Space and Space Security: 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
- **Our 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

A space system is more than just a satellite

Space segment

Ground segment

Internet

User segment

Setting the stage

- Parts of Satellites
  - Spacecraft Bus
  - Onboard Computer
  - Antennas
  - Payload and Transponders
  - Solar Panels
  - Attitude Control Systems

- Orbits
  - Low Earth Orbit (LEO): 100-2000 km
  - Medium Earth Orbit (MEO): 2000-36,000 km, but many are at 20,000 km
  - Geostationary Orbit (GEO): 36,000 km

Human-Generated Space Objects

- Active satellites as of Oct. 27, 2024:
  - Total: 10,576
    - United States: 7481
      - Of which, SpaceX' Starlink: 6441
    - Russia: 273
    - China: 905

Orbital Debris

Larger than 10 cm	~40,500	Sources of new debris
Between 1 and 10 cm	~1,100,000	Can cause major damage
Smaller than 1 cm	130 million	Can cause minor damage

Space Stability Challenges

- A lot more activity 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 can we ensure space is available for future generations?

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

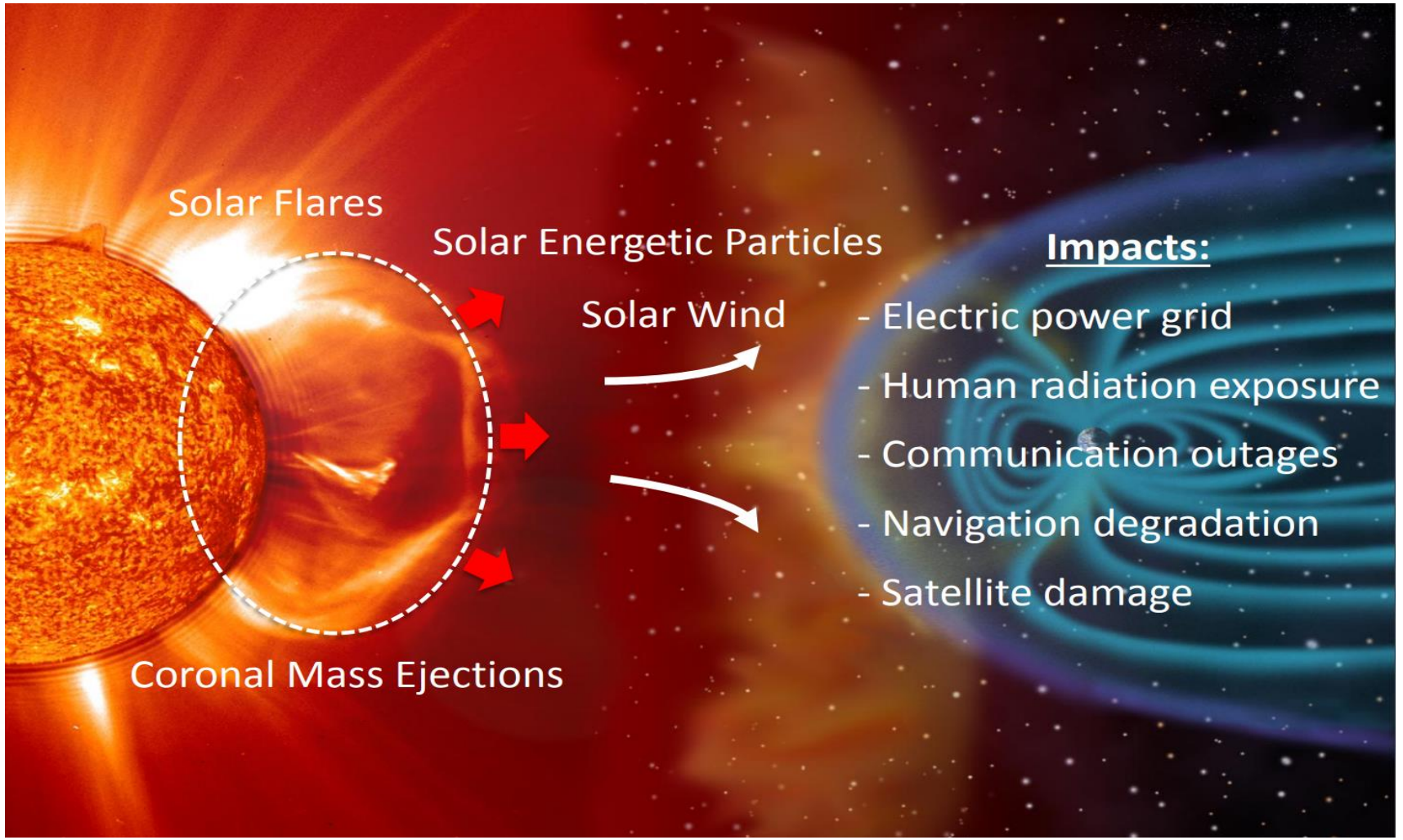
- Four main treaties: Outer Space Treaty, Registration Convention, Liability Convention, Rescue Agreement

- Norms are an important mechanism to address future challenges

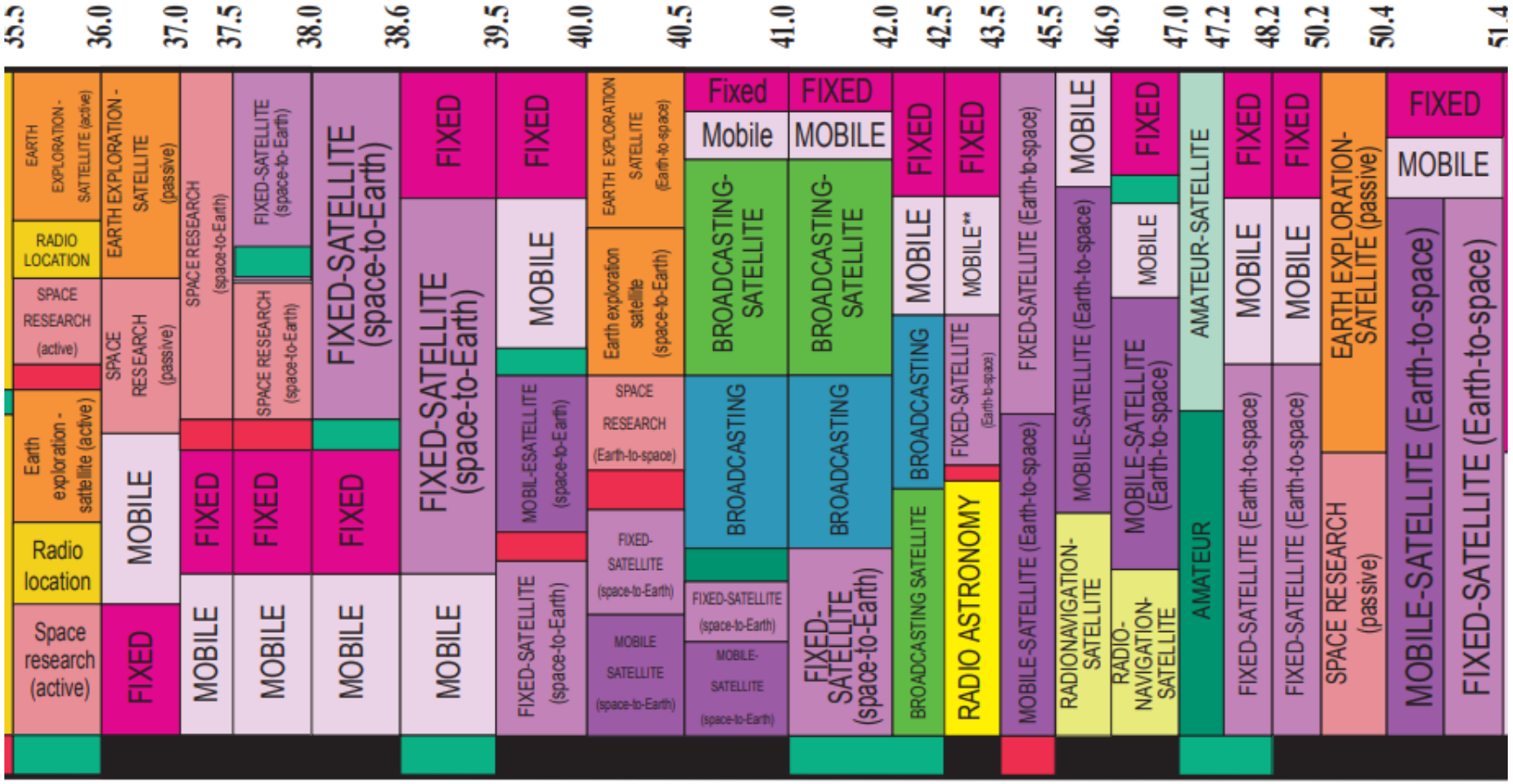
Very large constellations

- Meant to provide satellite communications (space-based internet)
- Tens/hundreds of thousands proposed
- Interfere with visual astronomy and radio astronomy
- Challenges to spectrum and space traffic management
- Launch and reentry of large numbers of objects could have effects on Earth’s atmosphere

Space Weather



RF Spectrum Congestion



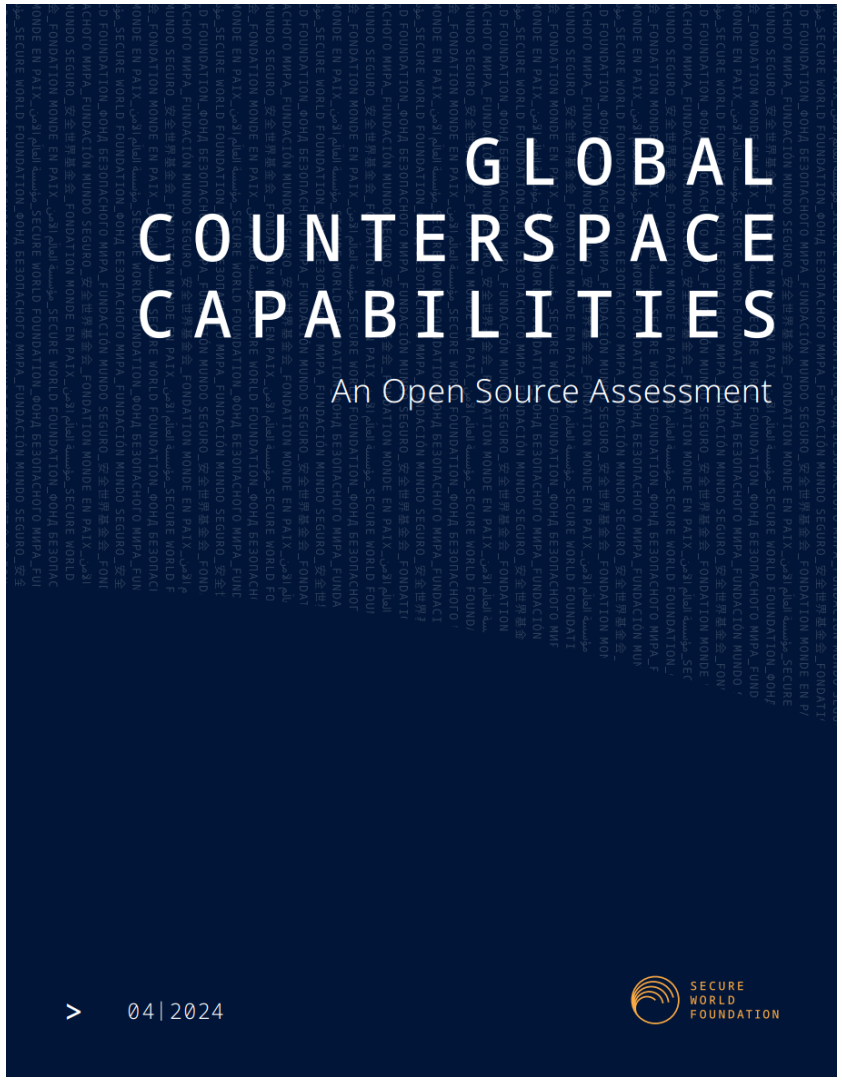
Close Approaches and Effects on Space Stability

- 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?
  - How do you determine right of way? Is there a way to quickly communicate amongst actors?
  - Space situational awareness is good but has limitations

- 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***



https://swfound.org/counterspace

Counterspace Capabilities

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

Direct Ascent: 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

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

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

Cyber: 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	▭	▲	▭	●	●	●	●	●	●	●	●	●
MEO/GEO Co-Orbital	▭	▭	▭	●	●	●	●	●	●	●	●	●
LEO Direct Ascent	▭	▭	▲	▭	●	●	●	●	●	●	●	●
MEO/GEO Direct Ascent	▭	▭	▭	●	●	●	●	●	●	●	●	●
Directed Energy	▭	▭	▭	●	●	▭	●	●	●	●	●	●
Electronic Warfare	▲	▲	▲	▭	▭	▭	▭	▲	▭	▭	●	●
Space Situational Awareness	▲	▲	▲	▭	▭	▭	▭	▭	▭	▭	▭	▭

Legend: none ● some ▭ significant ▲

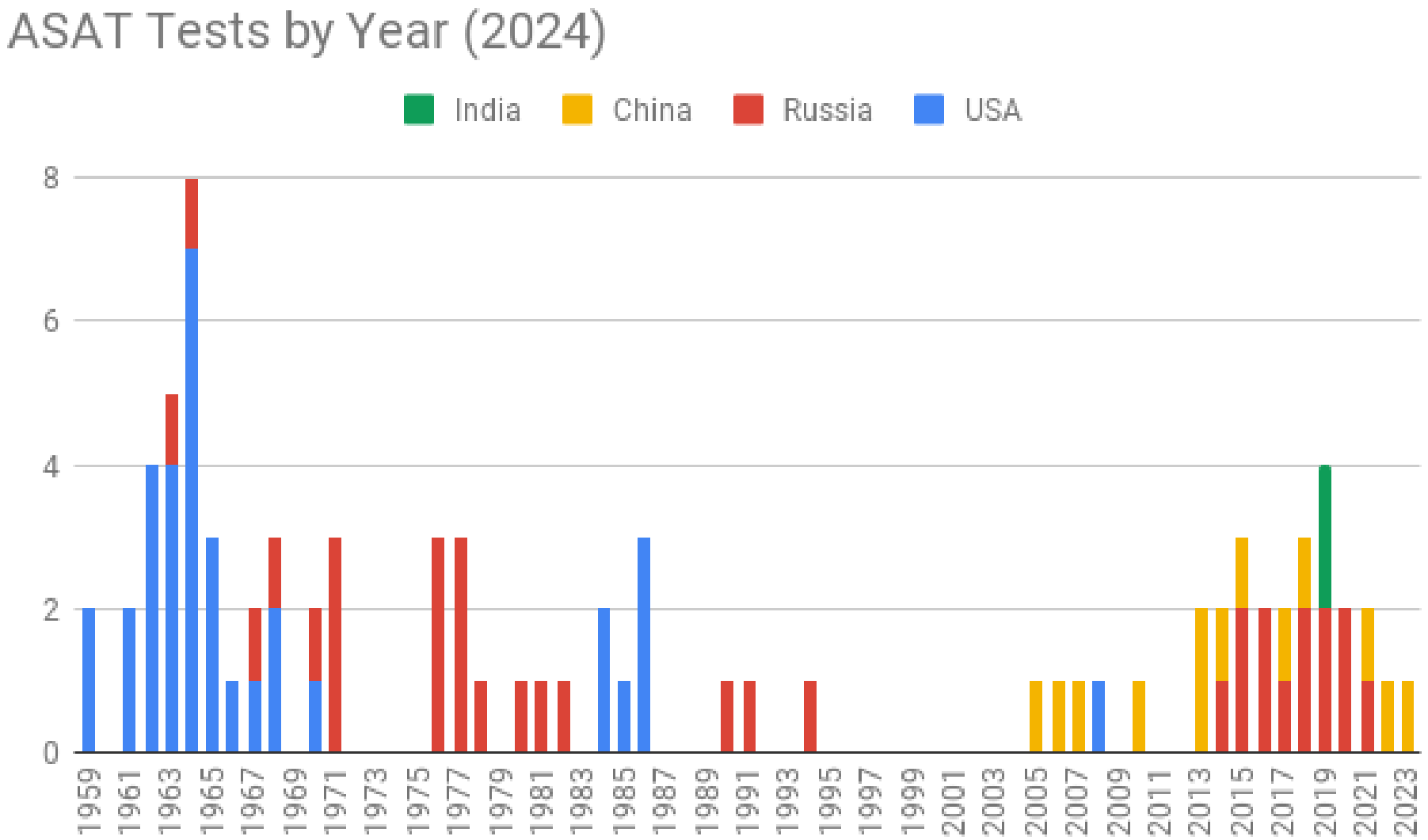

ASAT Tests by Year (2024)
India
China
Russia
USA
8
6
4
2
0
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023

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**	

Fallacy: Every satellite has the potential to be a co-orbital kinetic weapon

- An ordinary satellite ***cannot*** be maneuvered to collide with another one
  - Orbit measurements and propagation are too inaccurate and uncertain
  - The propulsion system on a satellite (if any) cannot deliver the △V to the required precision for a collision
  - The attitude control systems of satellites are not accurate enough to control the precise orientation that would be required for the △V
  - Satellites do not have terminal guidance sensors that enable last second corrections to a target (unlike ASAT or ballistic missile defense kinetic kill vehicles)

- However, satellites designed for servicing (refueling, inspection, towing, removal) ***might*** be able to be used as a weapon

Case study: Nuclear detonation as an ASAT weapon

- No shockwave (no air to transmit)
- Blind any optical sensors point in its direction
- Thermal pulse can overload & fry satellites
- Electromagnetic pulse (EMP) can damage satellites and terrestrial electronics and power grids
- Radiation gets trapped by Van Allen Belts for weeks/months and can degrade/destroy LEO satellites
- Violation of the Outer Space Treaty
- For more info, see: https://swfound.org/news/all-news/2024/04/faq-what-we-know-about-russia-s-alleged-nuclear-anti-satellite-weapon/

Image of Starfish Prime nuclear test.
Credit: Nuclearweaponarchive

Tools for Improving Communication, Transparency

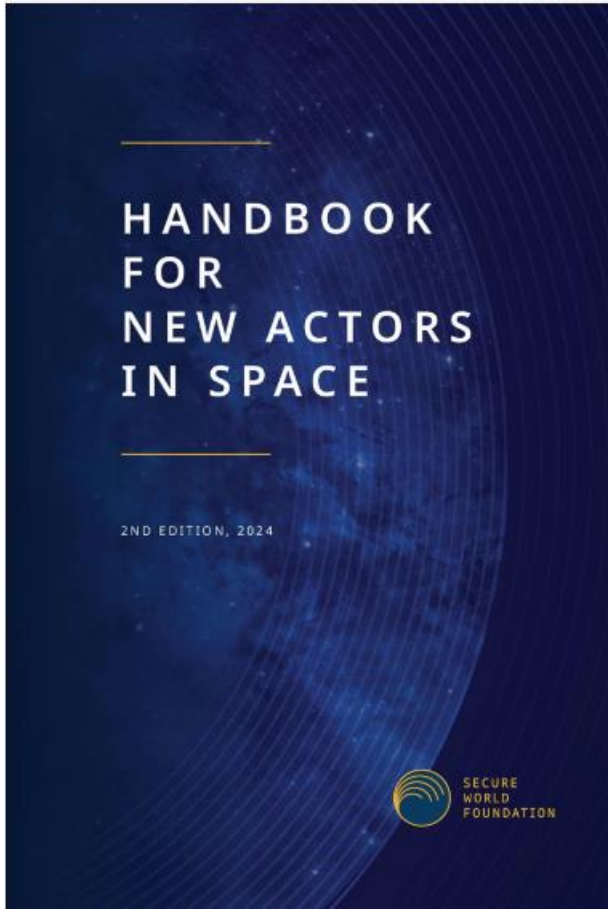
- ***Lexicon for Outer Space Security*** (https://unidir.org/publication/lexicon-outer-space-security)
  - Intended to facilitate shared understandings of key topics and terms
  - Three types of terms:
    - Acronyms
    - Common definitions
    - Terminology frequently used in space security discussions 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

Introducing the 2nd Edition of the Handbook for New Actors in Space

Goal is to provide a broad overview of the fundamental principles, laws, norms, and best practices for peaceful, safe, and responsible activities in space

2nd Edition is updated to account for new activities, trends, and data and is a more online-friendly format



Download for free from the SWF website:
https://swfound.org/handbook

A limited number of printed copies is available here today

Feedback is always welcome!

Three languages are available for the first edition:

- Spanish (2020)
- French (2021)
- Chinese (2021)

Questions?

Thanks.

Victoria Samson,
vsamson@swfound.org

@SWFoundation

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