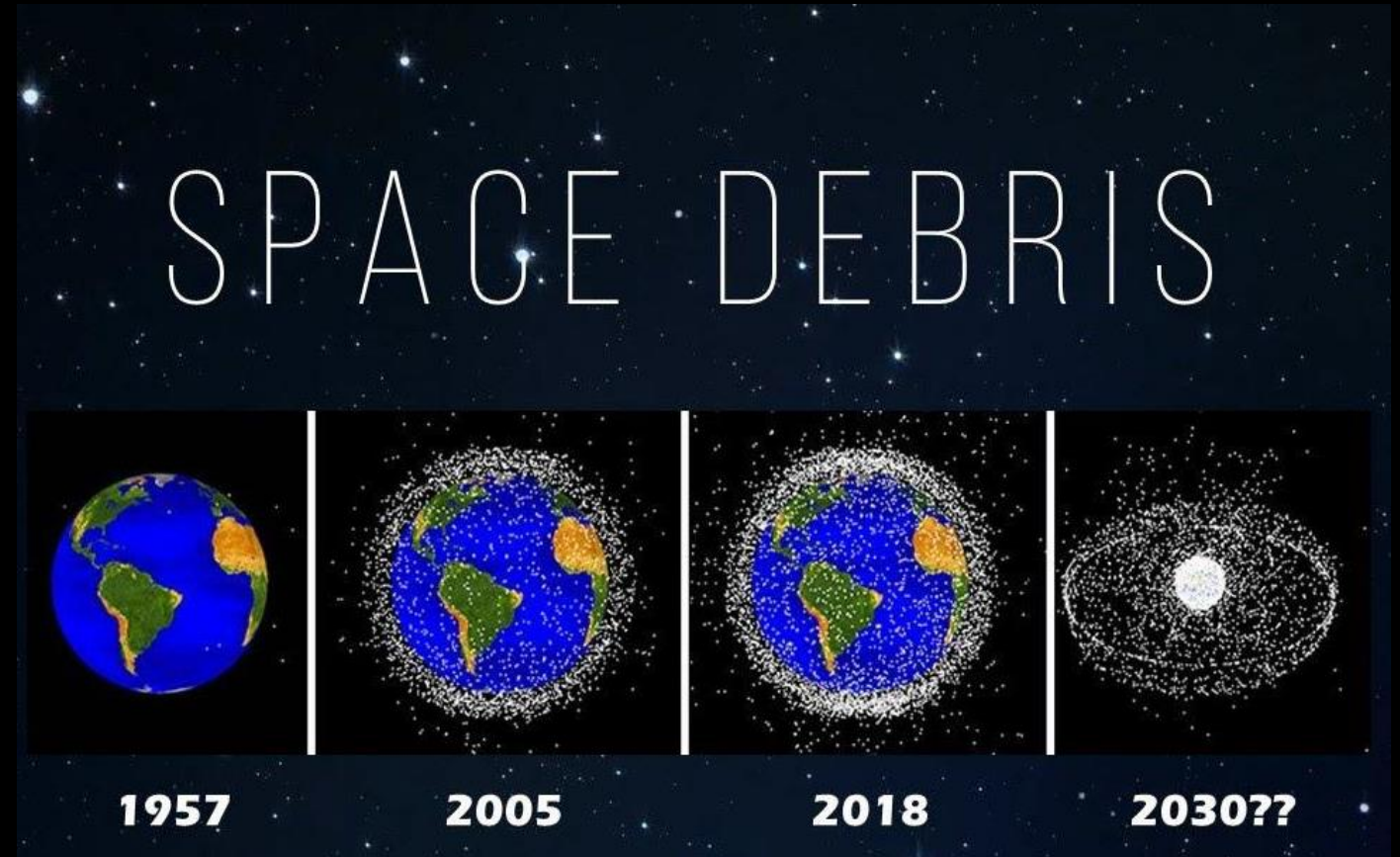
~36,000+

pieces of debris >10 cm

~1 million

pieces 1–10 cm

Over 130 million pieces <1 cm
(Only a fraction is trackable.)



Need for removing space debris

- **Protecting Active Satellites:** collision thus damage and failure
- **Ensuring Safe Human Space flights**
- **Maintaining the Use of Outer Space:** Removing space debris will ensure continued sustainability.
- **Cost-Effective:** Removing better than repairing or replacing damaged satellites.
- **Compliance with International Regulations:** We should comply with international agreements, Outer Space Treaty, prevention of harmful interference with other nations' activities in space.

Challenges of Space Debris

- **Tracking and Monitoring:** high speeds, small, tracking difficult
- **Debris removal:** Expensive and challenging
- **Mission failures:** due to collisions
- Unpredictive Debris behaviour during collisions
- Reducing the growth of Debris-needs International cooperation, Proper regulation and strict discipline
- Great threat to Human spacecraft as small pieces can cause great damage
- Who should be held responsible and bear the cost of removal

Natural decay of space debris

- **Atmospheric Drag**
 - **At LEO** with a thin atmosphere molecules create drag on objects, slowing them down and causing their orbit to decay and over time, this causes the debris to spiral downward.
- **Solar Activity (Solar Maxima)** every ~11 years increased solar radiation heats Earth's atmosphere, causing it to expand and then above phenomenon
- **Orbital Altitude**
 - **Below 600 km:** Debris may decay and re-enter the atmosphere within a few years.
 - **600–1,000 km:** Decay can take decades.
 - **Above 1,000 km:** Objects may remain in orbit for centuries or longer without active deorbiting.
- **Shape and Mass**
 - Larger, denser objects experience slower decay than lightweight, wide-area debris like insulation or solar panels.

Mitigation and Remediation Strategies

- **Debris Mitigation:** Proper designing to minimize debris. Post-mission disposal by deorbiting, incorporating better features for tracking
- **Active Debris Removal (ADR):** Robotic capture, electrodynamic tethers, and lasers etc.
- **Space Situational Awareness (SSA):** Developing robust SSA systems is crucial for tracking and monitoring space objects, predicting potential collisions, and enabling timely mitigation actions.
- **International Cooperation:** Addressing space debris requires global collaboration among space agencies, governments, and private companies. This includes sharing data, developing common standards, and coordinating efforts for debris removal.

Specific Focus areas

- **Tracking and Monitoring:** Advanced radar and optical tracking systems to track space debris, detection capabilities for smaller objects and objects in higher orbits.
- **Collision Avoidance:** Onboard propulsion systems and manoeuvring capabilities in satellites for collision avoidance. Development of Space traffic management systems to coordinate satellite movements and minimize the risk of collisions.
- **Debris Removal Technologies:** R&D in ADR technologies, robotic capture, electrodynamic tethers and laser ablation.
- **Space Debris Removal Optimization:** Formulating space debris removal using quantum computing

International Initiatives

- **RemoveDebris:** It is the European **Space Agency's** debris removal demonstration mission in the low Earth orbit (LEO) that aims to test and validate multiple active debris removal technologies.
- **e.Deorbit:** It is an **European Commission led** mission that aims to demonstrate the feasibility of capturing and deorbiting a non-functional satellite using a net and a harpoon.
- **DER:** It is NASA's Debris Elimination and Re-entry program aims to reduce the threat of re-entering debris and mitigate the growth of space debris.
- **IADC: Space Debris Mitigation Guidelines of the Inter-Agency Space Debris Coordination Committee ():** IADC's guidelines provide a set of best practices for reducing the generation of space debris and mitigating the impact of existing debris on operational spacecraft and infrastructure.

International Initiatives contd.

- **(JAXA):** It is **Japanese** Aerospace Exploration Agency's experiment to demonstrate the feasibility of capturing space debris using a device mounted on a spacecraft and to study the characteristics of space debris.
- **CNSA:** It is **China** National Space Administration's () to demonstrate the feasibility of cleaning up space debris using a combination of active and passive methods.
- **SDRS:** Space Debris Removal System It is a proposed mission by the **Russian** Space Agency (Roscosmos) to demonstrate the feasibility of removing space debris from low Earth orbit.
- **NASA's Space Debris Research:** NASA is actively involved in research on various aspects of space debris, including mitigation strategies, debris removal technologies, and the development of SSA systems.
- **ISS:** The International Space Station is deorbited at the end of its life, demonstrating a commitment to responsible space practices.

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(Environmental protection of the geostationary-satellite orbit)

- Minimizing the release of debris during satellite placement in the GSO region.
- Shortening the lifetime of debris in elliptical transfer orbits with apogees near GSO altitude.
- Removing GSO Satellites at the end of their life to a "graveyard orbit" (a perigee no less than 200 km above the GSO altitude)
- Carrying out disposal
- Passivating satellites at the end of life (e.g., venting residual propellants, depleting pressurants, safing batteries) to prevent explosions.

India's efforts

- **ISRO's Project Netra:** India's space agency, ISRO, has launched Project Netra, an early warning system for detecting debris and other threats to Indian satellites.
- ISRO is a member of Inter-Agency Space Debris Coordination Committee (IADC), IAA Space Debris Committee, International Astronautical Federation (IAF) STM Committee, ISO working group 7
- India following to maximum extent the UN/IADC guidelines for space debris mitigation and UN adopted guidelines for long-term sustainability of outer space activities.

Post mission Disposal of Indian GEO satellites

- General Strategy
 - Orbit raising with alternate burns at perigee and apogee (ensures nearly circular intermediate orbits)
 - On achieving intended graveyard orbit, expend residual fuel by inclination change, if needed
 - Final venting and electrical passivation

Spacecraft	Date of launch	Decommissioning Date	Apogee Height (km) above GEO	Perigee Height (km) above GEO
INSAT-2DT	26-Feb-92	24-Aug-04	369	314
GSAT-3	20-Sep-04	01-Oct-10	289	285
KALPANA-1	12-Sep-02	01-Feb-18	570	530
INSAT-4A	22-Dec-05	23-Oct-19	296	286
INSAT-4CR	02-Sep-07	26-Nov-20	300	293
INSAT-4B	12-Mar-07	05-Nov-20	388	297
GSAT-12	15-Jul-11	23-Mar-23	394	407

Way forward

- **Raise Awareness:** To inform policymakers, industry leaders, and the public about the growing problem of space debris and its potential consequences.
- **Promote Action:** To advocate for increased investment in debris mitigation and removal technologies and for stronger international cooperation.
- **Encourage Innovation:** To foster research and development in space debris technologies and to promote sustainable space operations.

Thank You.