On-Orbit Servicing, Active Debris Removal, and Related Activities

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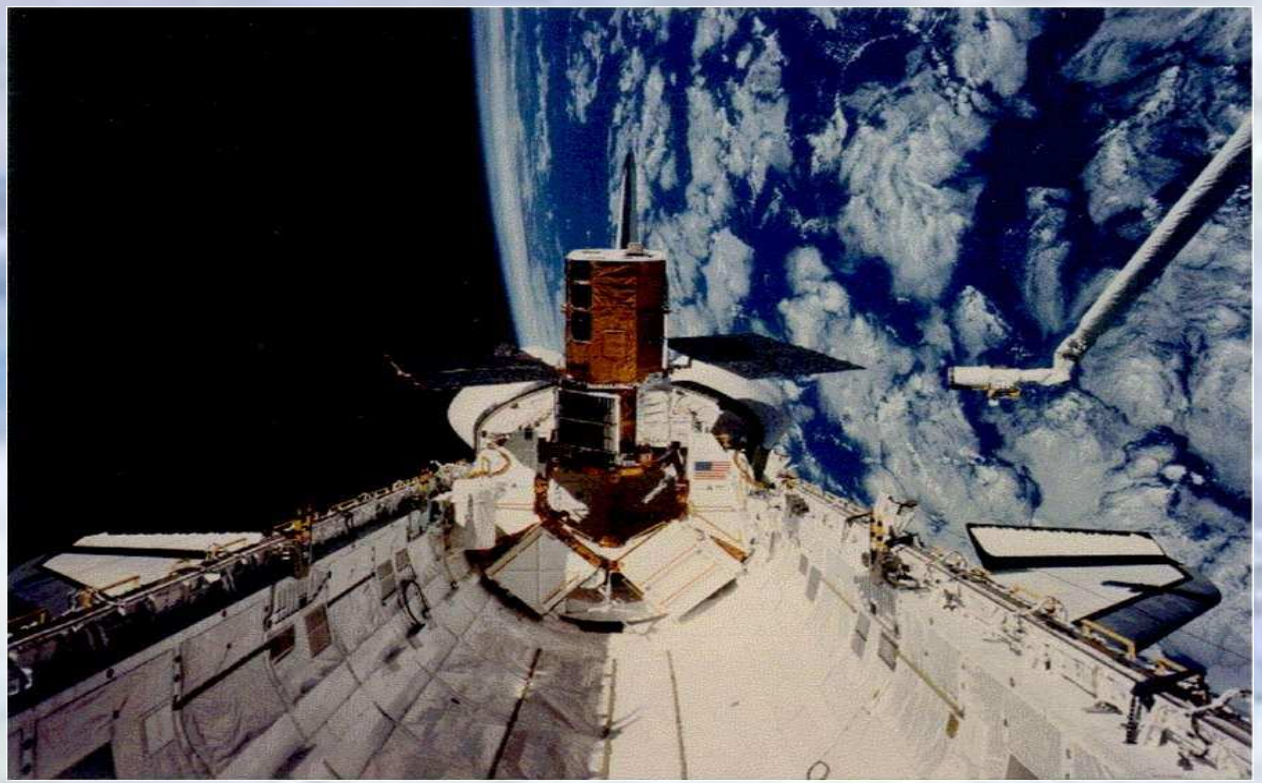
October 02, 2022

On-Orbit Servicing

On-Orbit Servicing - History

- The first servicing mission was done by NASA for the SolarMax research satellite in 1984, through a manned mission onboard Space Shuttle.



Source: https://www.airuniversity.af.edu/Wild-Blue-Yonder/Article-Display/Article/2538269/satellite-servicing-a-history-the-impact-to-the-space-force-and-the-logistics-b/

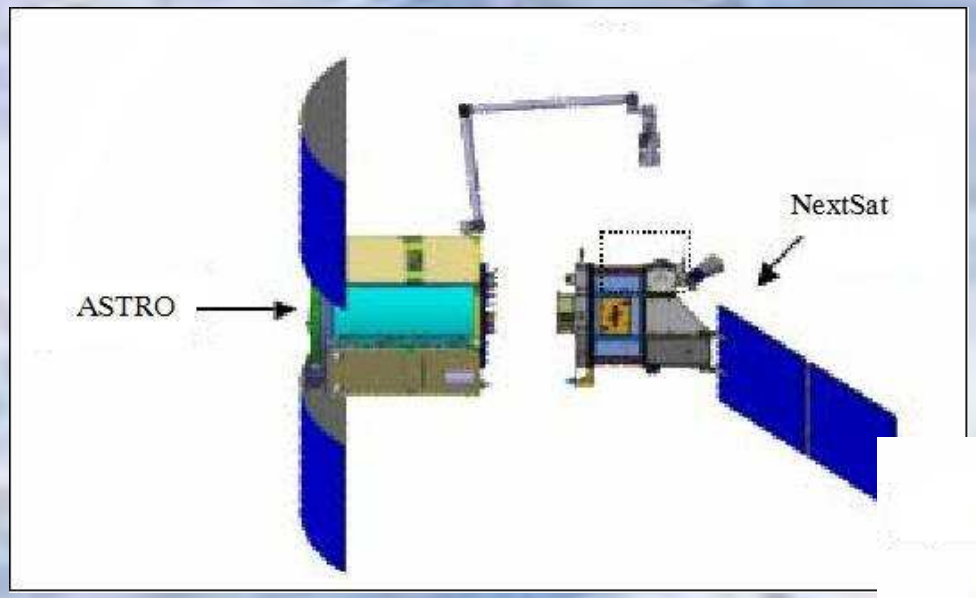
Launch & Return Capability (1984)

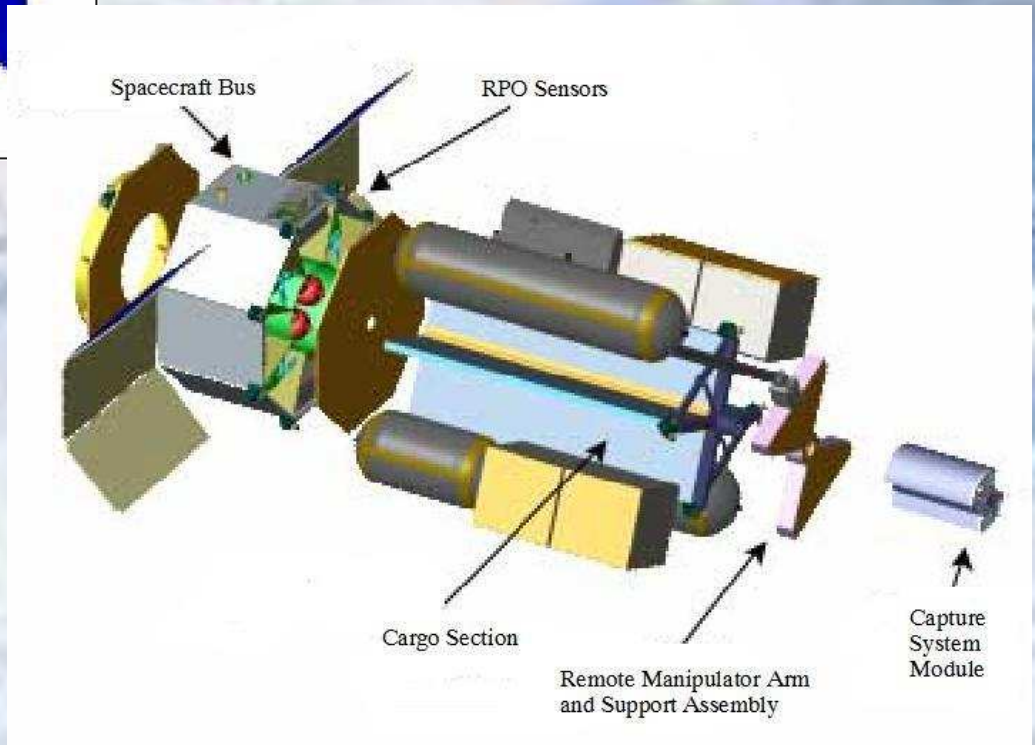
- STS-41B, in Feb 1984, successfully deployed two communications satellites from Space Shuttle Challenger's cargo bay – Westar 6 for Western Union and Palapa B2 for Indonesia. The Payload Assist Module (PAM) upper stages of both satellites malfunctioned, leaving them in non-useable 160-by-600-mile high orbits instead of the intended 22,300-mile high geostationary orbits required for their normal operations.
- STS-51A mission in November 1984.NASA retrieved the satellites during Extravehicular Activities (EVAs) or spacewalks using the jetpack known as the Manned Maneuvering Unit (MMU), after which the shuttle's Canadian-built Remote Manipulator System (RMS) or robot arm would grapple them and place them into the cargo bay for return to Earth.
- Satellites were again relaunched through other missions.

On-Orbit Servicing – Continuation

- 1990 – Repair of Hubble Space Telescope to correct for a spherical aberration in the optical path, and also to update electronics and sensors on the telescope.
- Subsquently, DARPA* initiated a number of technology development/ demonstration projects relating to on-orbit servicing. (*Defense Advanced Research Projects Agency, USA) in early 2000.
- Autonomous orbit matching (XSS 10 & XSS11 in 2003 & 2005), Demonstration of Autonomous Rendezvous Technology (DART) – Unsuccessful, due to a sensor problem.
- Orbital Express Program: A DARPA program, with partnership from the Air Force and NASA, to demonstrate autonomous refuelling and servicing. Orbital Express was composed of two satellites, ASTRO and NextSat that were launched together on STP-1 in 2007. Autonomous rendezvous and docking, on-orbit fuelling, swapping a battery and changing a flight computer were successfully performed

Orbital Express : NAXSAT- ASTRO





Consortium for Execution of Rendezvous and Servicing Operations (CONFERS), USA

- Few small business industries were working on development and demonstration of on on-orbit servicing technologies with funding support from DARPA, USA.
- Due to lack of industry standards and organizations in this area, DARPA to create an organization called the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS).
- It was conceived as an organization that would be industry led with the goal to leverage best practices that have been developed in government and industry.
- It also aimed to generate standards for on-orbit servicing and rendezvous and proximity operations.
- CONFERS also initiated to start a Global Satellite Servicing Forum to exchange technical information.

CONFERS .. *Contd.*

DEPARTMENT OF JUSTICE - Antitrust Division

(Notice Pursuant to the National Cooperative Research and Production Act of 1993—Consortium for Execution of Rendezvous and Servicing Operations)

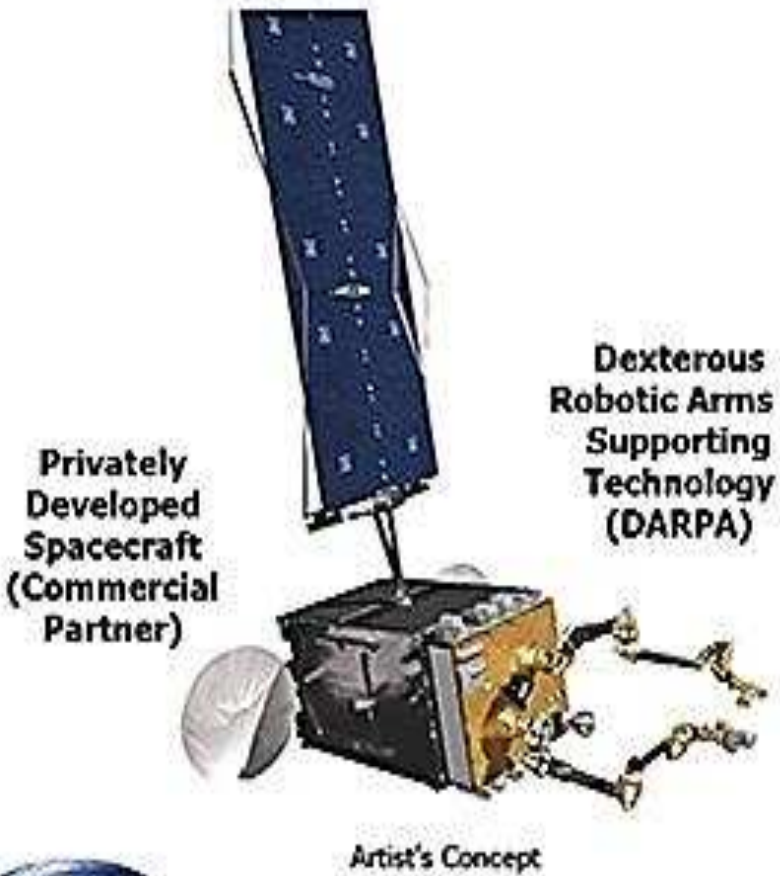
- **Notice is hereby given that, on September 10, 2018, … …. Consortium for Execution of Rendezvous and Servicing Operations (''CONFERS'') has filed written notifications simultaneously with the Attorney General and the Federal Trade Commission disclosing (1) the identities of the parties to the venture and (2) the nature and objectives of the venture.**
- **Parties to the venture are: Altius Space Machines, Inc., Broomfield, CO; Analytical Graphics, Inc., Exton, PA; Astroscale PTE. LTD., Tokyo, JAPAN; Ball Aerospace and Technology Corp., Boulder, CO; Chandah Space Technologies, Houston, TX; Hoffer Flow Controls, Inc. Elizabeth City, NC; iBOSS gmbH, Aachen, GERMANY; MacDonald, Dettwiler and Associates, Inc., Brampton, Ontario, CANADA; ThalesAlenia Space, Courbevioe, FRANCE; The Aerospace Corporation, El Segundo, CA; and XL Catlin, LLC, New York, NY.**

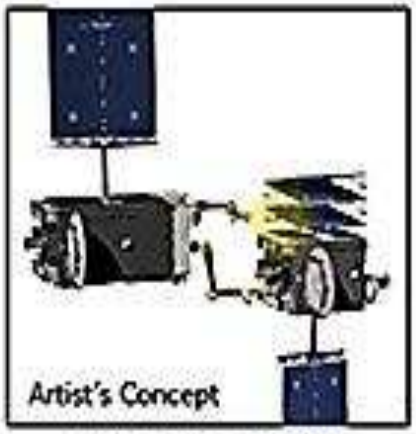
Source: Federal Register / Vol. 83, No. 203 / Friday, October 19, 2018 / Notices

Robotic Servicing of Geosynchronous Satellites (RSGS)

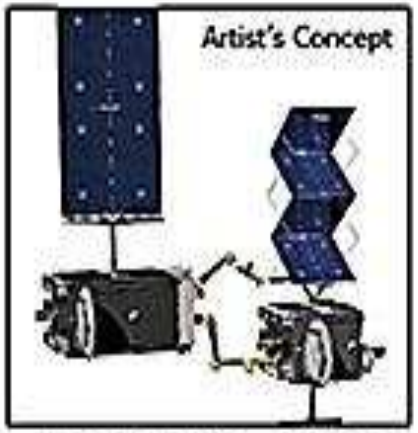
- DARPA's Robotic Servicing of Geosynchronous Satellites (RSGS) program is intended to develop technologies that would enable cooperative inspection and servicing in GEO and demonstrating those technologies on orbit.
- Under the RSGS vision, a DARPA-developed modular toolkit, including hardware and software, would be joined to a privately developed spacecraft to create a commercially owned and operated robotic servicing vehicle (RSV) that could make house calls in space.

Robotic Servicing Vehicle (RSV) & Envisioned Missions

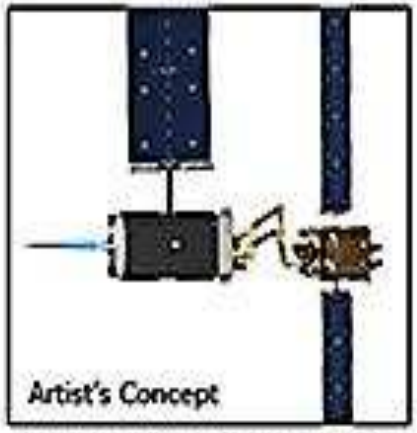




High-Resolution Inspection



Anomaly Correction



Cooperative Relocation

Upgrade Installation

Source: https://www.darpa.mil/program/robotic-servicing-of-geosynchronous-satellites

INTELSAT 901 Recovery (2001)

- **INTELSAT 901 launched on 11 June 2001; Healthy, but Ran out of fuel.**
- **MEV-1 (Mission Extension Vehicle) was launched in October, 2019 by Northrop Grumman. MEV 1 spent three months traveling to Intelsat 901, which had been placed in a "graveyard" orbit.**
- **In February 2020, the MEV-1 mission made history when the spacecraft successfully snagged Intelsat 901 with an onboard grappling device — marking the first time that two commercial satellites had ever docked in orbit. With the two satellites acting as one, MEV-1 then moved Intelsat 901 to its new location, and on April 2nd, 2020.**
- **Subsequently, A new company 'SpaceLogistics', a wholly owned subsidiary of Northrop Grumman, was established. It provides cooperative space logistics and in-orbit satellite servicing to geosynchronous satellite operators using its fleet of commercial servicing vehicles—the Mission Extension Vehicle, the Mission Robotic Vehicle and the Mission Extension Pods.**

Source: https://www.theverge.com/2020/4/17/21224896/satellite-servicing-northrop-grumman-mev-1-intelsat-901

Intesat 903 recovery Videos

- https://www.intelsat.com/global-network/satellite-network/launches/intelsat-901/

- https://youtu.be/_rgglvA5DdI

Active Debris Removal

Outer Space Environment

- **Congested**
  - More than 5700 space launches have placed more than 9000 satellites in orbit since 1957
  - More than 2700 operating satellites in space – Civil, Military and Commercial purposes.
- **Contested**
  - Military Uses of Outer Space is tending towards weaponization
  - Demonstration of Counter space capabilities
  - Space Security and Sustainability under threat
- **Competed**
  - More than 40 nations on full-fledged space activities
  - More than 100 nations engaged in space systems and services
  - Emerging trends of Commercial use of outer space by Govt and Private Sector
- **Effect**
  - Uncontrollable Growth of Space Debris Population -A Major Threat to Sustainability of Outer Space Activities for Peaceful Purposes

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Space Debris

- **Space debris is defined as all non-functional, human-made objects, including fragments and elements thereof, in Earth orbit or re-entering into Earth's atmosphere.** ***(ESA)***

(https://www.esa.int/Safety_Security/Space_Debris/FAQ_Frequently_asked_questions)

- **Orbital debris is any man-made object in orbit about Earth which no longer serves a useful purpose.** ***(NASA)***

(https://www.nasa.gov/news/debris_faq.html)

- **In low Earth orbit (2,000 km), orbital debris circle the Earth at speeds of between 7 to 8 km/s. However, the average impact speed of orbital debris with another space object will be approximately 10 km/s.**

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Kessler's Syndrome

- The Kessler syndrome is a theory proposed by NASA scientist Donald J. Kessler in 1978, used to describe a self-sustaining cascading collision of space debris in LEO.
- It refers to a scenario in which the density of objects in Low Earth Orbit (LEO) is high enough that collisions between objects could cause a cascade where each collision generates space debris that increases the likelihood of further collisions.
- Implication is that the distribution of debris in low earth orbit would seriously affect space activities
  - Ultimately the use of outer space through the satellites in low earth orbital ranges would become impractical for many generations.

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Sources of Space Debris

- Mission related - Satellites, Rocket bodies
- Accidental – Satellite break-ups, On-Orbit Collisions, Drop-outs from astronaut's extra-vehicular activities
- Intentional or Avoidable – ASAT tests, Intentional Destructions, Abandonment of space objects in LEO, launching of Space Objects non-compliant to UN debris mitigation measures, micro and small satellites … …

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Space Debris in motion

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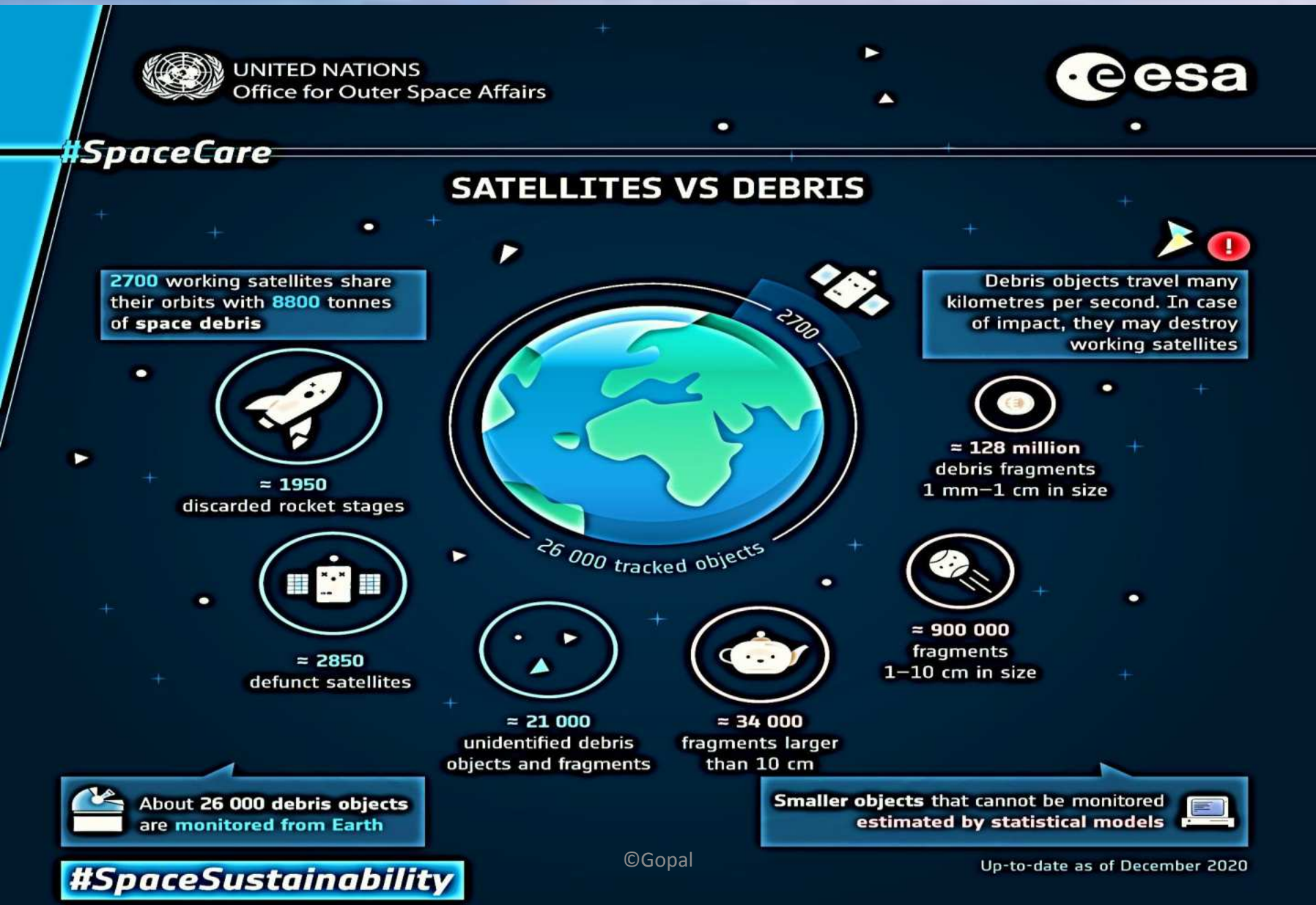
UNITED NATIONS
Office for Outer Space Affairs
esa
#SpaceCare
SATELLITES VS DEBRIS
2700 working satellites share their orbits with 8800 tonnes of space debris
Debris objects travel many kilometres per second. In case of impact, they may destroy working satellites
2700
26 000 tracked objects
≈ 1950
discarded rocket stages
≈ 128 million
debris fragments
1 mm–1 cm in size
≈ 2850
defunct satellites
≈ 900 000
fragments
1–10 cm in size
≈ 21 000
unidentified debris objects and fragments
≈ 34 000
fragments larger than 10 cm
About 26 000 debris objects are monitored from Earth
Smaller objects that cannot be monitored estimated by statistical models
#SpaceSustainability
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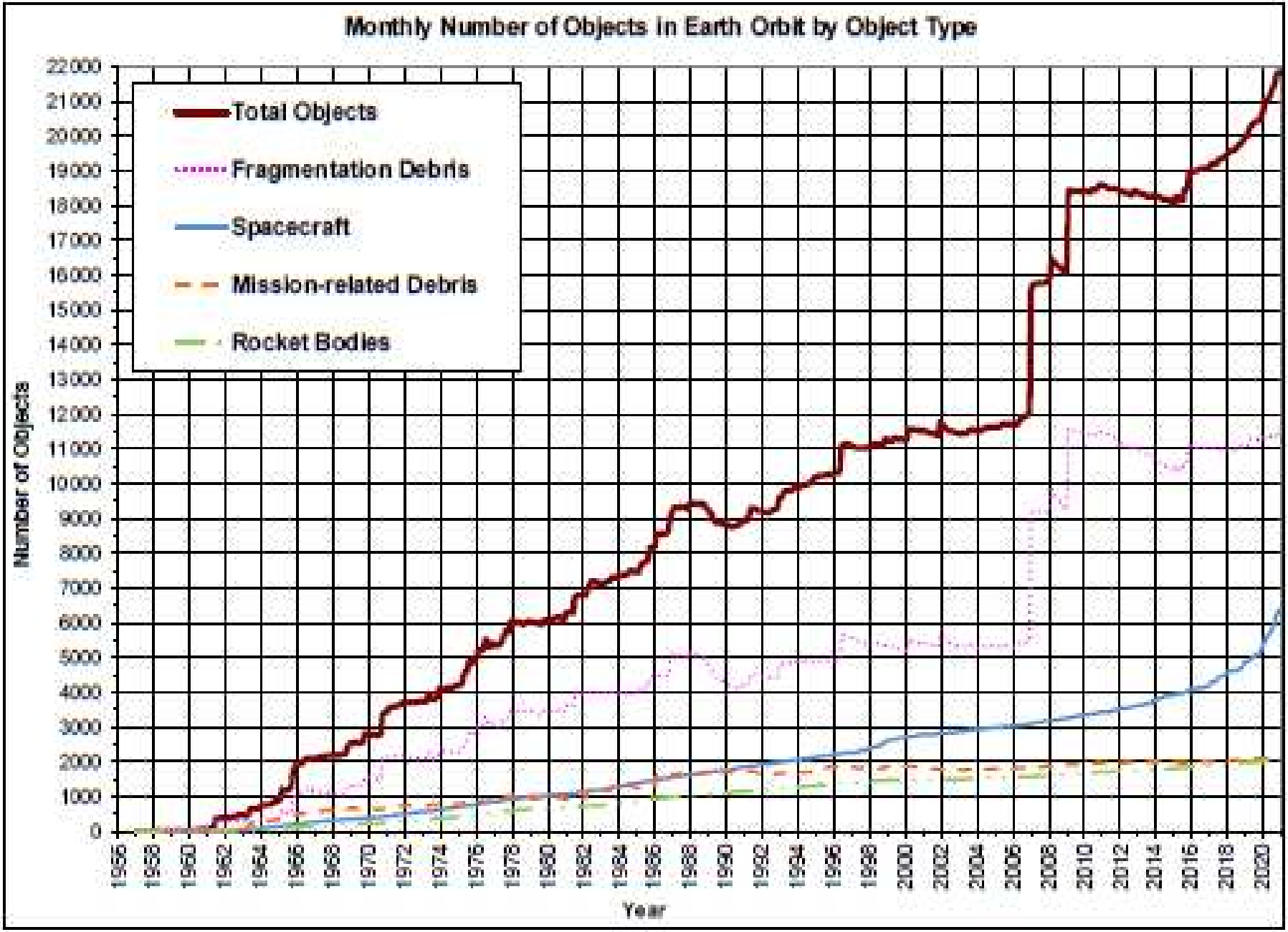
Up-to-date as of December 2020



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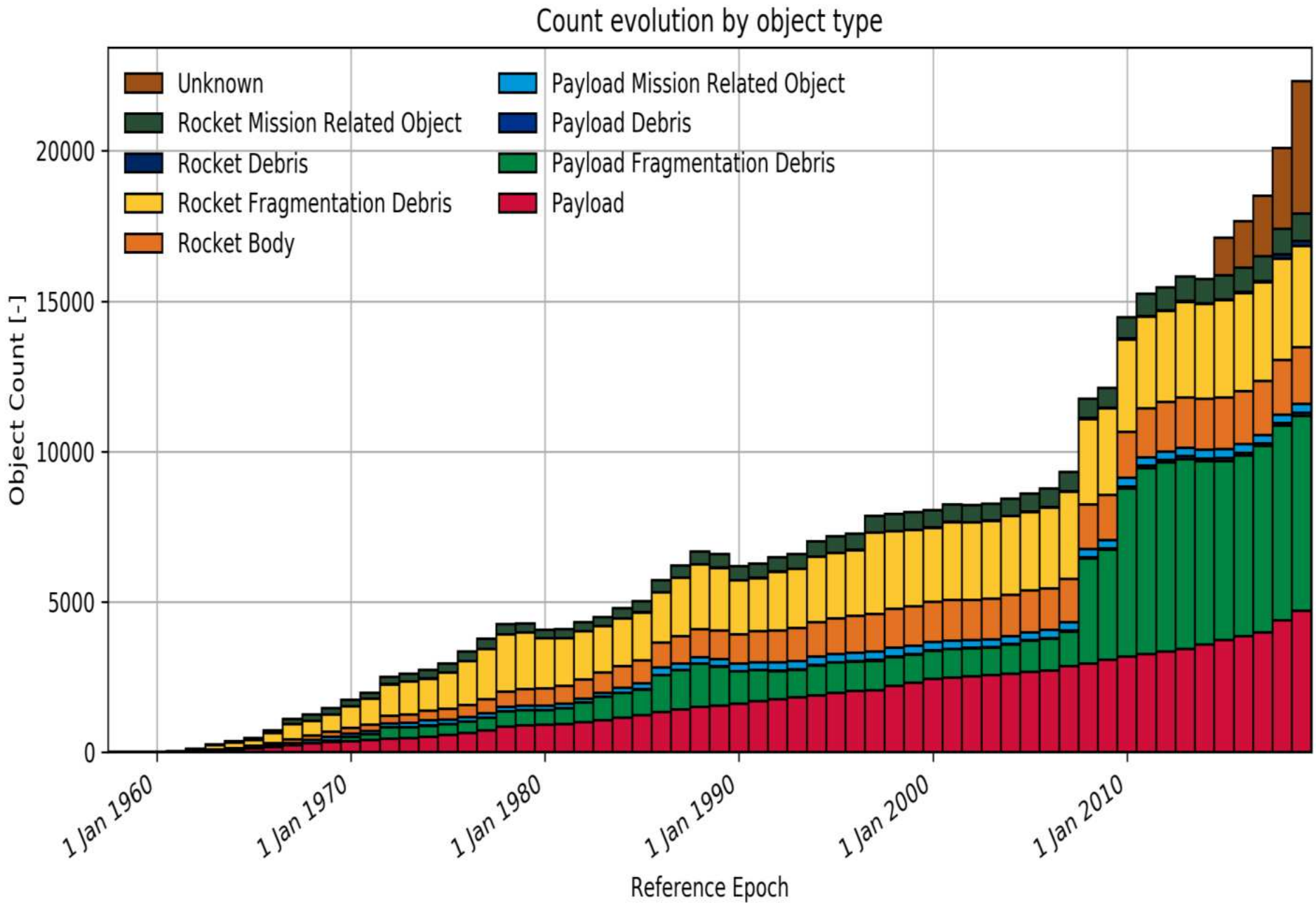
Orbital Debris- Quarterly news- Feb 2021- NASA



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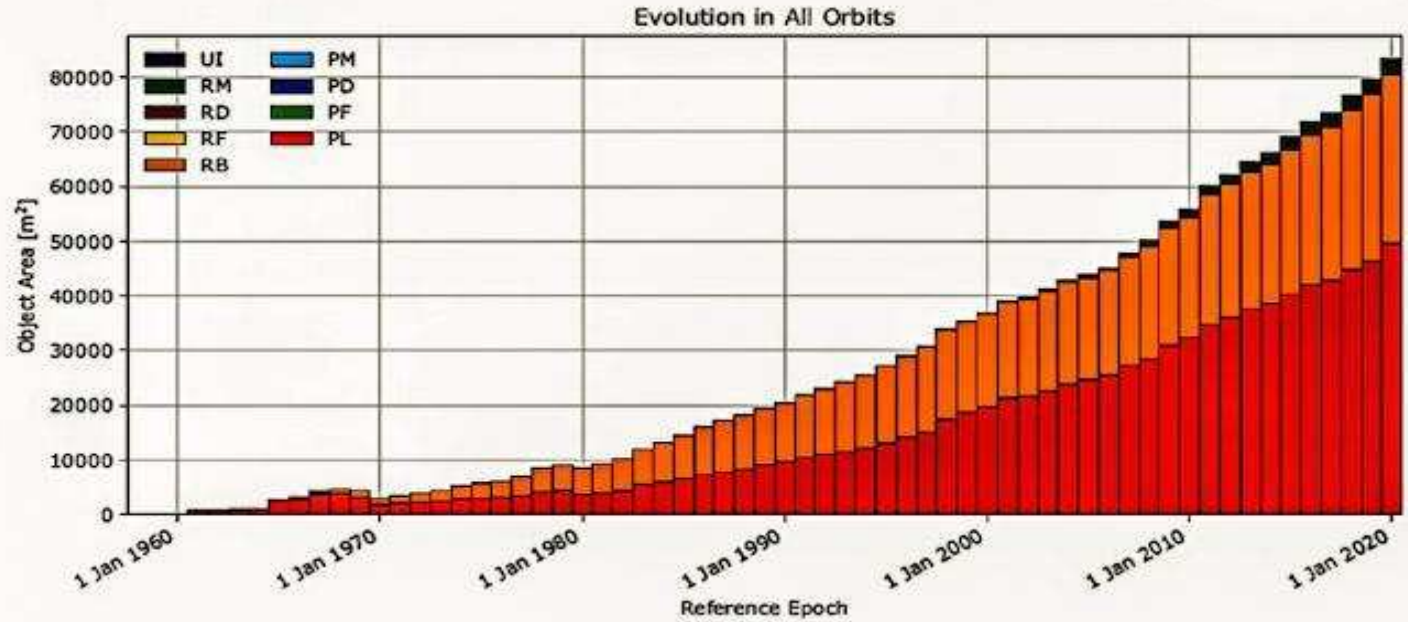
Source: ESA- Space Debris Office

Growth of Space Debris- Evolution of Area



(c) Evolution of area.

Image:

The objects we sent to orbit take up space, as does the debris they create. The increasing area of objects in space dramatically increases the likelihood of collisions.

Red (PL) = Payload;
Orange (RB) = Rocket body;
Dark Green (RM) = Rocket mission related object;
UI = Unidentified;
RD = Rocket debris;
RF = Rocket fragmentation debris;
PM = Payload mission related object;
PD = Payload debris;
PF = Payload fragmentation debris

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The History of Space Debris Creation

UNITED NATIONS
Office for Outer Space Affairs

esa

THE HISTORY OF SPACE DEBRIS CREATION

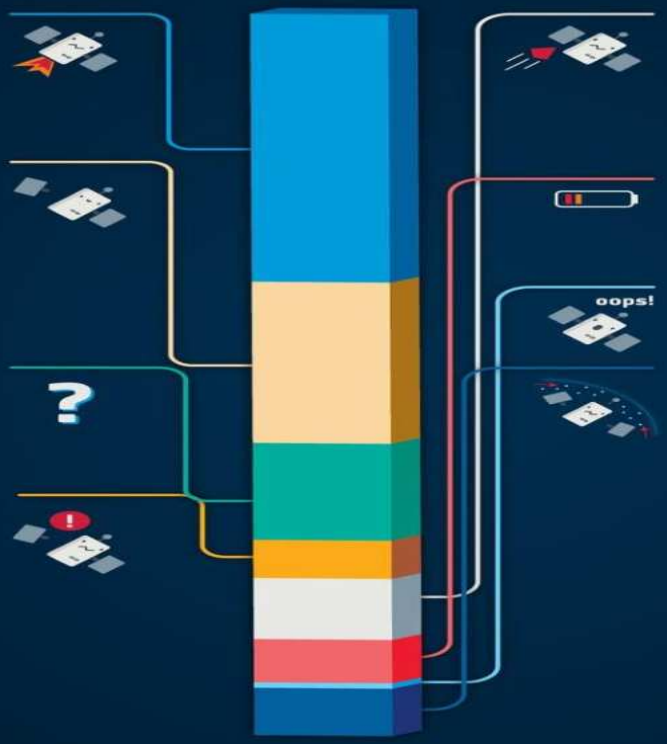
Since the beginning of the space age, there have been **more than 550 confirmed "fragmentation events"** in Earth orbit. Such events have various causes, and some are responsible for creating far greater **quantities of debris** than others.

PROPULSION — 39.52%
Energy left undisposed of on-board a satellite or rocket body can lead to **accidental explosions**, for example due to heat stress.

DELIBERATE — 23.77%
All **intentional breakup events**, e.g. satellites designed to explode if atmospheric re-entry went wrong or detonated as standard procedure once the mission ended, as well as military tests.

UNKNOWN - 14.29%
Assigned whenever there is **insufficient evidence** to support a more specific classification.

ANOMALOUS — 5.64%
Unplanned separation of one or more detectable objects from a satellite that remains essentially intact, e.g. objects shedding due to material degradation such as insulation material or solar panels.



COLLISION — 9.01%
There have been **several collisions observed** between known objects. In some cases, the impactor is too small to be observed, but changes in the orientation and functioning of the satellite indicate an impact has occurred.

ELECTRICAL — 6.4%
Events related to **failures in electrical subsystems**, most due to overcharged batteries exploding.

ACCIDENTAL — 0.8%
Design flaws ultimately leading to breakups.

AERODYNAMICS — 0.56%
A breakup most often caused when **atmospheric drag leads to "overpressure".**

Thanks to current knowledge and technological development, there will likely be far **fewer propellant-fuelled explosions in the future.** However, with space traffic increasing, the number of **in-space collisions are bound to rise.**

Debris mitigation rules require satellites to be 'passivated' at the end of their life. **ESA is developing technologies to passivate** electrical and propulsion systems, reducing debris creation.

Up-to-date as of December 2020

#SpaceSustainability

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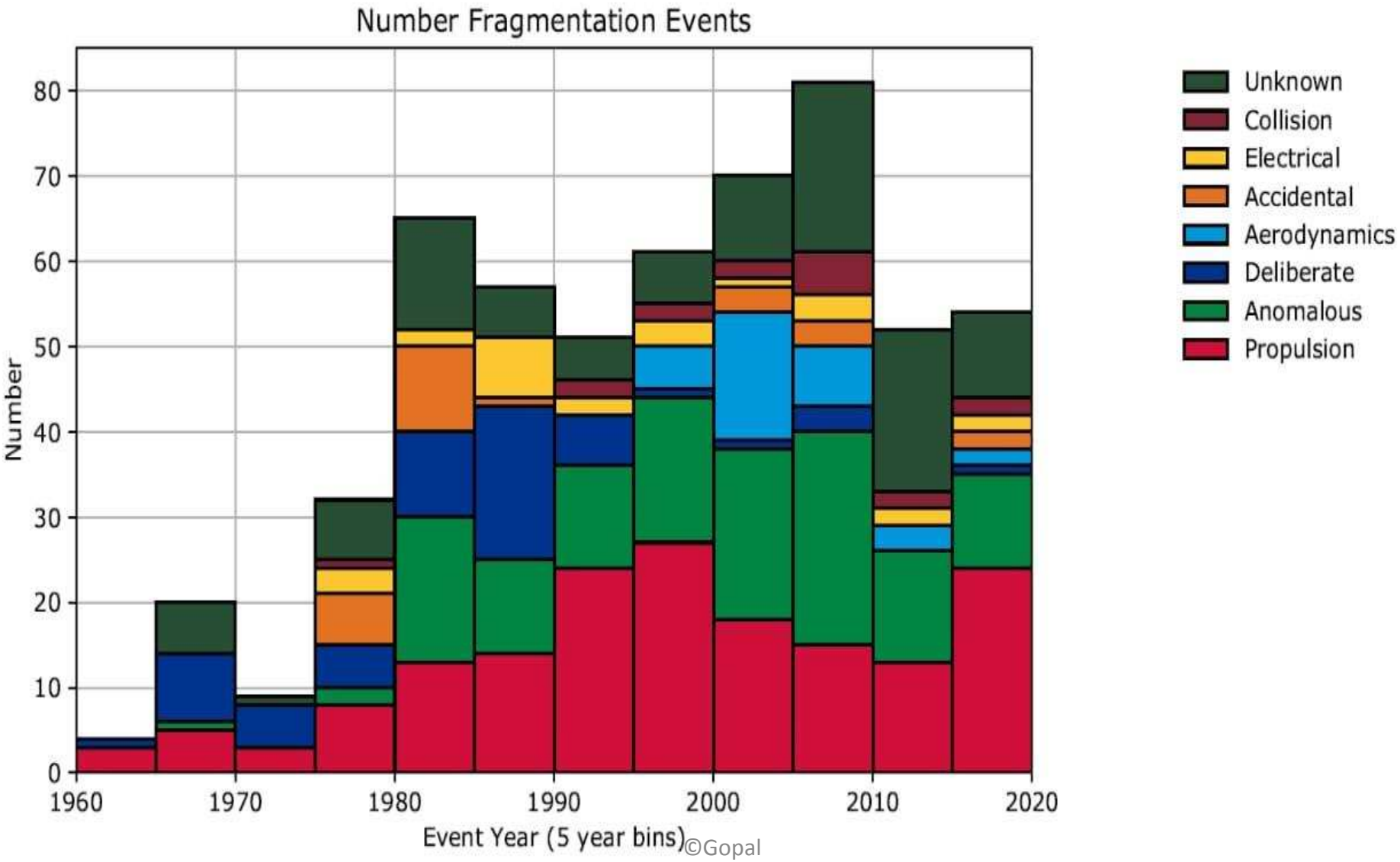
#SpaceCare

Number of Fragmentation Events



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Source: ESA- Space Debris Office

Evolution of Space Debris Mitigation Measures

- **Liberal dumping space debris - initial phase space players - Unaware of consequences -*Late realization***
- **Bilateral discussions initiated in 1986; Call for international cooperation in 1988**
- **UN General Assembly Resolution (48/39) in 1993 on International Cooperation- *concern on space debris***
- **Formation of IADC- 1993.**
- **UNCOPUOS STSC – Agenda on Space Debris in 1994**
- **International Law Commission – Resolution on space debris- 1994.**
- **IADC Guidelines on Space Debris Mitigation of 2002 – Introduced in STSC of UNCOPUOS- Adopted in 2007**
- **Adopted through a UN General Assembly Resolution (No.62/217) – December 2007 – *Legal Sanctity is a question ?***

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Space Debris Mitigation Guidelines

- **United Nations Space Debris Mitigation Measures Guidelines – 7 Guidelines**
  - **Limit Debris released during normal operations**
  - **Minimize the potential for break-ups**
  - **Limit probability of accidental collisions in orbit**
  - **Avoidance of intentional destructions**
  - **Minimize potential for post-mission break-ups**
  - **Limit long term presence of space objects after EOL**
  - **Limit long-term interference of space objects with GEO region at EOL**
- **Effectiveness of Mitigation Guidelines**
  - **Soft Law - For voluntary implementation -Legally Non -Binding**
  - **Offers neither incentives for compliance nor penalty for non-compliance**
  - **Not effective to control the existing debris population – *Kessler Effect***

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Space Debris – *Remedial Measures*

- **Alternate Measures**
  - **Active Removal of Debris**
  - **On-Orbit Satellite Servicing**
- **Challenges**
  - **Technology – Development – Demonstration**
  - **High Cost – Sharing - International co-operation**
  - **Policy – Consensus – Willingness**
  - **Legal – Liability – Dispute Settlement**

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Space Debris – *Legal Issues*

- **Definitional issues**
  - **Space Object *Vs.* Space Debris : Functional *Vs*. Non-Functional**
- **Liability**
  - **Article VII of OST – Liability for damages**
  - **Article II & III of Liability Convention- Absolute and fault based liability**
- **State Responsibility**
  - **Article VI of OST – Internationally responsible for outer space activities- No Bar on Government or Non-Governmental activities**
  - **Article-VIII of OST- Jurisdiction and Control over space objects**
  - **Article-IX of OST – Due regards to interests of other states**

Active Debris Removal (ADR) – Legal Issues.

- **Declaration of a Space Object as Space Debris**
  - Technical attempts for retrieval
  - Economic aspects – Cost of investment Vs. Returns through extended services
  - Past Experiences – Successful retrieval of spacecraft - Palapa B2, Galaxy -15, GOES-13
- **Abandonment of space objects**
  - State Responsibility – Art. VI of OST
  - Due Regards to Others interests – Art. IX of OST
  - Dereliction of ownership responsibility - Jurisdiction & Control - Art. VIII of OST
  - State Responsibility for Wrongful Act

Active Debris Removal (ADR) – Legal Issues.

- **Technology Controls**
  - **Dual-Use Nature of Space Technology & applications**
- **Access to or Recovery of Abandoned space objects of one state by other technically competent state**
  - **Exposure of Systems, Technologies, Stored Data ...**
  - **Control Regimes- MTCR, Wassenaar Arrangement**
  - **Salvage value**
  - **Breach of Intellectual Property Rights**
  - **Motive for Removal – Operational Necessity or Self Defence or Intentional**
- **Liability for Accidents during removal or recovery operations**

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ADR Techniques - *Technological Aspects*

- **For Objects < 10 cm**
  - **Space based lasers for orbit lowering and Re-entry – High cost**
  - **Post Mission Disposal Techniques – Viable**
- **For Objects : > 10 cm in LEO or >1 M in GEO**
  - **Electro Dynamic Tether, Attaching de-boost motor, Inflating balloon (LEO)**
  - **Adding device to increase Drag, Deploying reusable tugs etc.**
  - **Expertise in Robotic Technology warranted – *Location of objects, close monitoring, tracking, rendezvous, capturing, dragging and disposal***
  - **High Technology Oriented and High Cost oriented**

Active Debris Removal Technologies

- The RemoveDEBRIS platform developed by a technical team led by Surrey Space Centre at the University of Surrey, UK was launched to the International Space Station by Space X rocket in 2018.
- RemoveDEBRIS carried out a test of its onboard vision-based navigation (VBN) system on Sunday 28 October, 2018.
- The test saw the RemoveDEBRIS spacecraft release a target cubesat and then take images of the descending object and its surroundings using its flash LiDAR and colour camera – providing accurate information vital for measuring distance, direction and speed of space debris.

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Video Link: https://www.bbc.com/news/science-environment-

Principle of Common but Differentiated Responsibility (CDR) - *Kyoto Protocol*

- **United Nations Framework Convention on Climate Change – Kyoto Protocol**
- **Salient Features**
  - **Differential caps on green house gas emissions**
  - **Cluster of countries as single entity**
  - **Clean Development Mechanism (CDM)**
  - **Joint Implementation (JI) projects/ mechanism (JIM)**
  - **Carbon Credits & Trading etc.**

Principle of Common but Differentiated Responsibility (CDR) - *Debris Mitigation*

- **Proposed CDR Principle in respect of Space Debris Mitigation ***
  - *'the debris population is proportional to number of launches carried out by each country in the past; hence large responsibility lies with the countries that have performed more number of launches, than the countries that have performed less number of launches or countries that are yet to perform any launches'.*

**** Dr. M.Y.S. Prasad, and Dr. Rajeev Lochan- 'Common But Differentiated Responsibility – A Principle to maintain space environment with respect space debris'- IAC -07-E.56.3.07***

CDR Principle - *Debris Mitigation* *… Contd..*

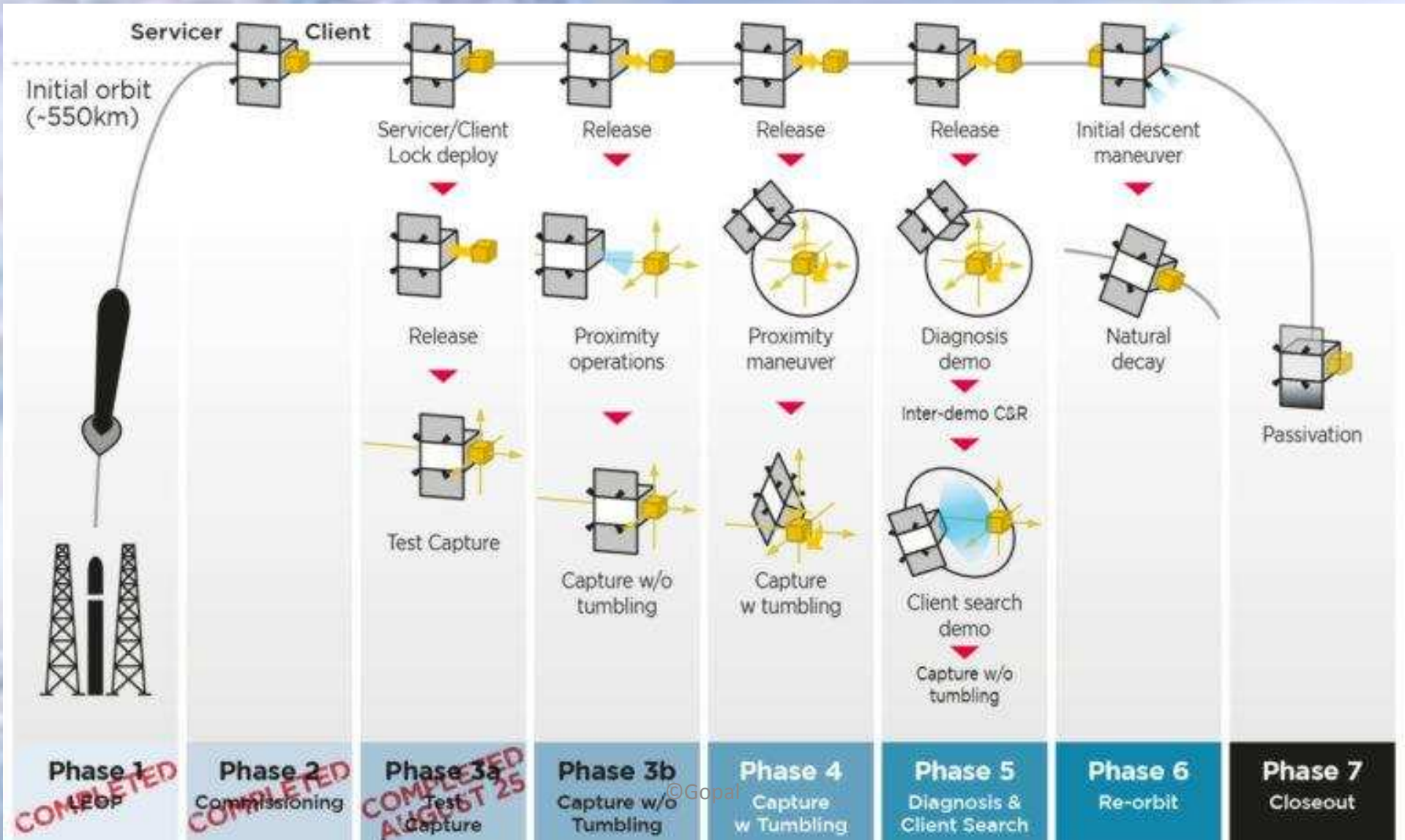
- **Factors proposed**
  - i. **To limit the future space debris generation, fixing launch quota caps**
  - ii. **Rewarding with 'Debris Credits' on implementation of mitigation guidelines**
  - iii. **Exchange of Debris Credits between countries on need basis**
  - iv. **Provision of fixed quota of Debris Credits for countries which are yet take up space activities**
  - v. **Creation of a Trust Fund to compensate damages caused to victims, with the contributions of funds by countries proportionate to the debris generated by them**
  - vi. **Special treatment for countries willing to share their knowledge and technology in the area of space debris etc.**

Active Debris Removal Technologies- ELSA-D

- M/s. ASTROSCALE, Japan/ USA, Launched a satellite, for providing retrieval services for satellite operators.
- End-of –Life Services by Astroscale – Demonstration (ELSA-D) on Mar 22, 2021
- ELSA-D consists of two spacecraft: a servicer satellite (~175kg) and a client satellite (~17kg), launched stacked together.
- The servicer satellite has been developed to safely remove debris objects from orbit, equipped with proximity rendezvous technologies and a magnetic docking mechanism. The client satellite is a piece of replica debris fitted with a ferromagnetic plate that enables the docking.
- The servicer will repeatedly release and dock with the client in a series of technical demonstrations, proving the capability to find and dock with defunct satellites and other debris. Demonstrations include client search, client inspection, client rendezvous, and both non-tumbling and tumbling docking

ASTROSCALE Demonstration Video link https://youtu.be/Po1BobDOjG8

ELSA-D Demonstration Techniques



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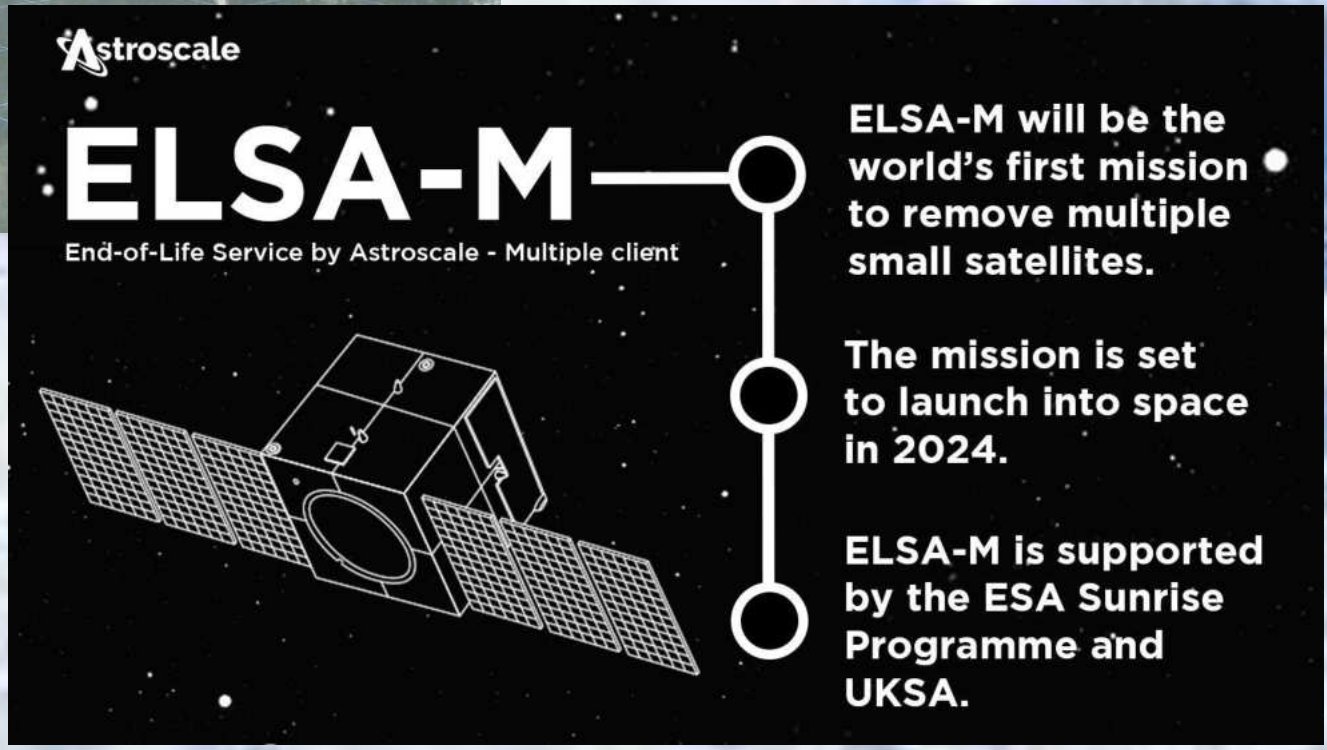
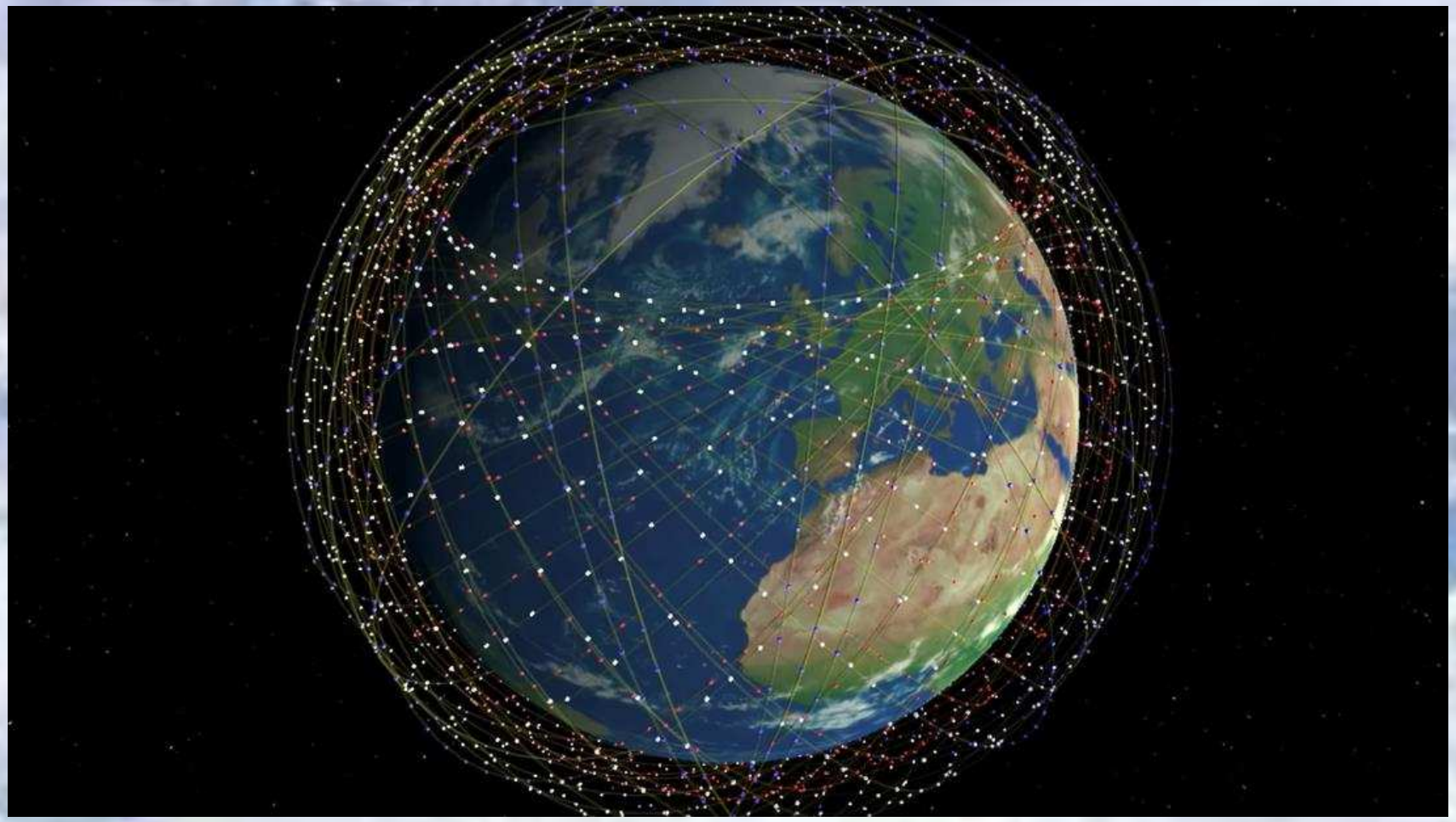
ELSA- D - Test Mission Completion & Further

On May 04, 2022,Astroscale's ELSA-D Mission Successfully Completed Complex Rendezvous Operation



Proposed Starlink Satellite Constellation



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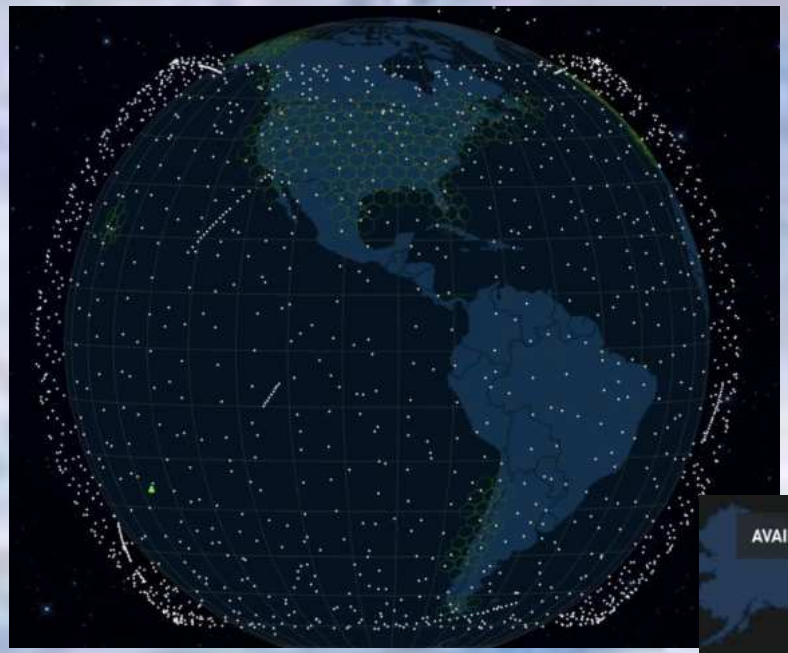
Real Time View of Starlink Satellites



Starlink is permitted to operate in about 25 countries. There are bureaucratic and regulatory delays getting permission to sell and provide services in countries like India.

Source: https://www.nextbigfuture.com/2022/06/real-time-view-of-starlink-satellites.html

Space Traffic Management

- **European Satellite Dodges Potential Collision with SpaceX Starlink Craft**

- **The European Space Agency's (ESA) Aeolus Earth Observation satellite fired its thrusters as an evasive maneuver on Sept. 2, 2019 to make sure it didn't collide with one of SpaceX's recently launched internet craft.**
- **Prior warnings/ Negotiations Failed**
- **ESA Calls for Space Traffic rules**

Recent News on Space Debris

SPACENEWS

Decommissioned NOAA weather satellite breaks up

by Jeff Foust — March 20, 2021

NOAA- M Spacecraft launched June 2002 - Decommissioned in April, 2013 – Break-up on March 20, 2021

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ESA’s recent Collison Avoidance Exercise

esa cryosat mission
@esa_cryosat
Collision avoided!
@esaoperations confirm that a collision avoidance manoeuvre executed at 16.44 yesterday afternoon was successful. #CryoSat moved to avoid space debris, a 2m chunk of a rocket weighing 202kg. We're back on track with instruments working as normal.
April, 09, 2022

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SpaceX Rocket Debris Lights Up Sky Over Pacific Northwest on 25th Mar 2021

- Video: SpaceX Rocket Debris Lights Up Sky Over Pacific Northwest
- On Thursday evening, residents in Oregon and Washington filmed bright lights resembling a meteor shower that turned out to be debris from the SpaceX Falcon 9 rocket, according to astronomers. Photo: Roman Puzhlyakov/AP

(https://www.wsj.com/video/video-spacex-rocket-debris-lights-up-sky-over-pacific-northwest/8E2CA911-88B4-499F-8A5E-905D162682B5.html

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Re-Entry of GSLV F04 (2011)

Figure- 1: LH2 Tank Fore-end Ring with lower stub adapter bracket

Figure- 2: Engine valve manifold

Figure- 3: Lower stub adapter bracket

Re-Entry of ESA's VEGA Launch Vehicle (2016)

Two rocket bodies (COPV- Composite overwrapped pressure vessel and a fuel tank) of upper stage of their launch vehicle VEGA/ AVUM have re-entered the earth on November 02, 2016, in Tamilnadu

Recently Re-entered Rocket Stages

An object suspected to be a part of China's Long March 5B rocket, found on the island of Borneo, in Malaysia. (Malaysia News Agency Aug 05, 2022).

CZ-3B R/B (Chinese rocket body from Long March launch vehicle fell over Tal Sindewahi in Chandrapur district of Maharashtra on April 04, 2022.

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Conclusion - Compliance Measures

- Implementation of Space Debris Guidelines
- Ease of Trackability
- De-Orbit mechanisms
- Disposal / Mission closure measures
- Registration of Space Objects with –
  - National Authorities
  - UN Registry
- Frequency Coordination with ITU
  - IARU + ITU Compliance -Advance Publication and Coordination
  - No harmful interference
- Due Authorization & Licence from State Authority
  - International Responsibility and Liability for damages
  - Compliance to Terms of License

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Space Based Solar Power (SBSP)

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Space Based Solar Power (SBSP)

- SBSP is the concept of collecting solar power in outer space and distributing it to Earth.
- Advantage: Higher collection rate and a longer collection period due to the lack of a diffusing atmosphere, and the possibility of placing a solar collector in an orbiting location where there is no night.
- The collecting satellite converts solar energy into electrical energy on board, powering a microwave transmitter or laser emitter, and transmit this energy to a collector (or microwave rectenna) on Earth's surface.
- Loss of Energy: A considerable fraction of incoming solar energy (55–60%) is lost on its way through the Earth's atmosphere by the effects of reflection and absorption.
- SBSP is considered a form of sustainable or green energy/ renewable energy.

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Source: Public Domain matrls including Wikipedia

Issues & Challenges

- Radio frequency interference and electromagnetic interference
- Need for better standards coordination between ITU, energy industries, and national administrations responsible for the regulation of electrical power grids
- New frequency allocations
- Health standards for SBSP system related emissions
- Coordination of orbital assignments for SBSP systems vis à vis telecommunications and other application satellites
- Possible Orbital Debris Build up

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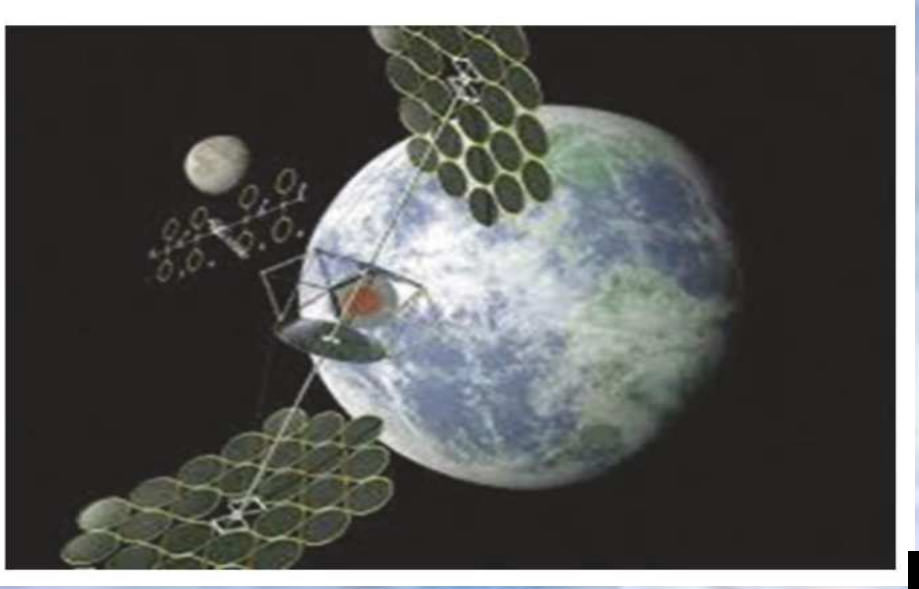
NASA's Low Mass Concentrators for Sunsats



Recent Development:
NASA plans to re-examine the feasibility of space-based solar power, an approach that is finding new support based on lower launch costs, technological advances and interest in clean energy sources.
Space News- May 28, 2022

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China's Ground Array for Space Based Power

- China's newly built ground station is a part of the team's space-based solar power proposal called OMEGA, (Orb-Shape Membrane Energy Gathering Array)
- It is a The 75-meter-tall ground structure transmits energy wirelessly across approximately 55 meters (180 feet)

Source: https://gizmodo.com/space-based-solar-power-omega-china-1849058366

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Proposed Action Plans

- Improve procedures to minimize EMI and radio frequency interference between all types of application and scientific satellites and SBSP systems
- Health and safety standards for SBSP system transmission from space to ground based rectennas
- Allocation of new radio frequency spectrum for space to Earth transmission of power to ground rectennas
- Improved updating of satellite communications user terminals to reduce interference and new standards for SBSP rectennas, including the issue of potential reflected energy back into space.

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Proposed Action Plans

- Campaign for new requirements via national laws that have to be consistent with space treaties to set new standards for active de orbit of debris; the risks related to SBSP systems presented by space debris is elevated because of the larger profile of these systems
- Convening of international conference concerning the use of outer space for SBSP –
  - to examine the state of technology, frequencies, interference mitigation, space weapon issues, and energy and sustainable development,
  - with the purpose of developing specific proposals on the above topics and timetable for implementation and
  - specifically for creating an international joint venture (like the erstwhile INTELSAT) for developing and operating a global SBSP system

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- ***Thank you for your kind attention!***

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