Satellite Infrastructure Security and Resilience

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Agenda

- Political and Technological Evolution
- Cybersecurity and Notable Attacks
- Collisions and Accumulating Waste
- Security Measures
- Resiliency Initiatives
- Laws Governing Space Operations

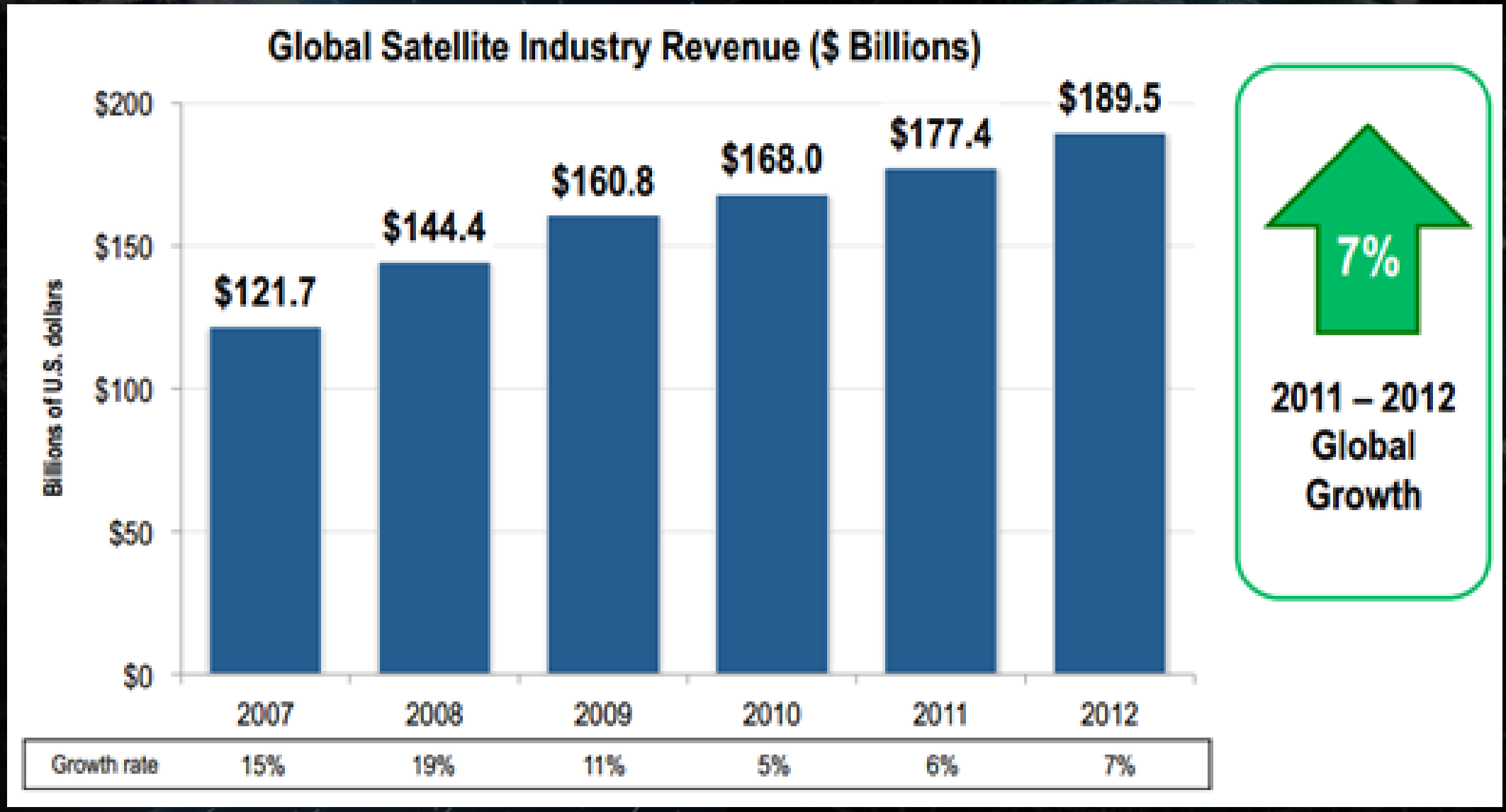
What is a satellite?

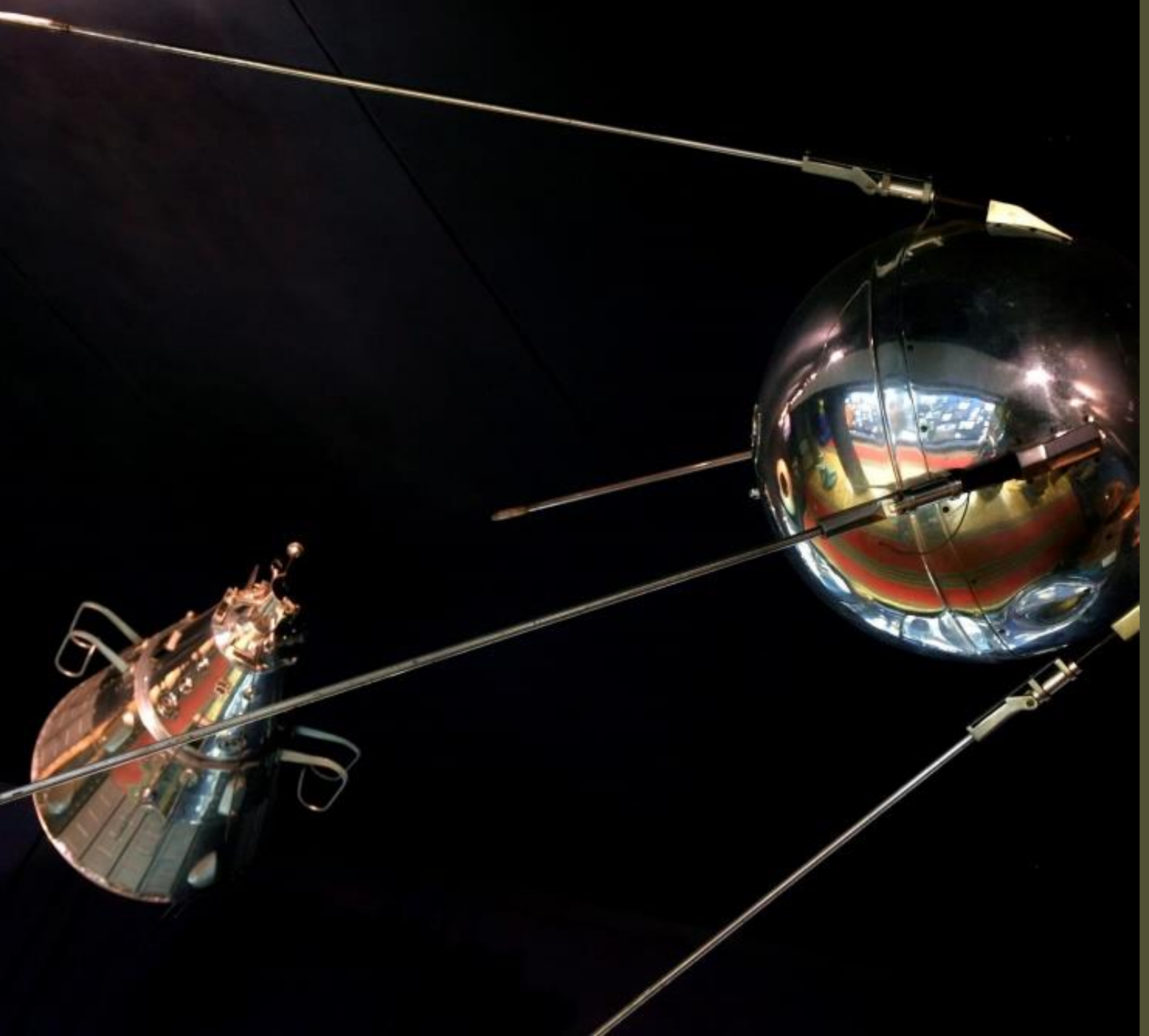
Definition: A body that orbits another body in Space.

Background

- Remote Location: Upper Atmosphere and Beyond
- Capabilities: Overestimated and Underestimated
- Cross Medium: Cyberspace and Atmospheric Space
- Distant but Integral: Increasing Societal Dependence
- Serious Investment: Technological Strides
  vs. Unforgiving Environment

Projected Growth in 2013





Political and Technological Evolution

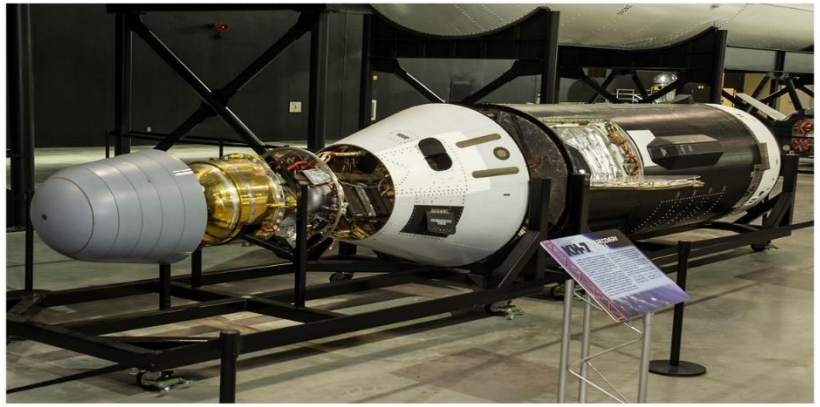
Left: Sputnik (pronounced “Spoot-nik”), the first satellite successfully launched into space by the Soviet Union on Oct. 4th 1957

Early Political Origins

- During the Space Race of the 20th century (1955-1971), the United States and the Soviet Union sought to gain an upper hand in the Cold War by attaining superior space technologies
- Soviet Union achieved the first major milestones with the successful **launch of Sputnik(1957)** and the successful **orbital flight of Yuri Gagarin(1961).**
- Through the continual development of its NASA Space Program, the U.S. quickly gained ground and with the success of the **Apollo 11 Mission(1969)** and **Neil Armstrong's walk on the moon** proved itself superior.

Space Reconnaissance during Cold War

Gambit 3 KH-8
DAYTON, Ohio -- Gambit 3 KH-8 reconnaissance satellite in the Cold War Gallery at the National Museum

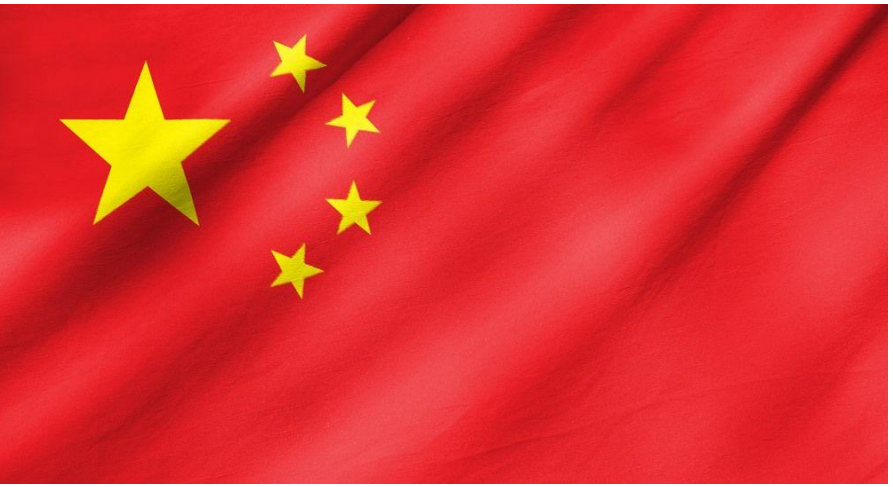


GAMBIT 1 KH-7 Reconnaissance Satellite
DAYTON, Ohio -- Gambit 1 KH-7 reconnaissance satellite in the Space Gallery at the National Museum of the U.S. Air Force. (U.S. Air Force Photo)

HEXAGON KH-9 Reconnaissance Satellite
DAYTON, Ohio -- The HEXAGON KH-9 Reconnaissance Satellite in the Space Gallery at the National

- Both the U.S. and U.S.S.R. used satellites for photo reconnaissance
- During 1960s-1990s, satellites images allowed the U.S. to track adversaries progress towards developing nuclear weapons.
- In upper atmosphere → not vulnerable to anti-aircraft weapons
- Development supported by NRO, DoD, and CIA
- Long-standing asset to National Security

Additional info available on National Museum of the United States Air Force



Modern Political Role

- Three world powers, **U.S. (2,944), China(499),** and **Russia(169)** compete for space superiority
- Space is the next frontier for expansion: Limited governance, room for technological expansion
- Dr. Marial Borowitz, Associate Professor:
  - **Guidelines needed for permissible behavior**
  - **Establishment of Safety Zones**
- Major Brian Stewart, Ph.D. Student:
  - **"Space has always been weaponize"**
  - **"Unlikely place for military action"**
- Countries are hesitant to **share data,** but mutual interest must be invested to build **effective laws**.

Cybersecurity and Notable Attacks

Cyber Vulnerability

- Cyberattacks are a very economical and viable threats
  - Less detectable than Missile Attacks, ASAT
  - Leave little evidence
  - Attribution is challenging
- Hackers seek to attempt exploit vulnerabilities to hijack satellites
  - Seize control of less secure satellite to use as projectile against more secure satellite
  - Orientate hijacked satellite in the wrong direction
  - Move hijacked satellites into orbit of another satellite
- Nation-States attempt to disrupt each other's satellite operations
  - Jamming of GPS Satellites
  - Corrupting of Data Transmission of Satellites
  - Hijack another satellite without causing damage
  - Hacking Third-Party Vendors

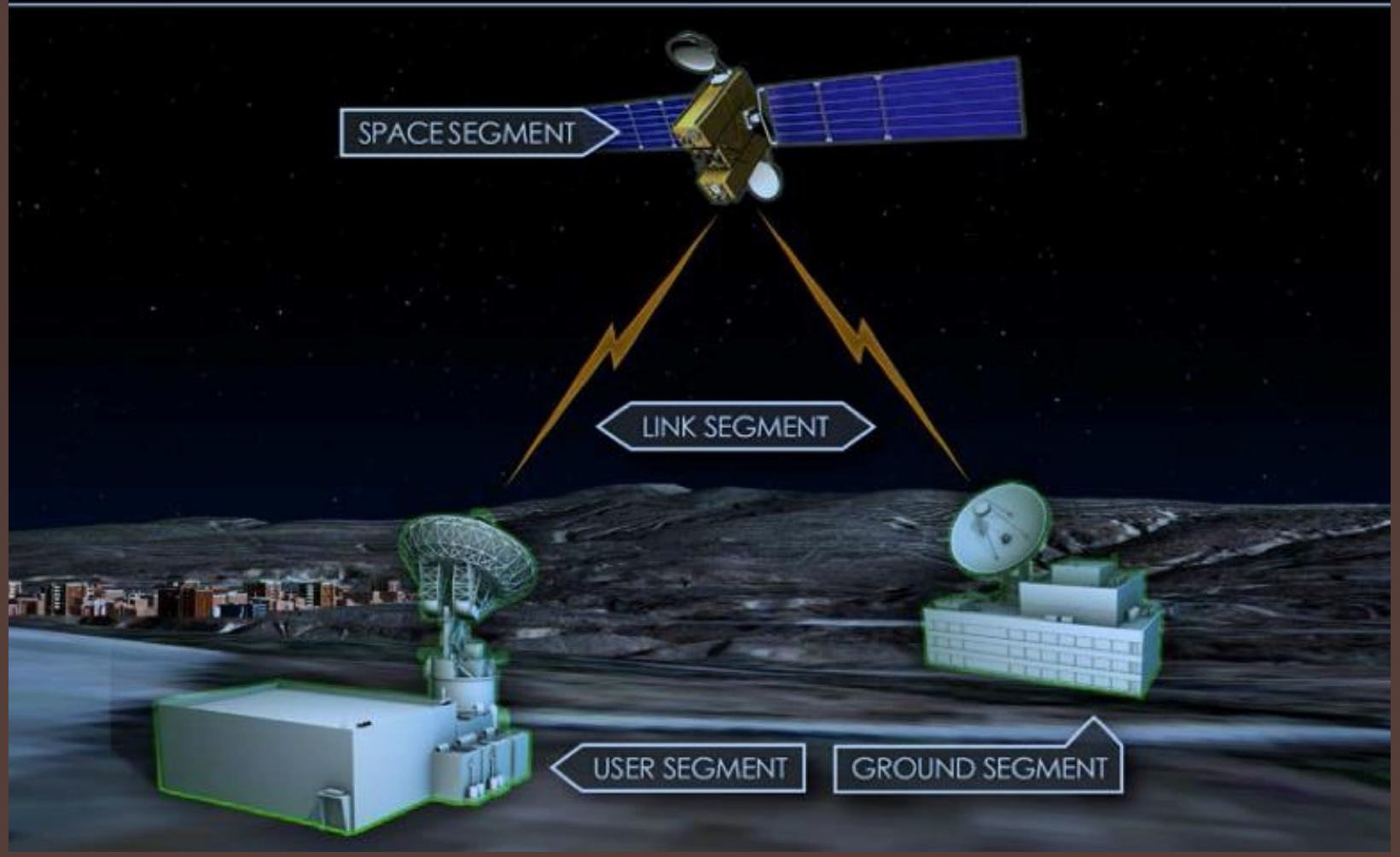
CYBER THREATS TO SPACE SYSTEMS

SPACE SEGMENT
- Command Intrusion
- Payload Control
- Denial of Service
- Malware

USER SEGMENT
- Spoofing
- Denial of Service
- Malware

LINK SEGMENT
- Command Intrusion
- Spoofing
- Replay

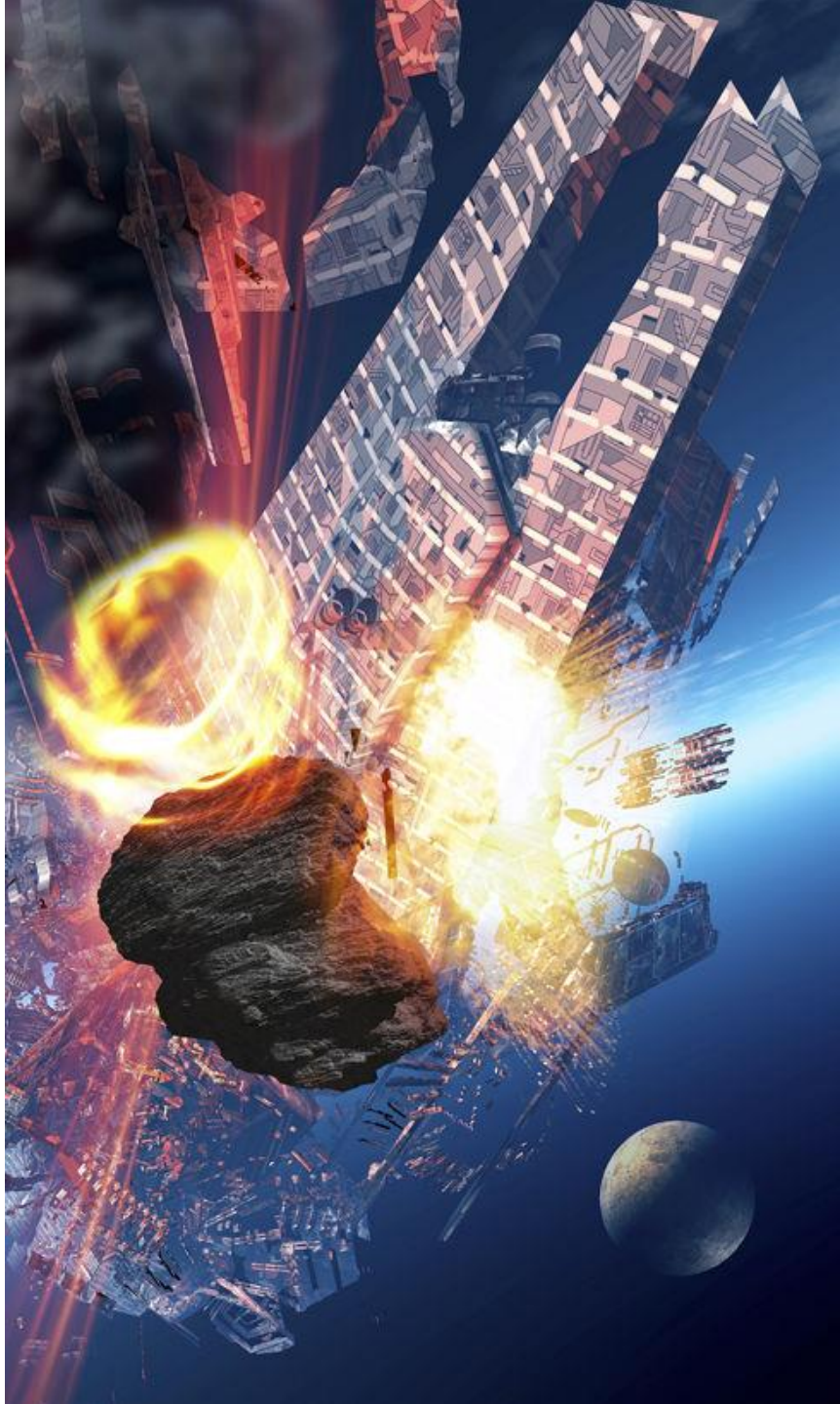
GROUND SEGMENT
- Hacking
- Hijacking
- Malware



Threat of Accumulating Waste

Danger of Collisions

- Dr. Mariel Borowitz: Excessive debris in space poses the greatest threat to space sustainability
- Cleaning space debris → Tedious task → Not highly prioritized.
- China, European Space Agency, CleanSpace initiatives to clean up space
- Nations are responsible for debris of their satellites
- Misinterpreted collisions could escalate tensions



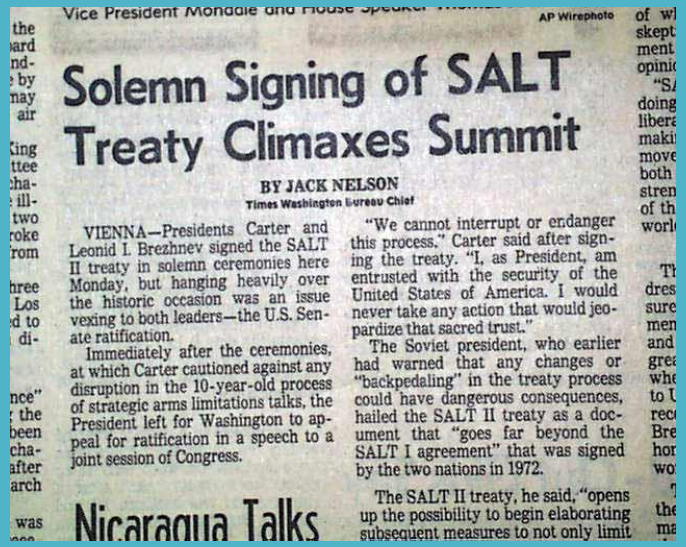
THE PRESENT — DECEMBER 7, 2020

Giant 'space claw' to begin cleaning cosmic debris in 2025

The rush to clean up outer space has begun.

Security and Resilience

Security Measures Against Malicious Cyber Attacks



Vice President Mondale and House Speaker ... AP Wirephoto

Solemn Signing of SALT Treaty Climaxes Summit

BY JACK NELSON
Times Washington Bureau Chief

VIENNA—Presidents Carter and Leonid I. Brezhnev signed the SALT II treaty in solemn ceremonies here Monday, but hanging heavily over the historic occasion was an issue vexing to both leaders—the U.S. Senate ratification.

Immediately after the ceremonies, at which Carter cautioned against any disruption in the 10-year-old process of strategic arms limitations talks, the President left for Washington to appeal for ratification in a speech to a joint session of Congress.

"We cannot interrupt or endanger this process," Carter said after signing the treaty. "I, as President, am entrusted with the security of the United States of America. I would never take any action that would jeopardize that sacred trust."

The Soviet president, who earlier had warned that any changes or "backpedaling" in the treaty process could have dangerous consequences, hailed the SALT II treaty as a document that "goes far beyond the SALT I agreement" that was signed by the two nations in 1972.

The SALT II treaty, he said, "opens up the possibility to begin elaborating subsequent measures to not only limit

Nicaragua Talks

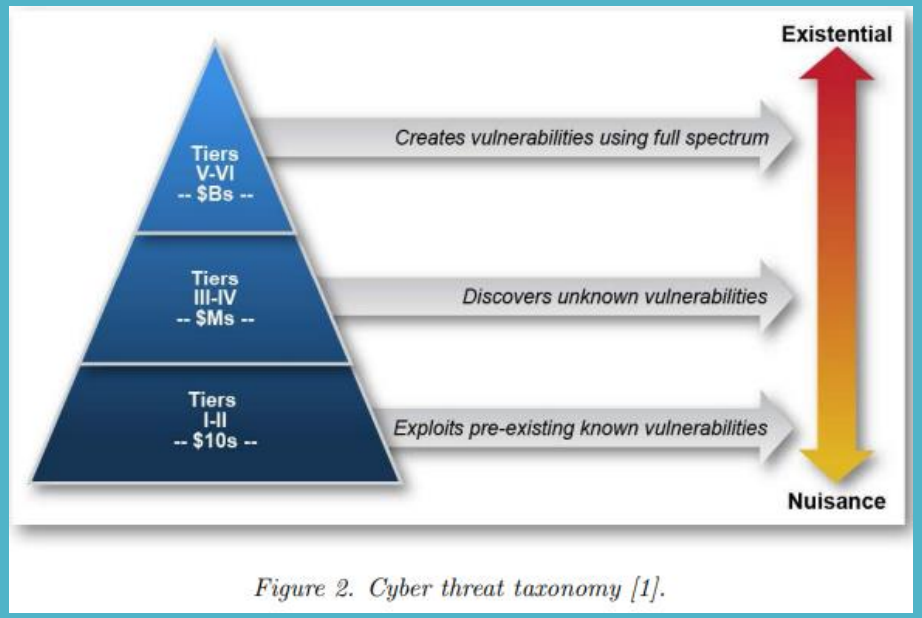
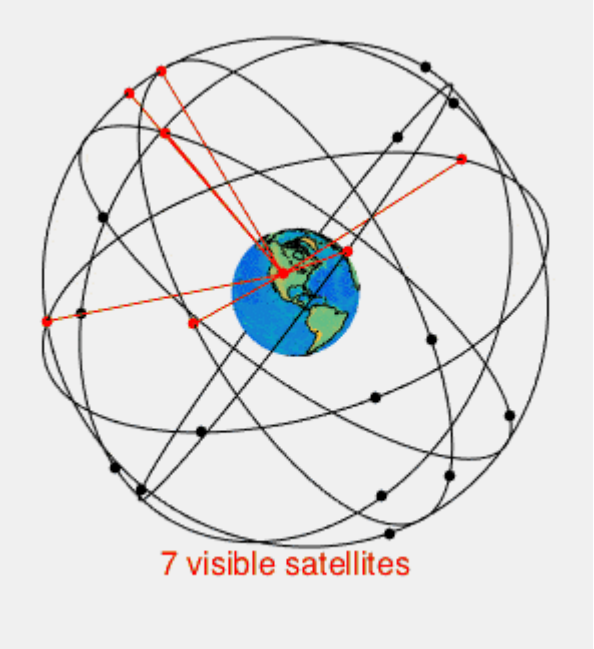


Figure 2. Cyber threat taxonomy [1].

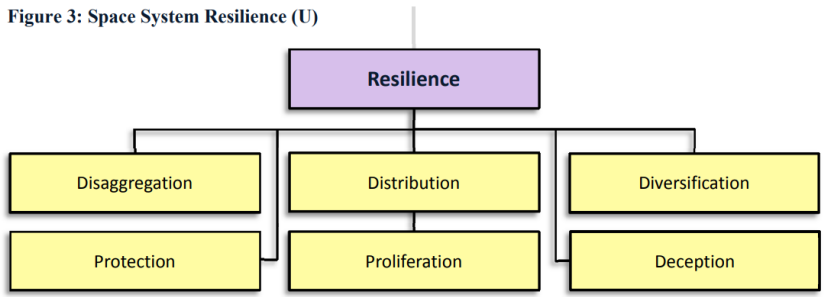
- Technical Staff at MIT: Not possible to measure vulnerability of satellite as attack surface too broad
  - Possible to test system against known threat models
  - Tiered System for testing attacks based on resources available to hacker
- Major defense contractors (national labs, private companies) work with the government to maintain high-functioning satellite systems and assist in creating new satellites.
- International treaties that offer guidelines on 'Space Etiquette'
  - Legal minimum distance between satellites in orbit
  - Expected response to various damages to satellites
- Require third-party vendors contracting with satellite systems to have a consistent standard of operations

Resilience Initiatives

- **Space Domain Resilience White Paper:** "Resilience now squarely becomes the capability designer's problem and becomes tradable with other system characteristics"
- **Satellite Constellations:** Distributing task and functionality of larger satellite over cheaper, more compact satellites that can be lost without crashing system.
- Schools of Thought to develop better Strategic Space Operations: **Space Sanctuary, Space Superiority, Space Survivability, and Space Dominance**
- **Agencies and Branches dedicated to space operations:** Space Development Agency, Space Force
- Backup Systems in place in **case satellite constellation disrupted**



GPS Constellation Model

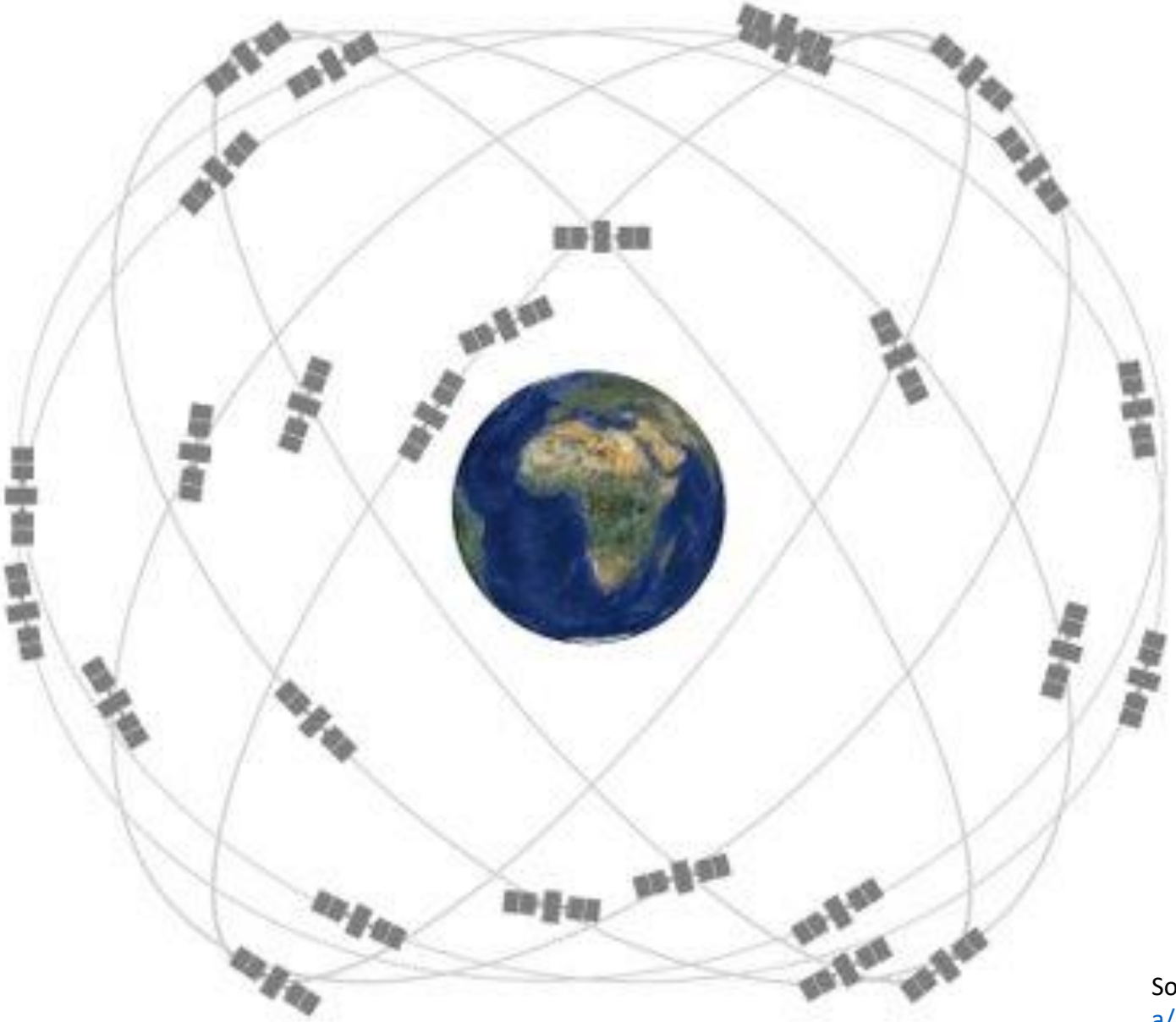


Security measures

- NIST Federal Information Processing Standard 140-3
- Defense Department's Instruction 8420-2
- USSF's Defensive Cyber Operations (DCO) team
- Remote operations capabilities
- Incident response
- Symposiums on Space Cybersecurity
- Project Moonlighter (Hack-A-Sat initiative)

Resiliency of Satellites

- Satellite Constellation
- Multiple stakeholders
- Space Domain Mission Assurance
  - Defensive Operations
  - Reconstitution
  - Resilience



Source: https://www.gps.gov/multimedia/images/constellation.jpg

Laws Governing Satellite Security

- Outer Space Treaty
- UNOOSA – United Nations Office of Outer Affairs
  - Technical Sub-committee
- National Space Policy
    - SPD 5
- Re-establishment of National Space Council

Questions for Discussion

- China and other countries has recently launched initiatives to clean up space debris. Should private companies (SpaceX, BlueOrigin, Bigelow) also try to join this initiative? Should they prioritize this plan over other new markets such as Space Tourism?
- Policy discussions with Russia regarding space policy have been put on hold due to the Ukraine Invasion. Should the rest of the world resume diplomacy without Russia or wait longer to see how situation evolves?
- Nations often outsource some of their development to third-party vendors. The potential trade-offs may include lower standards of security and resilience in exchange for concentrated expert development and cheaper cost. Do you think this trade off is reasonable?

References

https://www.satellitetoday.com/cybersecurity/2021/12/16/us-space-force-to-launch-project-moonlighter-cybersecurity-satellite/