

Why Space Sustainability Matters

Brian Weeden, PhD



SECURE
WORLD
FOUNDATION

About Secure World Foundation



- **SWF** is a *private operating foundation* that promotes cooperative solutions for space sustainability.



- **Vision:** The secure, sustainable, and peaceful uses of outer space that contribute to global stability on Earth.



- **Our mission:** Work with governments, industry, international organizations, and civil society to develop and promote ideas and actions to achieve *the secure, sustainable, and peaceful uses of outer space* benefiting Earth and all its peoples.

What is “Space Sustainability”?

- Lots more stuff happening in space
 - Growing number & diversity of space actors (governments and commercial companies)
 - Growing number & diversity of space activities
- Negative externalities could have widespread impacts for everyone
- Very few hard “rules” about what is and isn’t allowed

How do we balance continued growth and innovation with ensuring space remains usable for current and future generations?

Space Sustainability Challenges

Human-generated space objects

Active Satellites

Total number of operating satellites: 8,406			
United States: 5,493	Russia: 263	China: 740	Other: 1,910
LEO: 6,418	MEO: 141	Elliptical: 59	GEO: 580

Current through 7/15/2023
 Source: [Union of Concerned Scientists](#)
[Celestrak](#)

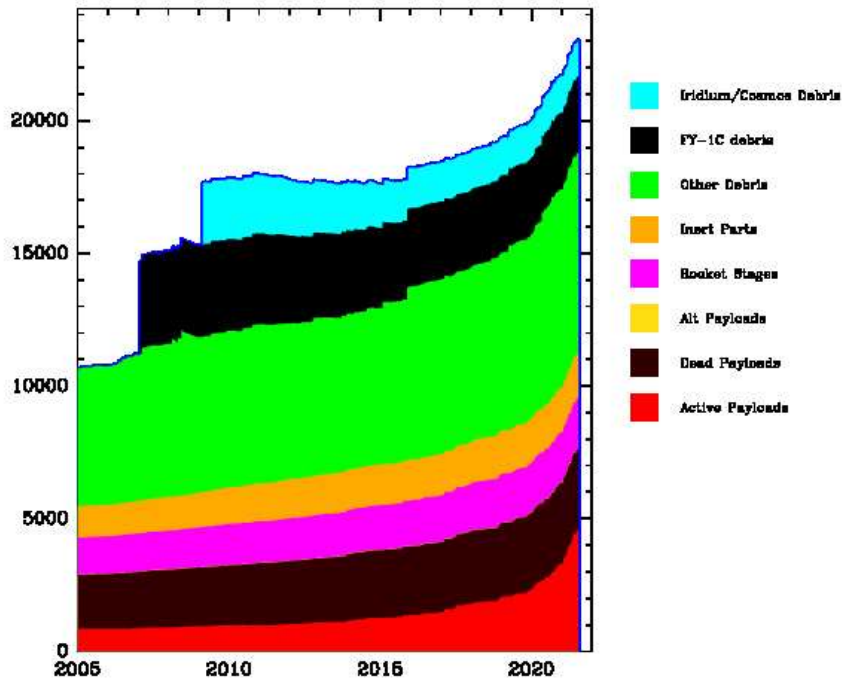
Space Debris

Larger than 10 cm	~45,000	Sources of new debris
Between 1 and 10 cm	~850,000	Can cause major damage
Smaller than 1 cm	Many millions	Can cause minor damage

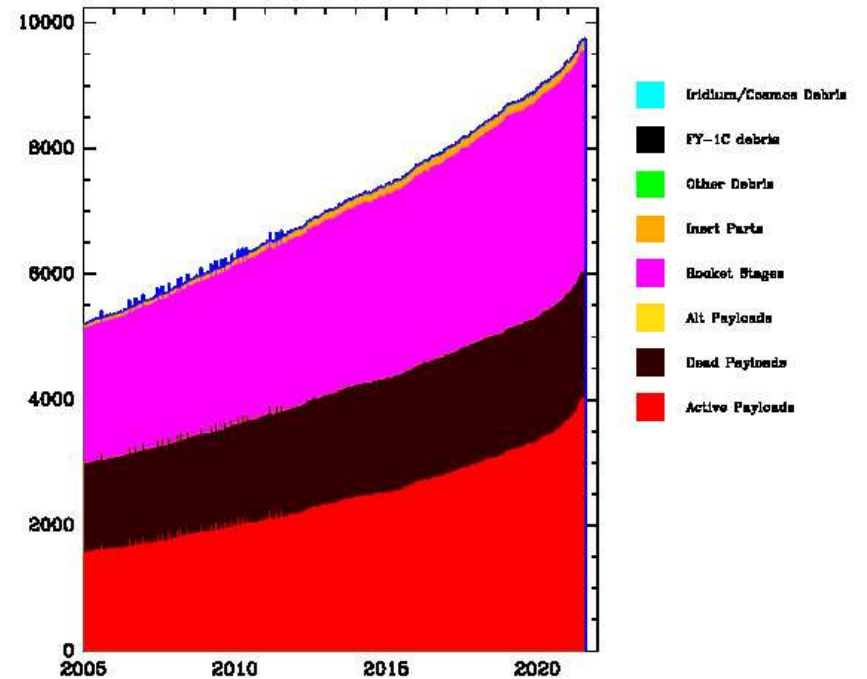
Source: Data compiled from U.S. Space Command, NASA, and ESA.

Growth of Orbital Debris

Orbital Population

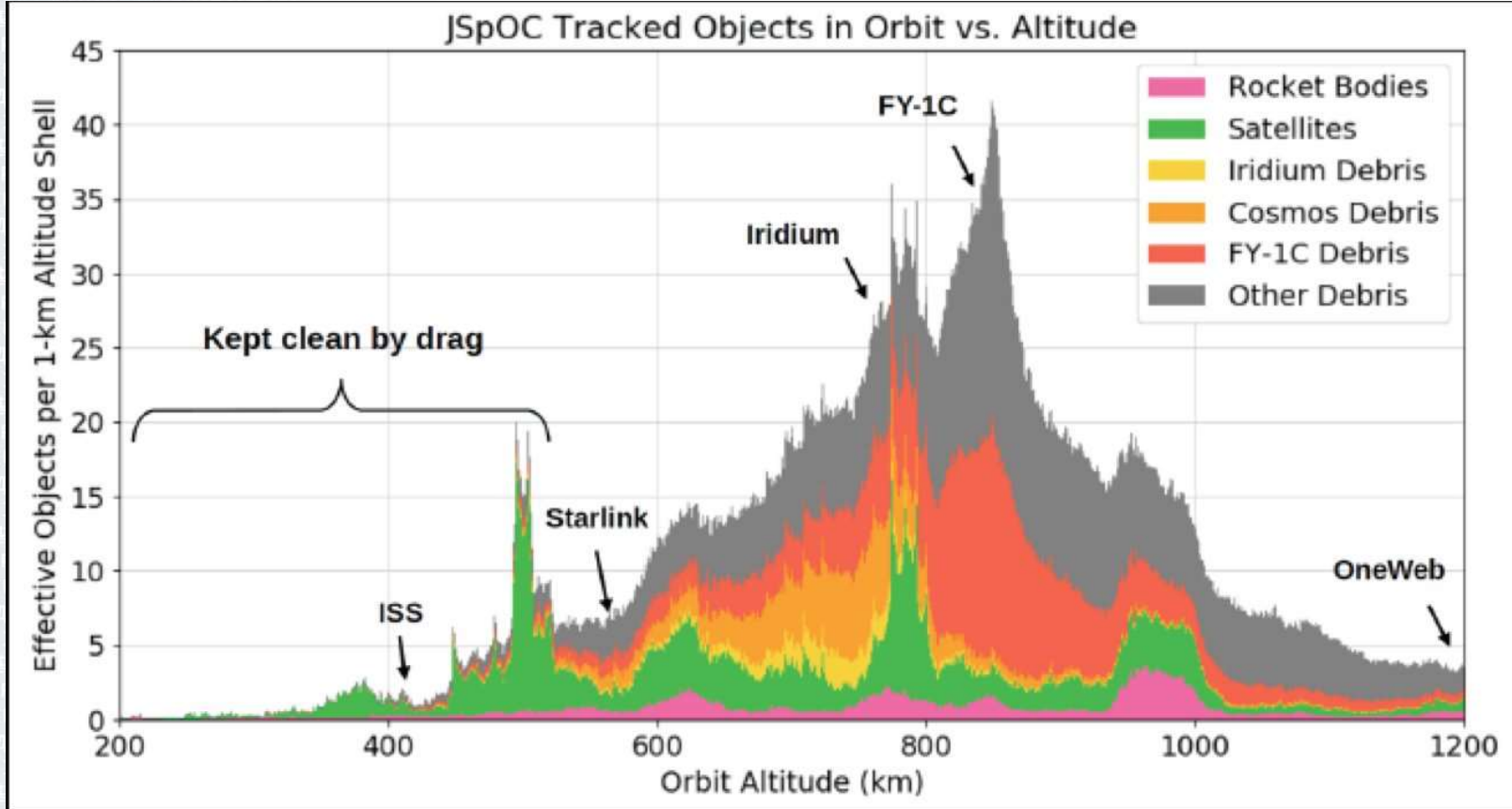


Orbital Tonnage



Source: [Jonathan's Space Page](#)

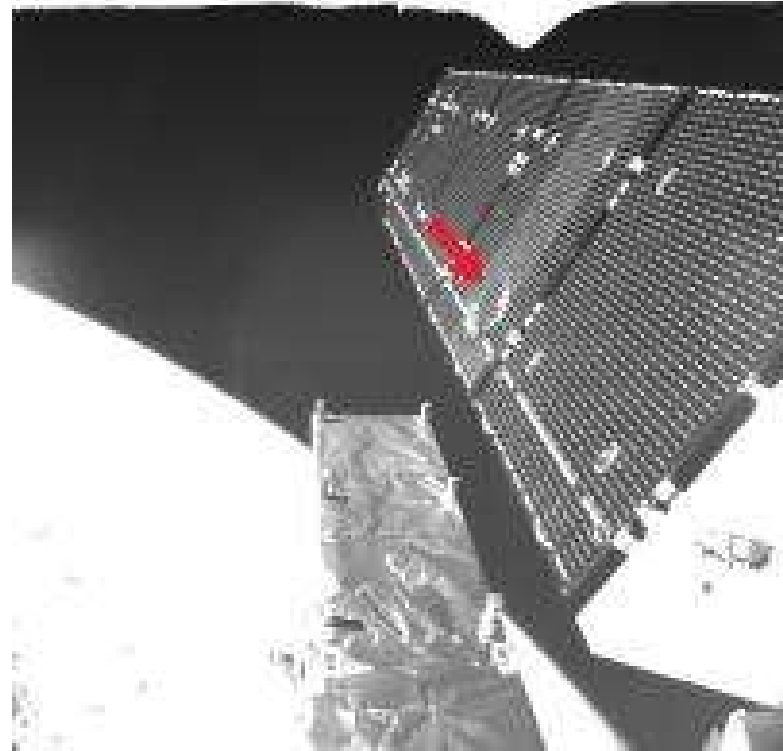
Highest congestion is in low Earth orbit (LEO)



SpaceX filing to the FCC, compiled from multiple sources



Impact crater created by a 13 mm object hitting an aluminum plate at 7 km/s (Credit: [European Space Agency](#))

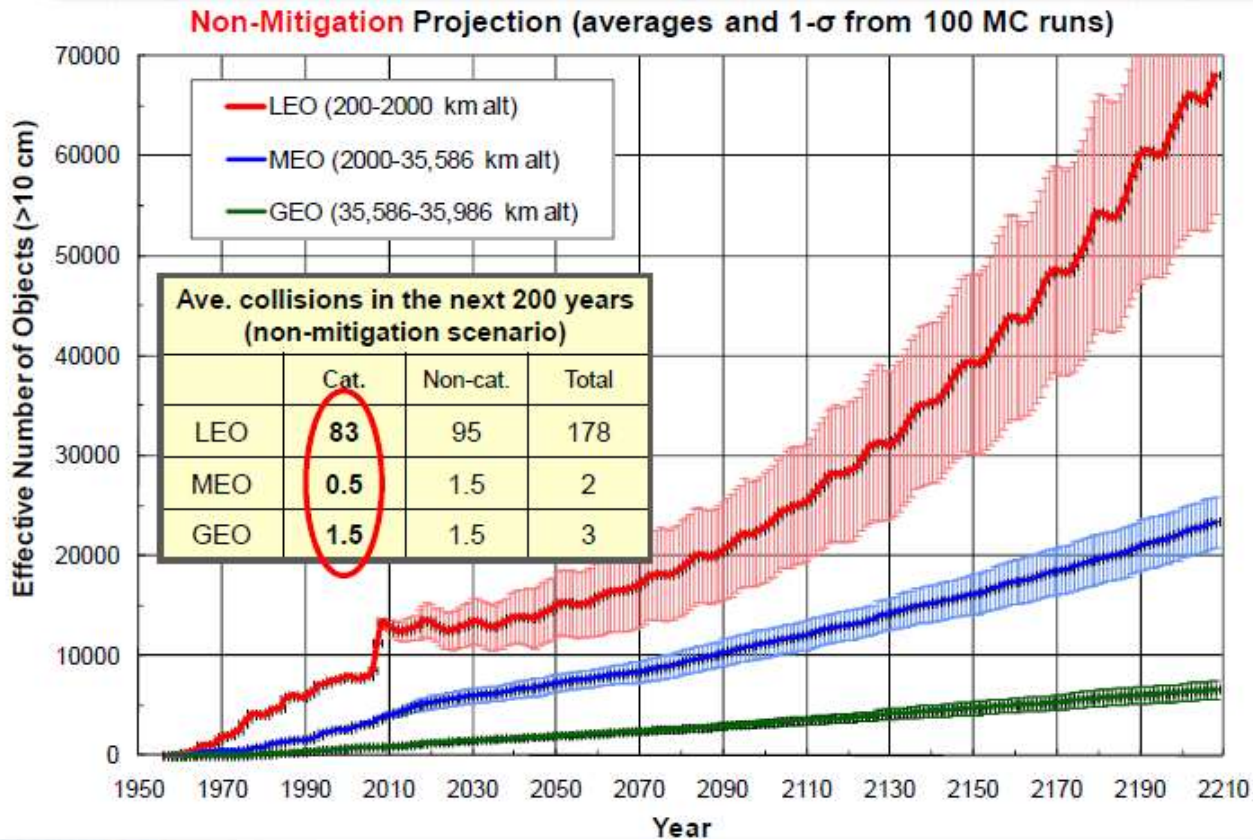


Impact damage of a millimeter-size object to EU's Sentinel1A spacecraft (Credit: [European Space Agency](#))

Orbital Debris Re-entry

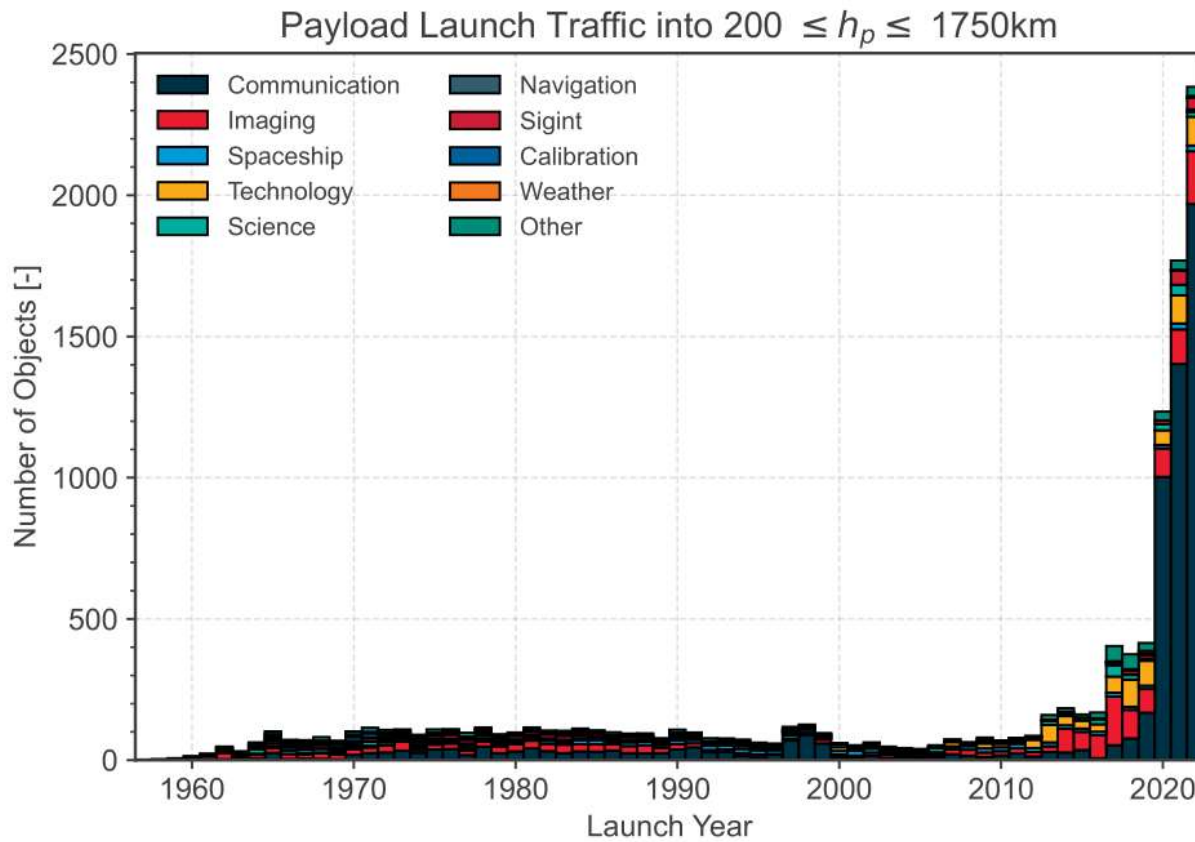


The next 200 years, if things stay the same



Source: J-C Liou, NASA Orbital Debris Program Office (2009)

Recent Rapid Growth

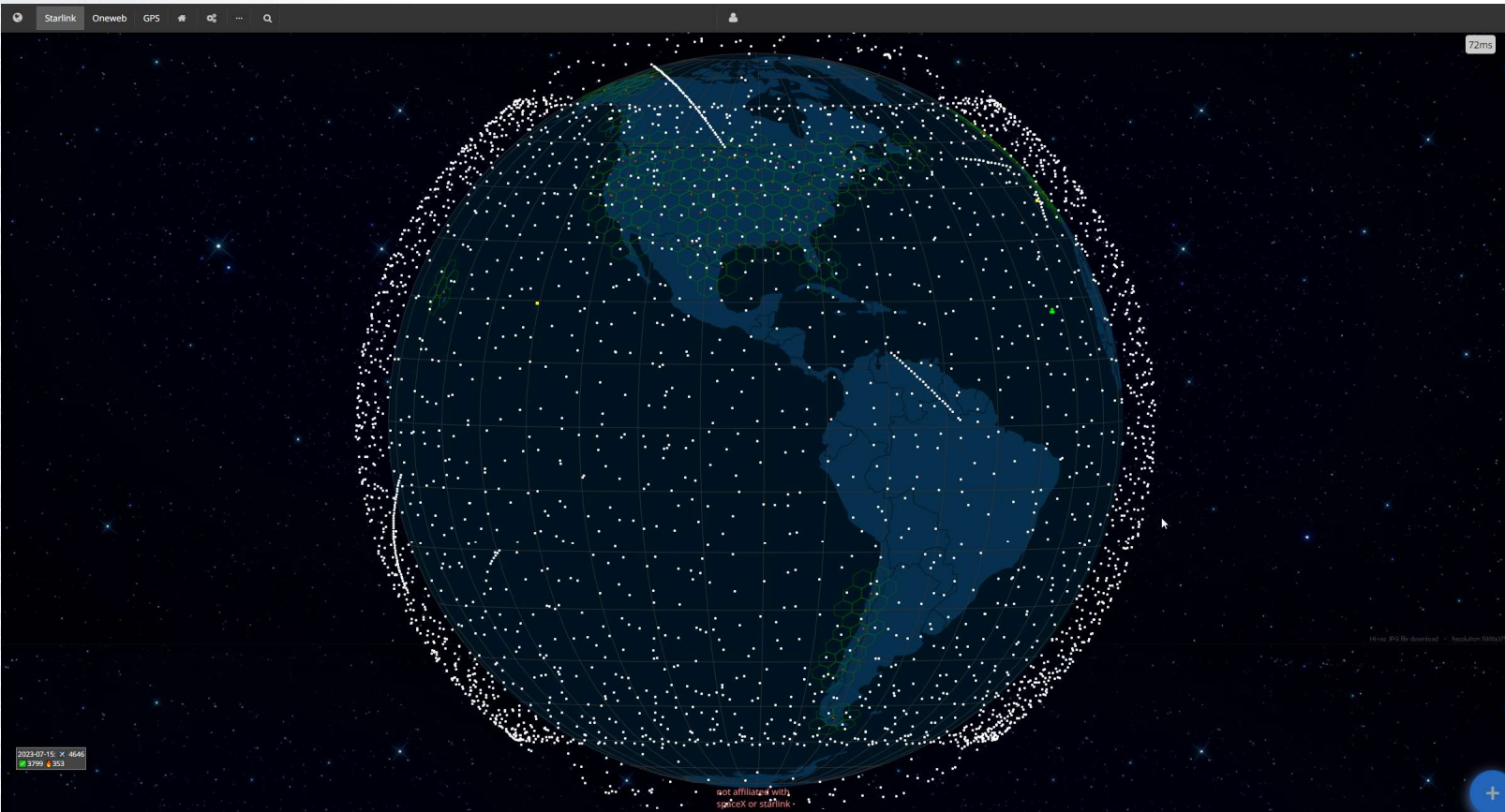


Source: [ESA Space Environment Report \(2023\)](#)

Planned Large Constellations

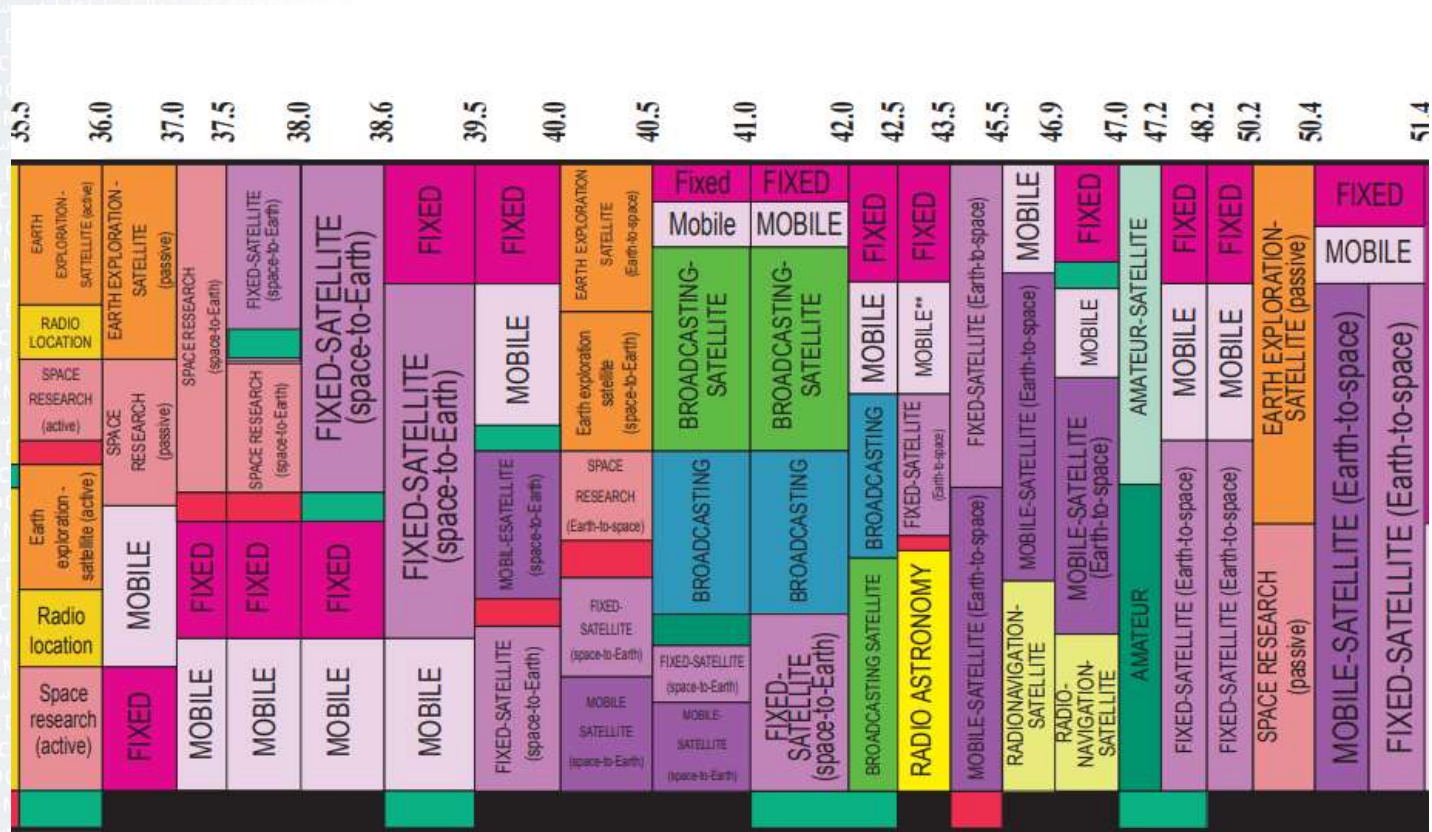
Constellation	Total Satellites Planned	Altitude	Country	Status
OneWeb Gen1	716	1,200 km	UK	634 launched 500 operational 12 re-entered
OneWeb Gen2	6,372			Planning
Starlink Gen1	4,408	540 – 570 km	US	3,982 launched 3,3370 operational 324 re-entered
Starlink Gen2A	7,500	523 – 530 km	US	750 launched 367 operational 12 re-entered
Starlink Gen2	34,396	328 – 614 km	US	Planning
Kuiper	3,232	590 – 630 km	US	First launch Q2 2024
Lynk	2,000	450 – 500 km	US	7 launched 3 operational
AST SpaceMobile	243	700 km	Papua New Guinea	1 launched
Lightspeed	1,969	1,015 – 1,325 km	Canada	First launch 2024?
Guanwang (GW)	12,992	590 – 1145 km	China	Planning
Cinnamon/eSpace	327,320	550 – 638 km	Rwanda	Filed

Current Starlink constellation



Source: [Satellitemap.space](https://satellitemap.space)

Radiofrequency Interference



Orbital debris costs (now)

Time frame	Type of cost/impact	Description
Current impacts	Debris-related damage	Loss of functionality or loss of entire satellites. Many incidents go unreported.
	Satellite and constellation design	Costs associated with satellite shielding, collision avoidance capabilities, safehold modes and redundancies (i.e. launch extra satellites as spares). Satellite constellations increasingly include spares for system resilience, but this solution often becomes part of the problem.
	Operations costs	Costs of Space Situational Awareness (SSA) activities, services and software. Data-blackouts when conducting avoidance manoeuvres.
	Orbit clearance costs	In the geostationary orbit: Relatively low, equivalent to about three months of station-keeping. In the low-earth orbit above 650 km altitude: Very high and requiring specific satellite subsystems (on-board computer).
	Insurance costs	Overall, limited use of in-orbit insurance by operators for space debris. Space debris collisions have historically been considered low-probability and not affecting insurance

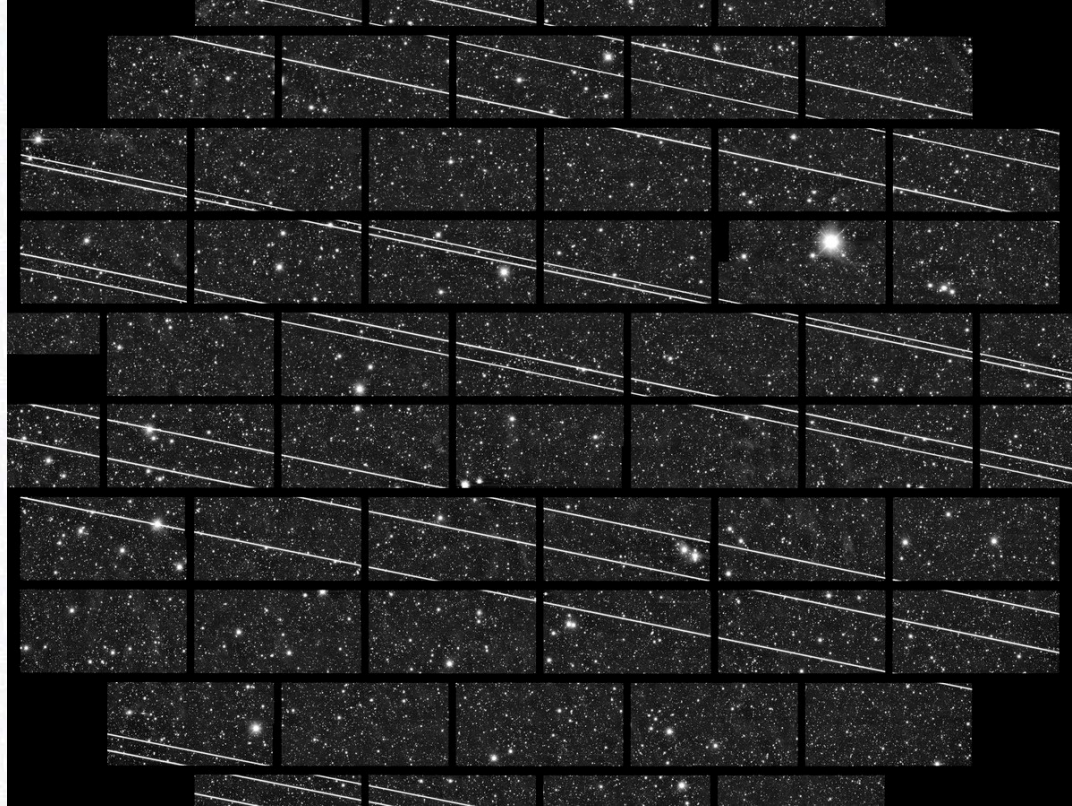
Source: [OECD Space Sustainability – The Economics of Orbital Debris in Perspective \(2020\)](#)

Orbital Debris Costs (future)

Potential future impacts	Loss of unique applications and functionalities	Space observations from some of the orbits most vulnerable to space debris are often the best or the only source of data and signals in their domain. This applies in particular to polar-orbiting weather and earth observation satellites. The loss of polar-orbiting weather satellite observations would heavily affect the Southern hemisphere, where there are fewer terrestrial observations.
	Lives lost	The International Space Station is located at about 400 km altitude. Although debris at that altitude decays naturally, it still poses a real collision threat.
	Interrupted time series for earth science and climate research	Uninterrupted time series are crucial for the accuracy and reliability of weather prediction and climate models.
	Curbed economic growth and slowdown in investments in the sector	Satellite broadband is widely considered as a key driver of space activities and revenues in the coming decades. More than ten broadband satellite constellations are in different stages of development. Practically all LEO communication services would be affected, on orbit and/or during orbit-raising, as the majority of constellations are located near or above the thickest LEO debris belts. Reduced access to venture finance, with investors preferring more affordable and less risky terrestrial alternatives.
	Distributional effects	The loss or perturbation of certain low-earth orbits could be felt more heavily in rural low-density residential areas and low-income countries

Source: [OECD Space Sustainability – The Economics of Orbital Debris in Perspective \(2020\)](#)

Light Pollution?



Starlink satellites captured by a telescope in Chile. Source: [The Atlantic](#)

Sustainability Initiatives

International Legal Framework

- Under the Outer Space Treaty of 1967, each Launching State is responsible for **authorization and continuing supervision** of their national space activities
 - Includes both government and private sector activities
- Each Launching State is also liable for damages their space activities cause
 - Absolute liability for damages to people and property on the ground, aircraft in flight
 - Fault-based liability for damages to other space objects

International Initiatives

- International guidelines for Orbital Debris Mitigation
 - Limits debris created through launch, on-orbit, and re-entry operations
 - Developed by the Inter-Agency Debris Coordination Committee (IADC), which includes all major space agencies
 - Voluntary at the international level
- UN Guidelines for the Long-term Sustainability of Outer Space Activities
 - 21 guidelines adopted by 92 Member States and endorsed by the UN General Assembly
 - Policy and regulatory, Safety of space operations, Cooperation and capacity-building. Scientific and technical R&D

U.S. National Initiatives

- U.S. Orbital Debris Mitigation Standard Practices (ODMSP)
 - First released in 2001, latest update 2020
 - Basis for the IADC guidelines
 - Apply to both U.S. government space missions and licensing of U.S. private sector space activities
- Space Traffic Management
 - Official policy signed by President Trump in June 2018
 - Dept of Commerce should be the lead agency for providing close approach warnings and developing a space traffic management framework based on industry standards

Private Sector Initiatives

- Space Data Association

- Not-for-profit entity created in 2009 by major satellite operators that provides value-added services for close approach warnings and radio-frequency interference

- Space Safety Coalition

- Group of 40+ “like-minded” companies and NGOs that developed best practices for sustainable space operations and pledge to abide by them

- CONFERS

- Industry association of 50+ companies that are developing best practices and standards for satellite servicing

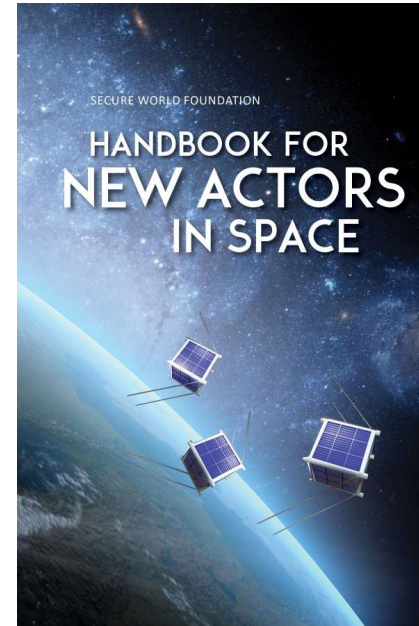
If You'd Like to Learn More...

Goal: Create a publication that provides an overview fundamental principles, laws, norms, and best practices for safe, predictable, and responsible activities in space

Two specific audiences:

Countries developing space programs and/or having to oversee and regulate their first satellites

Universities and start-up companies that are developing/operating satellites



swfound.org/handbook



Thank you.

bweeden@swfound.org



[@swfound](#)



[@SWFoundation](#)



swfound.org



SECURE
WORLD
FOUNDATION



9.6.23

WASHINGTON, D.C.
ASU BARRETT & O'CONNOR CENTER

NAVIGATING SPACE LAW AND POLICY BOOTCAMP

- September 6th
- Online and In Person
- Washington D.C., ASU Barrett and O'Connor Center
- Get Tickets Now:
<https://acsp.ticketspice.com/navigating-space-law-and-policy>
- More Info:
<https://acsp.space/events/navigating-space-law-and-policy-bootcamp>



BEYOND TOMORROW, TODAY.

MEMBERSHIP HAS
ITS PRIVILEGES



25% off all-new Navigating Space Law and Policy Bootcamp



25% off Space Regulatory Bootcamp on Orbit Forum



FREE access to CSRP: White Belt Certification Exam



10% off Export Compliance Training Institute courses



Complimentary consultations with Aegis Trade Law



More to see: visit acsp.space/membership