

Space Sustainability: An Overview

Victoria Samson, Secure World Foundation

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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.



Space Governance

- Much of the existing space governance framework is based on norms
 - Example: Freedom of overflight for satellite reconnaissance
 - Was not codified into “hard law” until Outer Space Treaty of 1967
- Four main treaties: OST, Registration Convention, Liability Convention, Rescue Agreement
- Norms are likely going to be a major mechanism to address future challenges
 - Focus on identifying responsible behavior
 - Non-legally binding approaches like the Artemis Accords becoming popular



Human-Generated Space Objects

- Active satellites as of 4.14.2024:
 - Total: Nearly 9900 (<https://celestrak.org/satcat/boxscore.php>)
 - US: 6800
 - Russia: 281
 - China: 867
 - SpaceX' Starlink: 5744 (<https://planet4589.org/space/con/star/stats.html>)

Orbital Debris

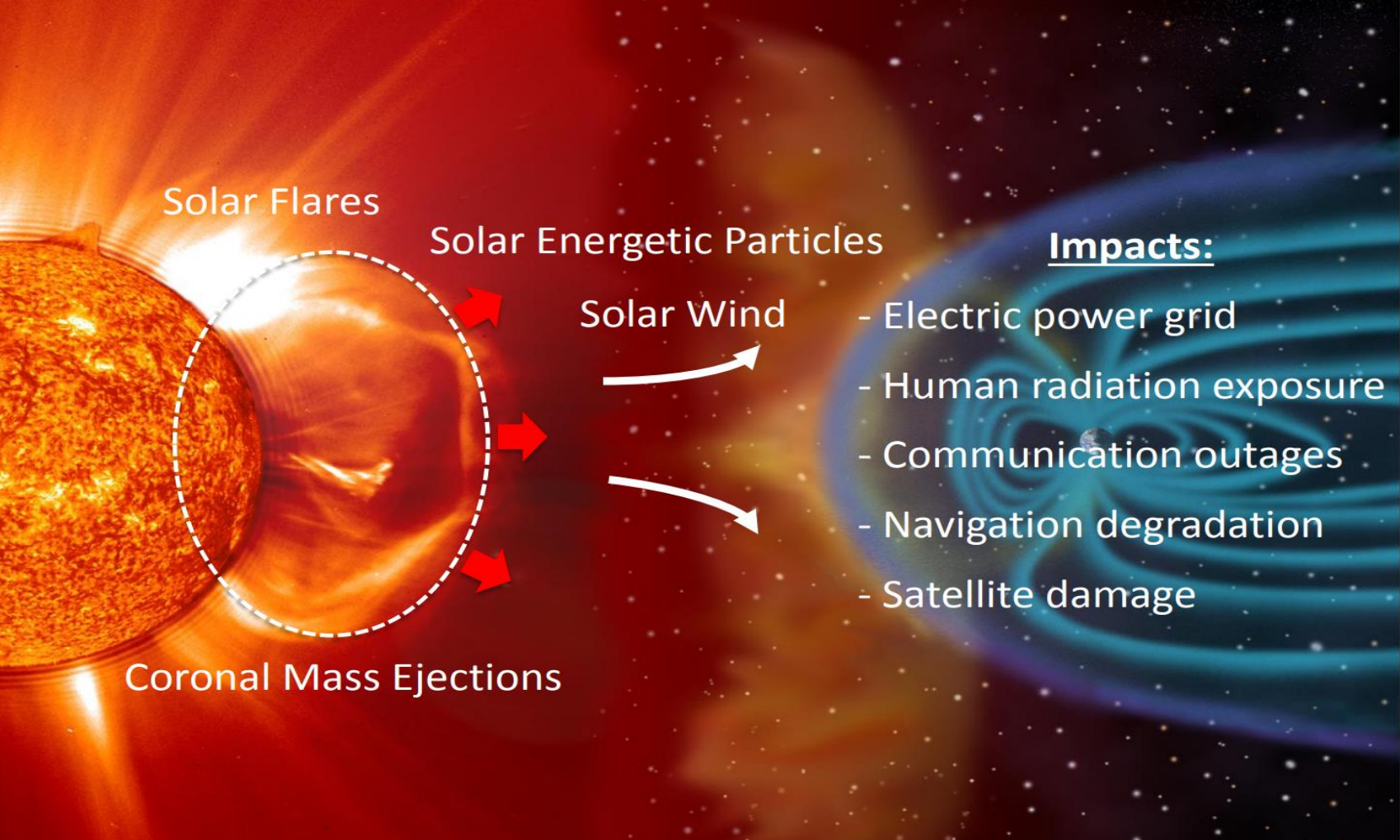
Larger than 10 cm	~20,000	Sources of new debris
Between 1 and 10 cm	~850,000	Can cause major damage
Smaller than 1 cm	Many millions	Can cause minor damage

Planned Large Constellations

Constellation	Total Satellites Planned	Altitude	Country	Status
OneWeb Gen1	716	1,200 km	UK	640 launched 620 operational 6 re-entered
OneWeb Gen2	6,372			Planning
Starlink Gen1	4,408	540 – 570 km	US	4,015 launched 3,549 operational 361 re-entered
Starlink Gen2A	7,500	523 – 530 km	US	1,724 launched 1,107 operational 26 re-entered
Starlink Gen2	22,488	328 – 614 km	US	Planning
Kuiper	3,232	590 – 630 km	US	2 launched
Lynk	2,000	450 – 500 km	US	8 launched 4 operational
AST SpaceMobile	243	700 km	Papua New Guinea	1 launched
Lightspeed	1,969	1,015 – 1,325 km	Canada	First launch 2024?
Xingwang	966	880 – 1,110 km	China	15 launched 9 operational
Guanwang (GW)	12,992	590 – 1,145 km	China	Planning
Cinnamon/eSpace	327,320	550 – 638 km	Rwanda	Filed



Space Weather





RF Spectrum Congestion

	35.5	36.0	37.0	37.5	38.0	38.6	39.5	40.0	40.5	41.0	42.0	42.5	43.5	45.5	46.9	47.0	47.2	48.2	50.2	50.4	51.4
Space research (active)	FIXED	MOBILE	MOBILE	MOBILE	MOBILE	MOBILE	MOBILE	FIXED-SATELLITE (space-to-Earth)	FIXED-SATELLITE (space-to-Earth)	FIXED-SATELLITE (space-to-Earth)	BROADCASTING SATELLITE	RADIO ASTRONOMY	MOBILE-SATELLITE (space-to-Earth)	RADIONAVIGATION-SATELLITE	AMATEUR	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	SPACE RESEARCH (passive)	MOBILE-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)
Radio location	MOBILE	MOBILE	FIXED	FIXED	FIXED	FIXED-SATELLITE (space-to-Earth)	MOBILE	FIXED-SATELLITE (space-to-Earth)	FIXED-SATELLITE (space-to-Earth)	FIXED-SATELLITE (space-to-Earth)	BROADCASTING SATELLITE	BROADCASTING SATELLITE	BROADCASTING SATELLITE	AMATEUR	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	SPACE RESEARCH (passive)	MOBILE-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)
Earth exploration - satellite (active)	MOBILE	MOBILE	FIXED	FIXED	FIXED	FIXED-SATELLITE (space-to-Earth)	MOBILE	FIXED-SATELLITE (space-to-Earth)	FIXED-SATELLITE (space-to-Earth)	FIXED-SATELLITE (space-to-Earth)	BROADCASTING SATELLITE	BROADCASTING SATELLITE	BROADCASTING SATELLITE	AMATEUR	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	SPACE RESEARCH (passive)	MOBILE-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)
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EARTH EXPLORATION - SATELLITE (active)	MOBILE	MOBILE	FIXED	FIXED	FIXED	FIXED-SATELLITE (space-to-Earth)	MOBILE	FIXED-SATELLITE (space-to-Earth)	FIXED-SATELLITE (space-to-Earth)	FIXED-SATELLITE (space-to-Earth)	BROADCASTING SATELLITE	BROADCASTING SATELLITE	BROADCASTING SATELLITE	AMATEUR	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	SPACE RESEARCH (passive)	MOBILE-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)
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RADIO LOCATION	MOBILE	MOBILE	FIXED	FIXED	FIXED	FIXED-SATELLITE (space-to-Earth)	MOBILE	FIXED-SATELLITE (space-to-Earth)	FIXED-SATELLITE (space-to-Earth)	FIXED-SATELLITE (space-to-Earth)	BROADCASTING SATELLITE	BROADCASTING SATELLITE	BROADCASTING SATELLITE	AMATEUR	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	SPACE RESEARCH (passive)	MOBILE-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)



Close Approaches and Effects on Space Sustainability

- Uncoordinated close approaches: potential for (inadvertent) escalation
- Not as easy to make hard and fast requirements about
- Different risk assessments by different actors in space
- Very few hard “rules” about what is and isn’t allowed
 - Intent is key – how do you demonstrate intent?
 - Need for rules of the road: right of way, ways to quickly communicate amongst actors, IncSea for space?
 - Role of space situational awareness and its limitations



Congestion on and around the Moon Affecting Cislunar Sustainability

- 106 cislunar and lunar missions by 19 countries and one multilateral organization (ESA)
- Complications on Earth replicating on the Moon?
- Activities on the Moon changing – more commercial players
 - Just because an activity can happen, should it?
- Artemis Accords vs International Lunar Research Station?



Efforts to Enhance Space Sustainability

- Multilateral Efforts
 - ESA Zero Debris Charter
 - UN Committee on Peaceful Uses of Outer Space' Long-Term Sustainability Guidelines
 - LTS 2.0 Working Group
- Commercial Sector Initiatives
 - Space Data Association
 - Space Safety Coalition
 - CONFERS
 - Satellite Industry Association
 - Space Sustainability Rating
 - AIAA Satellite Orbital Safety Best Practices



- Existence of counterspace capabilities is not new, but the circumstances surrounding them are
- Significant R&D/testing of a wide range of destructive & non-destructive counterspace capabilities by multiple countries
- ***Only non-destructive capabilities are actively being used in current military operations***

GLOBAL
COUNTERSPACE
CAPABILITIES

An Open Source Assessment

> 04 | 2024

<https://swfound.org/counterspace>



Counterspace Capabilities

Direct Ascent: weapons that use ground, air-, or sea-launched missiles with interceptors that are used to kinetically destroy satellites through force of impact, but are not placed into orbit themselves;

Co-orbital: weapons that are placed into orbit and then maneuver to approach the target to attack it by various means, including destructive and non-destructive;

Directed Energy: weapons that use focused energy, such as laser, particle, or microwave beams to interfere or destroy space systems;

Electronic Warfare: weapons that use radiofrequency energy to interfere with or jam the communications to or from satellites;




Cyber: weapons that use software and network techniques to compromise, control, interfere, or destroy computer systems.

Space Situational Awareness: knowledge about the space environment and human space activities that enables both offensive and defense counterspace operations



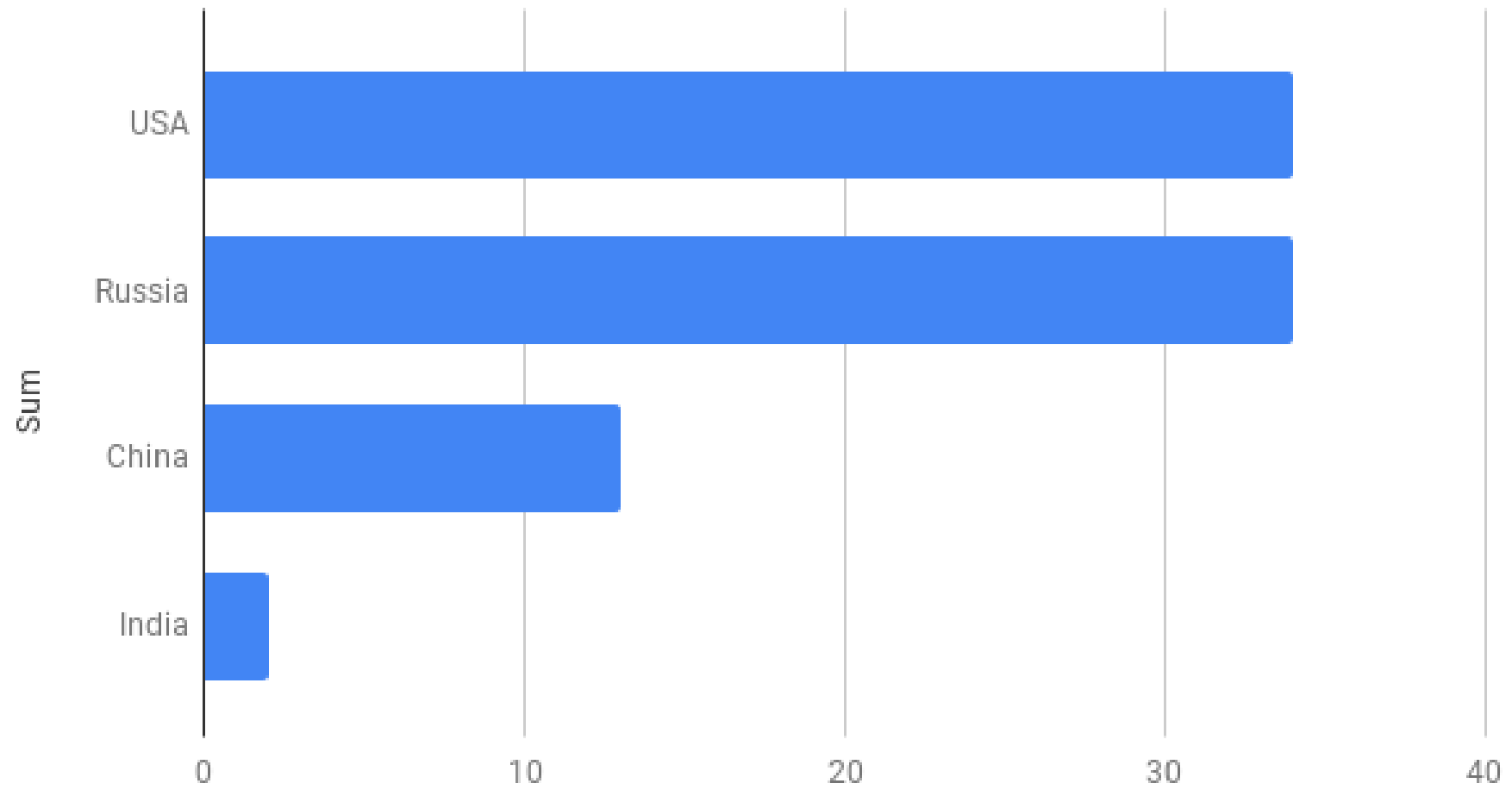
2024 Global Assessment

	US	Russia	China	India	Aus.	France	Iran	Israel	Japan	North Korea	South Korea	UK
LEO Co-Orbital	some	significant	some	none	none	none	none	none	none	none	none	none
MEO/GEO Co-Orbital	some	some	some	none	none	none	none	none	none	none	none	none
LEO Direct Ascent	some	some	significant	some	none	none	none	none	none	none	none	none
MEO/GEO Direct Ascent	some	some	some	none	none	none	none	none	none	none	none	none
Directed Energy	some	some	some	none	none	some	none	none	none	none	none	none
Electronic Warfare	significant	significant	significant	some	some	some	some	significant	some	some	none	none
Space Situational Awareness	significant	significant	significant	some	some	some	some	some	some	some	some	some

Legend: none  some  significant 



ASAT Tests by Country (2024)





ASAT Tests by Year (2024)

India China Russia USA

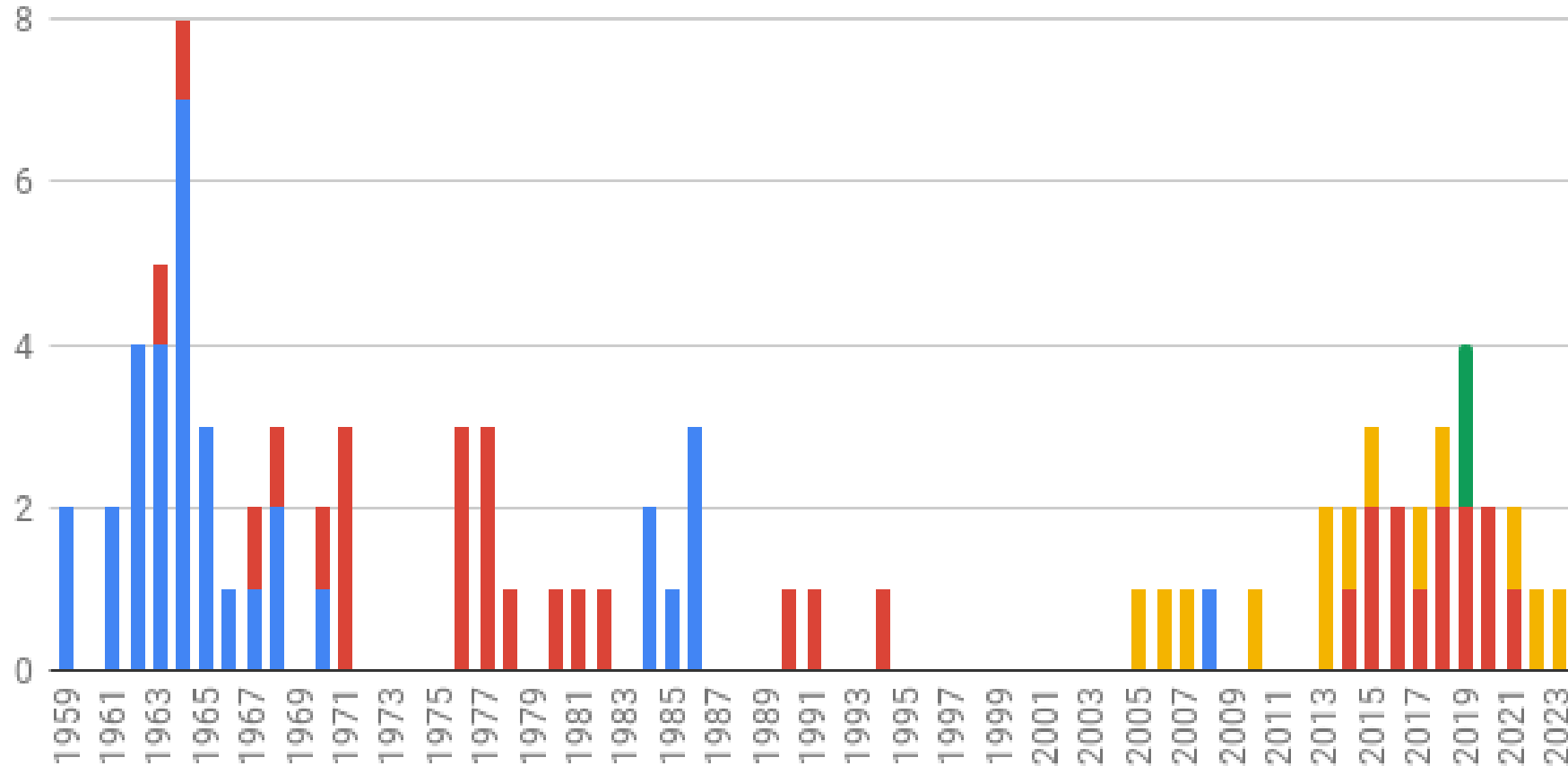




TABLE 5-1 – ORBITAL DEBRIS CREATED BY ASAT TESTS IN SPACE

DATE	COUNTRY	ASAT SYSTEM	TARGET	INTERCEPT ALTITUDE	TRACKED DEBRIS	DEBRIS STILL ON ORBIT	TOTAL DEBRIS LIFESPAN
Oct. 20, 1968	Russia	IS	Cosmos 248		252	76	50+ years
Oct. 23, 1970	Russia	IS	Cosmos 373		147	35	50+ years
Feb. 25, 1971	Russia	IS	Cosmos 394		118	45	50+ years
Dec. 3, 1971	Russia	IS	Cosmos 459		28	0	3.3 years
Dec. 17, 1976	Russia	IS	Cosmos 880		127	56	45+ years
May 19, 1978	Russia	IS-M	Cosmos 970		71	64	40+ years
Apr. 18, 1980	Russia	IS-M	Cosmos 1171		45	5	40+ years
Jun. 18, 1982	Russia	IS-M	Cosmos 1375		63	59	35+ years
Sept. 13, 1985	U.S.	ASM-135	Solwind	530 km	287	0	18+ years
Sept. 5, 1986	U.S.	Delta 180 PAS	Delta 2 R/B		18	0	< 1 year
Dec. 26, 1994	Russia	Naryad-V?	Unknown		27	24	25+ years
Jan. 11, 2007	China	SC-19	FengYun 1C	880 km	3536	2686	15+ years
Feb. 20, 2008	U.S.	SM-3	USA 193	220 km	175	0	1+ year
Mar. 27, 2019	India	PDV-MK II	Microsat-R	300 km	130	0	3+ years
Aug.-Dec. 2019	Russia	Cosmos 2535	Cosmos 2536		30	14	3+ years
Nov. 15, 2021	Russia	Nudol	Cosmos 1408	470 km	1807	67	Unknown

Total 6863 3133



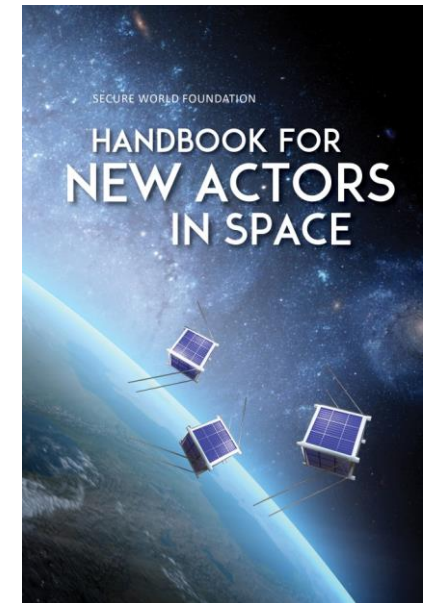
Tools for Improving Communication, Transparency (1)

- ***Lexicon for Outer Space Security*** (<https://unidir.org/publication/lexicon-outer-space-security>)
 - Intended to facilitate shared understandings of key topics and terms
 - Three types of terms:
 - Acronyms
 - Common definitions
 - Terminology frequently used in space security discussions that could benefit from further clarification
- ***Space Security Portal*** (<https://spacesecurityportal.org/>)
 - Interactive map of global space governance landscape
 - Seeks to support informed participation by interested stakeholders and support transparency, information-sharing, and capacity-building



Tools for Improving Communication, Transparency (2)


- **Handbook for New Actors in Space** (<https://swfound.org/handbook>)
 - Goal: create a publication that provides an overview of fundamental principles, laws, norms, and best practices for safe, sustainable, and responsible activities in space
 - Audiences:
 - Countries developing space programs and/or having to oversee and regulate satellites
 - Universities/start-ups that are developing/operating satellites



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Questions?

Thanks.

Victoria Samson,
vsamson@swfound.org

@SWFoundation

