Introduction to Space Security

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Outline

- Concept and Definition of Space Security , Space Safety
- Space Security Index
- Space Debris Issues
- Constellation Satellites
- Weaponization of Outer Space
- Private Sector Participation
- UN Treaties
- Conclusion

Safety Vs Security

- **Security & Safety Challenges in a Globalized World,** Universiteit Leiden
- Safety is the condition of being protected from harm caused by non-intentional failure - *protection against accidental harm*
- Security is the condition of bring protected from harm caused by intentional human actions or behaviours- *protection against intentional harm*

(https://www.coursera.org/lecture/security-safety-globalized-world/what-is-safety-and-security-VXD42)

Space Safety Vs Space Security

- Space Safety is a result of measures precluding inherent malfunction and mitigating the risks of accidental damage that would be caused by or undergone by a space object, including its component parts.
- Space Security is the protection of a space object, including its component parts, against the risk of intentional actions undertaken by external or unauthorized actors.

Space Security - Definitions

- The secure and sustainable access to, and use of, space and freedom from space-based threats- Space Security Index

- Secure and sustainable access to, and use of outer space in accordance with international laws and treaties, free from the threat of disruption - Space Generation Council

Why Space Security Issues?

- Increased use of space for civil, commercial and military purposes, besides exploration
- New and Multiple actors- More Space faring & Space active nations and Private players of these nations
- New technologies for access to space, spacecraft system, Space operations
  - Constellation satellites, Space Resources Mining, Space Tourism, Space Colonization etc.
- **Outer Space Is Congested, Contested and Competed**
- **Safety, Security and Sustainability under threat**

Dimensions of Space Security

- **Security – in Space**
  - Security to Space Objects, Space station and all activities performed in outer space through human endeavours - Threats From Ground or Space
- **Security – From Space**
  - Services availed from space objects in outer space for military, economic (commercial) and national security
- **Security - To Space Environment**
  - Creation of space debris, Placement of conventional arms and weapons of mass destruction, accidental dumping of nuclear materials, contamination of outer space by earth bound biological systems (living organisms, bacteria etc.) - (***Israeli Lunar Lander Beresheet crashed on lunar surface in 2019 - Spilled Tardigrades on the Moon)***

Space Security Index Project

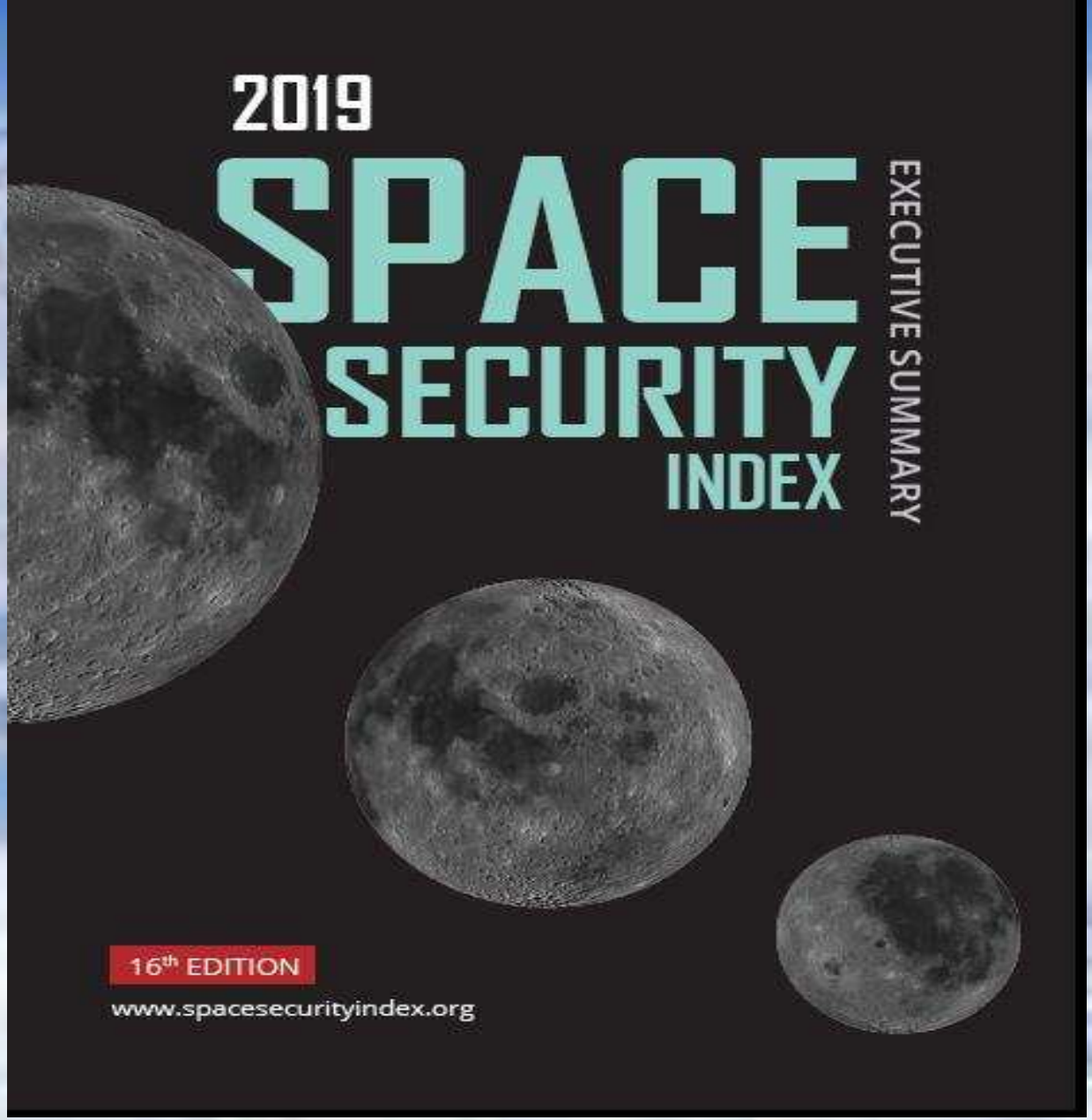
- The Space Security Index Project aims to improve trust and transparency related to space activities, and to provide a common, comprehensive, objective knowledge base to enhance capacity for dialogue and policies that contribute to the governance of outer space as a shared global commons.

- https://spacesecurityindex.org/

Space Security Index

The Space Security Index publication surveys developments in space security by assessing annual changes in eight indicators of space security. These are:

1. **The space environment**
2. **Space situational awareness**
3. **Laws, policies, and doctrines**
4. **Civil space and global utilities**
5. **Commercial space**
6. **Space support for terrestrial military operations**
7. **Space systems protection**
8. **Space systems negation**



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Space Debris

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 … …

Space Debris in motion

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

≈ **1950**
discarded rocket stages

≈ **2850**
defunct satellites

≈ **21 000**
unidentified debris objects and fragments

≈ **34 000**
fragments larger than 10 cm

≈ **900 000**
fragments
1–10 cm in size

≈ **128 million**
debris fragments
1 mm–1 cm in size

About **26 000 debris objects** are **monitored from Earth**

Smaller objects that cannot be monitored **estimated by statistical models**

#SpaceSustainability

Up-to-date as of December 2020

Space Debris – *Remedial Measures*

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

Key Counterspace Concepts

- **Kinetic Energy Threats:** Kinetic energy threats, or antisatellite (ASAT) missiles, are designed to destroy satellites without placing the weapon system or any of its components into orbit. These systems typically consist of a fixed or mobile launch system, a missile, and a kinetic kill vehicle. These weapons could also be launched from aircraft. Once released, the kinetic kill vehicle uses an onboard seeker to intercept the target satellite. Ground-based ASAT missile attacks are more easily attributed than some other counterspace weapons, such as DEW, and their effects can create orbital debris.
- **Directed Energy Weapons (DEW):** DEW use directed energy to disrupt, damage, or destroy enemy equipment and facilities. These weapons, which can have effects ranging from temporary to permanent, include lasers, high-power microwaves, and other types of radiofrequency weapons. It can be difficult to attribute the origin of a DEW attack, depending on the type.
- **Electronic Warfare:** EW includes using jamming and spoofing techniques to control the electromagnetic spectrum. EW can be challenging to attribute and distinguish from unintentional interference. Uplink jamming is directed toward the satellite and impairs services for all users in the satellite reception area. Downlink jamming has a localized effect because it is directed at ground users, such as a ground forces unit using satellite navigation to determine their location. Spoofing deceives the receiver by introducing a fake signal with erroneous information.

Key Counterspace Concepts

- **Orbital Threats:** Orbital or space-based systems are satellites that can deliver temporary or permanent effects against other spacecraft. These systems could include payloads such as kinetic kill vehicles, radiofrequency jammers, lasers, chemical sprayers, high-power microwaves, and robotic mechanisms. Some of these systems, such as robotic technology for satellite servicing and repair and debris removal, have peaceful uses but can also be used for military purposes.
- **Cyberspace Threats:** Cyberspace pervades all other warfighting domains, including space, and many space operations depend on cyberspace and vice versa. With sophisticated knowledge of satellite and data distribution networks, actors can use offensive cyberspace capabilities to enable a range of reversible to non-reversible effects against space systems, associated ground infrastructure, users, and the links connecting them.
- **Space Situational Awareness (SSA):** SSA is having current knowledge of a space object's location and the ability to track and predict its future location; it also incorporates understanding of an actor's intent for their spacecraft.22 SSA is necessary for space operations, including the ability to successfully target space objects and assess the effectiveness of an attack. Space object surveillance and identification sensors, which can include telescopes, radars, and space-based sensors, provide the data for SSA.

Trend of Space Weaponization

- The weaponization of space often refers to the deployment of conventional and nuclear weapons into orbit or their launch from orbit to Earth.
- This definition includes –
  - ground-to-space weapons (such as a direct-ascent anti-satellite missile),
  - Space-to-space weapons (such as manoeuvring one satellite close to another in order to be within range to interfere with its electronics), and
  - space-to-ground weapons (such as proposed space-based interceptors).

  These weapons categories are often referred to as counterspace weapons.

Space Weapon

The Union of Concerned Scientists has offered a series of definitions that attempt to address these issues.

- A space weapon is defined as “any device or component of a system designed to inflict physical harm through deposition of mass and/or energy on any other object.”
- “Weapons in space” are defined as “those that travel on a complete or partial orbit, or are placed at a stable point beyond Earth orbit.”
- In addition “a component that is part of a system not exclusively based in space, such as a relay for a ground-based laser, would be considered a space-based weapon” *(United Nations Institute for Disarmament Research 2004, pp. 45–46).*

Types Of Space Weapons

- **Kinetic Physical** - A direct-ascent ASAT
- **Non-Kinetic Physical** - lasers, high-powered microwave (HPM) weapons, and electromagnetic pulse (EMP) weapons
- **Electronic**- jamming, or spoofing radio frequency (RF) signals.
- **Cyber**- cyberattacks target the data itself and the systems that use this

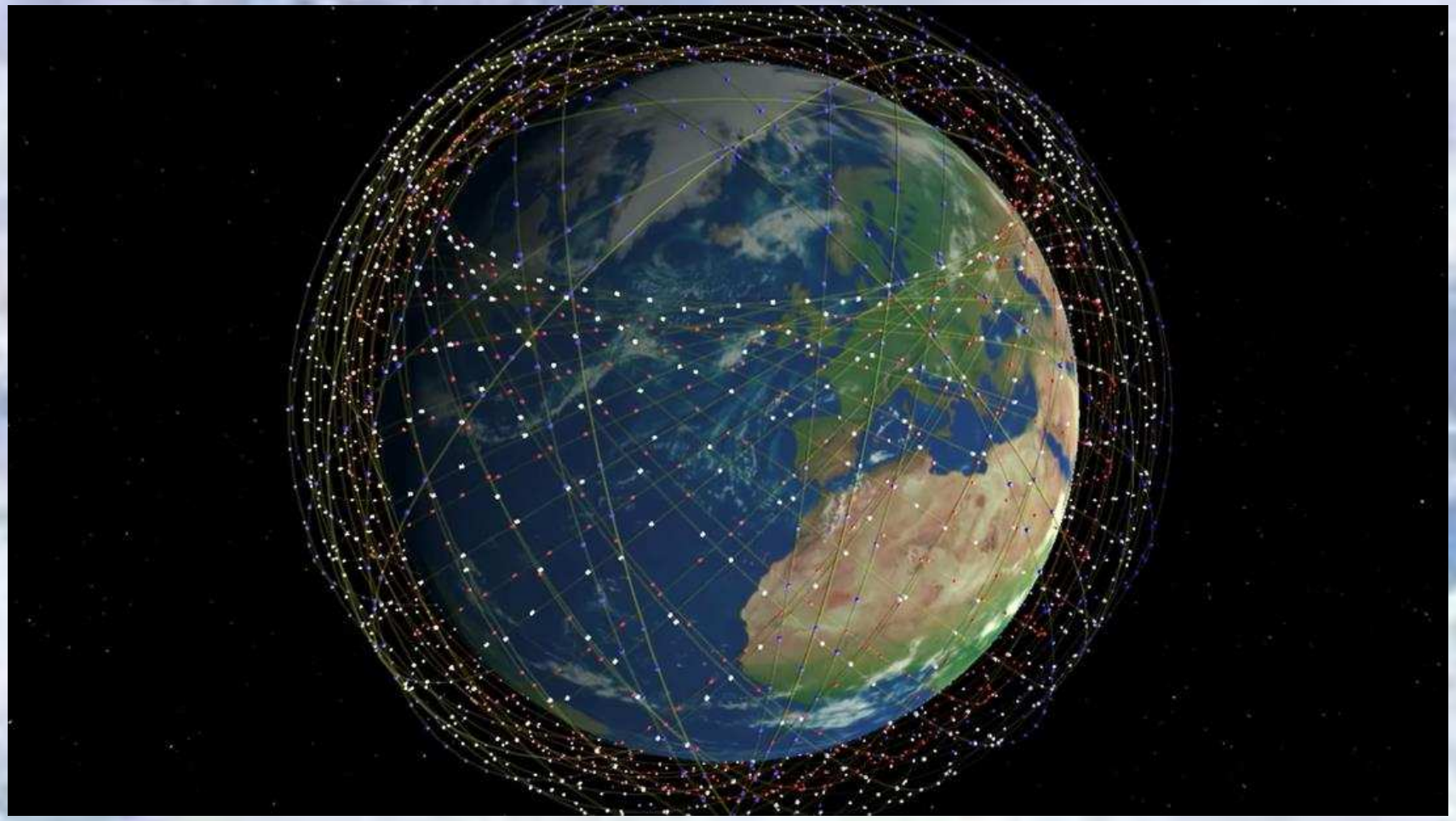
TYPES OF COUNTERSPACE WEAPONS

	Kinetic Physical			Non-Kinetic Physical			
Types of Attack	Ground Station Attack	Direct-Ascent ASAT	Co-Orbital ASAT	High Altitude Nuclear Detonation	High-Powered Laser	Laser Dazzling or Blinding	High-Powered Microwave
Attribution	Variable attribution, depending on mode of attack	Launch site can be attributed	Can be attributed by tracking previously known oribt	Launch site can be attributed	Limited attribution	Clear attribution of the laser's location at the time of attack	Limited attribution
Reversibility	Irreversible	Irreversible	Irreversible or reversible depending on capabilities	Irreversible	Irreversible	Reversible or irreversible; attacker may or may not be able to control	Reversible or irreversible; attacker may or may not be able to control
Awareness	May or may not be publicly known	Publicly known depending on trajectory	May or may not be publicly known	Publicly known	Only satellite operator will be aware	Only satellite operator will be aware	Only satellite operator will be aware
Attacker Damage Assessment	Near real-time confirmation of success	Near real-time confirmation of success	Near real-time confirmation of success	Near real-time confirmation of success	Limited confirmation of success if satellite begins to drift uncontrolled	No confirmation of success	Limited confirmation of success if satellite begins to drift uncontrolled
Collateral Damage	Station may control multiple satellites; potential for loss of life	Orbital debris could affect other satellites in similar orbits	May or may not produce orbital debris	Higher radiation levels in orbit would persist for months or years	Could leave target satellite disabled and uncontrollable	None	Could leave target satellite disabled and uncontrollable

	Electronic			Cyber		
Types of Attack	**Uplink Jamming**	**Downlink Jamming**	**Spoofing**	**Data Interccept or Monitoring**	**Data Corruption**	**Seizure of Control**
Attribution	Modest attribution depending on mode of attack	Modest attribution depending on mode of attack	Modest attribution depending on mode of attack	Limited or uncertain attribution	Limited or uncertain attribution	Limited or uncertain attribution
Reversibility	Reversible	Reversible	Reversible	Reversible	Reversible	Irreversible or reversible, depending on mode of attack
Awareness	Satellite operator will be aware; may or may not be known to the public	Satellite operator will be aware; may or may not be known to the public	May or may not be known to the public	May or may not be known to the public	Satellite operator will be aware; may or may not be known to the public	Satellite operator will be aware; may or may not be known to the public
Attacker Damage Assessment	No confirmation of success	Limited confirmation of success if monitoring of the local RF environment is possible	Limited confirmation of success if effects are visible	Near-real time confirmation of success	Near-real time confirmation of success	Near-real time confirmation of success
Collateral Damage	Only dirupts the signals targeted and possible adjacent frequencies	Only disrupts the signals targeted and possible adjacent frequencies	Only corrupts the specific RF signals targeted	None	None	Could leave target satellite disabled and uncontrollable

Small / Nano Satellite Constellations

Proposed Starlink Satellite Constellation



Starlink Satellites in orbit

A train of SpaceX Starlink satellites are visible in the night sky in this still from a video captured by satellite tracker Marco Langbroek in Leiden, the Netherlands on May 24, 2019, just one day after SpaceX launched 60 of the Starlink internet communications satellites into orbit. (Source: Space.com; Image: © Marco Langbroek via SatTrackBlog)

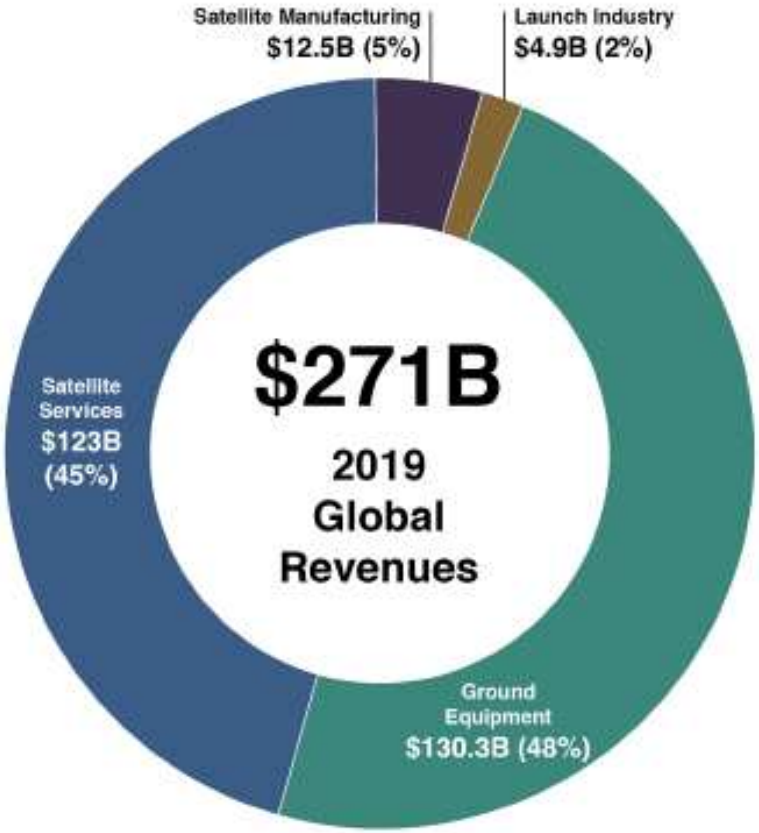
Space Traffic Management

- **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**

Private Sector Participation

2019 Top-Level Global Satellite Industry Findings



For more information on the satellite industry, or for previous SSIR reports, contact SIA:

Satellite Industry Association
info@sia.org
202-503-1560
www.sia.org

Prepared by:
Bryce Space and Technology
brycetech.com

Satellite Services

2019 Revenues: $123B

Television	$92B
Radio	$6.2B
Broadband	$2.8B
Fixed	$17.7B
Mobile	$2B
Remote Sensing	$2.3B

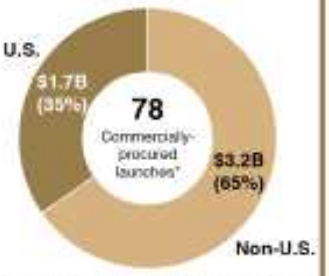
Satellite Manufacturing

2019 Revenues: $12.5B

Satellites Launched by Mission Type

Launch Industry

2019 Revenues $4.9B



* There were 102 total orbital launches in 2019. Of these, 78 were commercially procured, 9 were not commercially procured, and 15 involved space vehicles.

Commercial Launch Revenues by Region

Ground Equipment

2019 Revenues $130.3B

$17.9B
Consumer Equipment
(Satellite TV dishes, etc.)

$97.4B
GNSS Equipment
(GNSS devices/chipsets)

$15B
Network Equipment
(VSATs, gateways, etc.)

Article VI of Outer Space Treaty

- **States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty. ….**

Constituent Elements of body of Space Law

- **UN Principles-** *Declaration of Legal Principles, 1963; Broadcasting Principles, 1982; Remote Sensing Principles, 1986; Nuclear Power Sources" Principles, 1992; Benefits Declaration, 1996.*
- **UN Treaties –** ***Five Treaties*** **-** ***(Details in next slide)***
- **UNGA Resolutions –** *International Cooperation 1961; Launching State, 2004; Registration Practices, 2007; National Legislation, 2013, … …*
- **Other Documents** – *Space Debris Mitigation Guidelines, 2007; Safety Frame Work for NPS, 2009, Transparency and Confidence Building Measures (TCBMs) 2013, Long Term Sustainability of Outer space activities (2010.. 2018?)*

UN Treaties on Outer Space Activities

- **Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty) 1967**
- **Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (Rescue Agreement) 1968**
- **Convention on International Liability for Damage Caused by Space Objects (Liability Convention) 1972**
- **Convention on Registration of Objects Launched into Outer Space (Registration Convention) 1975**
- **Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement) 1979**

Conclusion

- **Outer Space – Province of Man-kind**
- **Fair & Responsible use of Outer Space Activities by all stake holders**
- **Space Systems for wide variety of applications – Becomes critical national infrastructure**
- **Outer Space Resources – Common Heritage of mankind – Deriving benefits of all countries**
- ***Outer Space environment to be used for peaceful purposes and to be sustained for future generation.***
- ***Way Forward.. Cooperation all nation states towards reaching common security in outer space affairs***

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