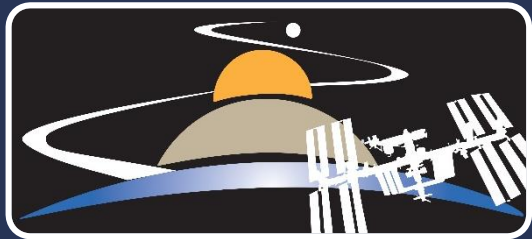


UNIP



**Exploration Research and
Technology Programs**



Mission Relevance

6 June 2023

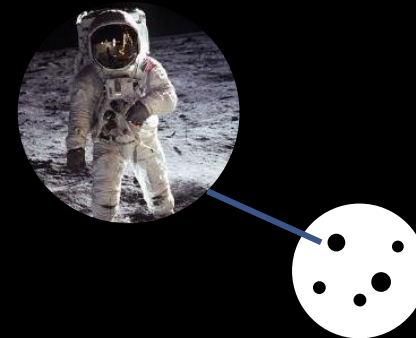
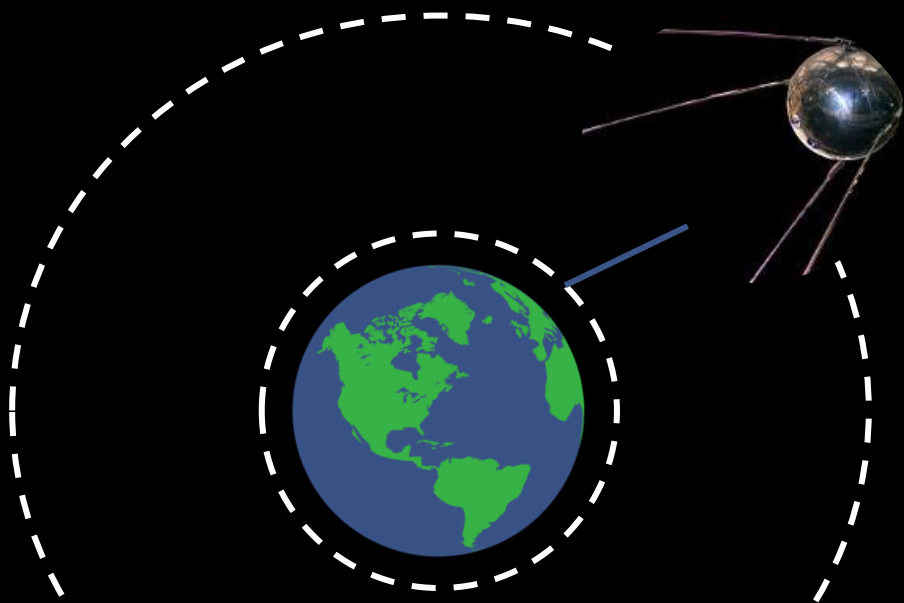
Dr. Lawrence M. Robertson III

Lead Space Experimentalist, Air Force Research
Laboratory

AFRL/RV



UNP The Original Space Race



1969

~1500 objects

LEO, MEO, GEO, Lunar, Keplerian

~7 nations, 2 to moon

UNP The Current Space Race



SPACEX +12,000
amazon +3500
OneWeb +2500
ACCESS FOR EVERYONE



Mission Extension Vehicle



Satellite collisions and breakups

ASAT tests



Lunar Gateway



Lunar X Prize



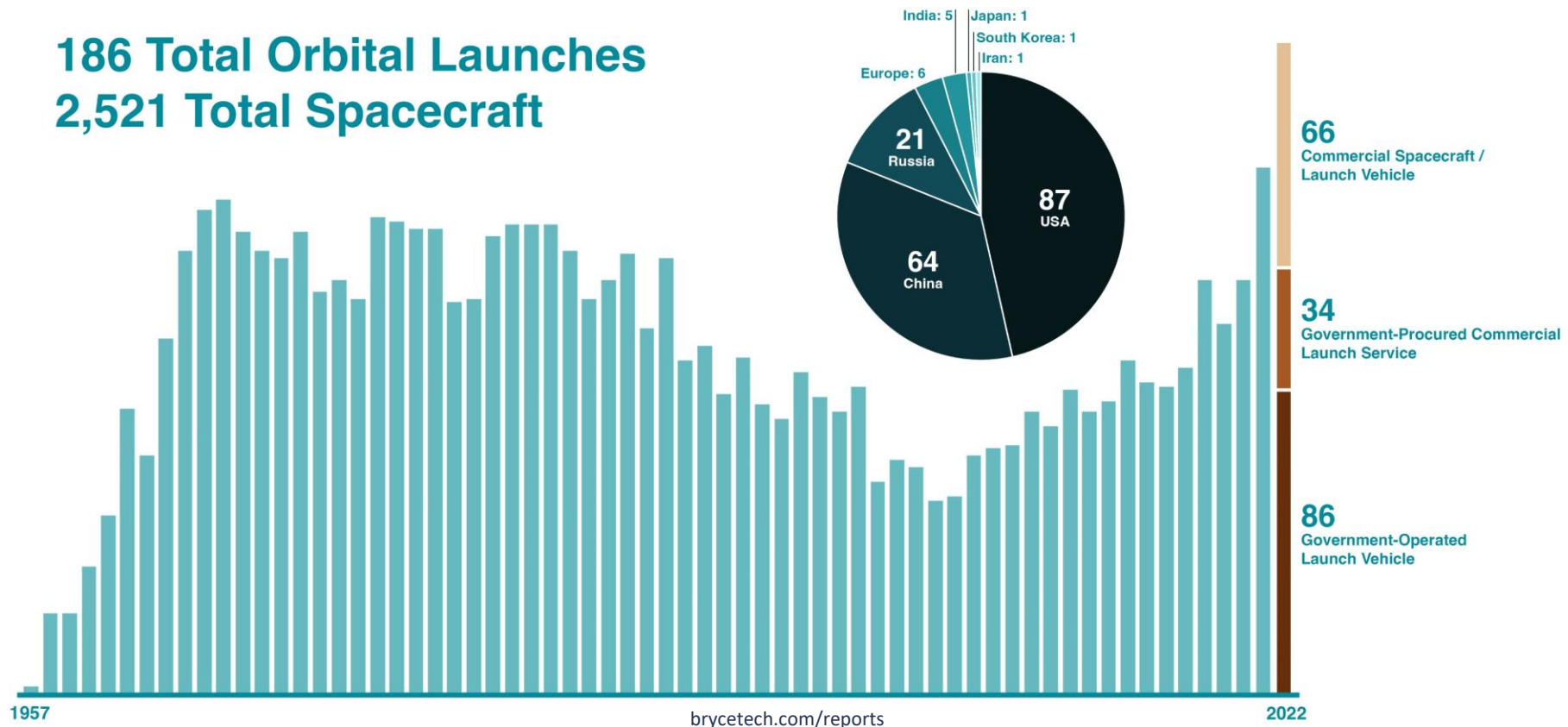
Queqiao

1969	Today	2030+
~1500 objects	~10 ⁴ objects, varied sizes, human operated	10 ⁶ objects, shoebox-sized, autonomous
LEO, MEO, GEO, Lunar, Keplerian	LEO, MEO, GEO, Keplerian	Cis-lunar sphere, non-Keplerian
~7 nations, 2 to moon	~12 space faring nations, ~90 nations with satellites	Many nations, non-state actors, corporations



2022 Launch Year in Review

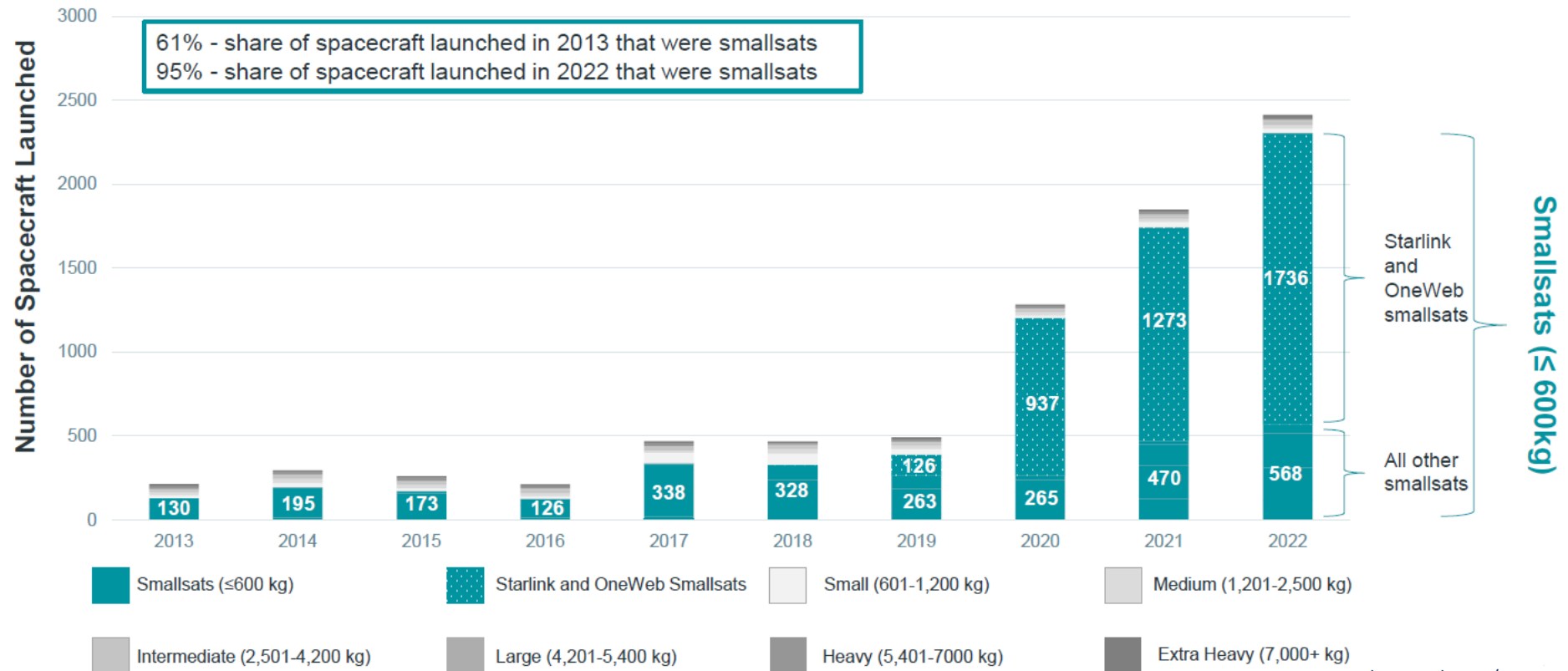
186 Total Orbital Launches
2,521 Total Spacecraft





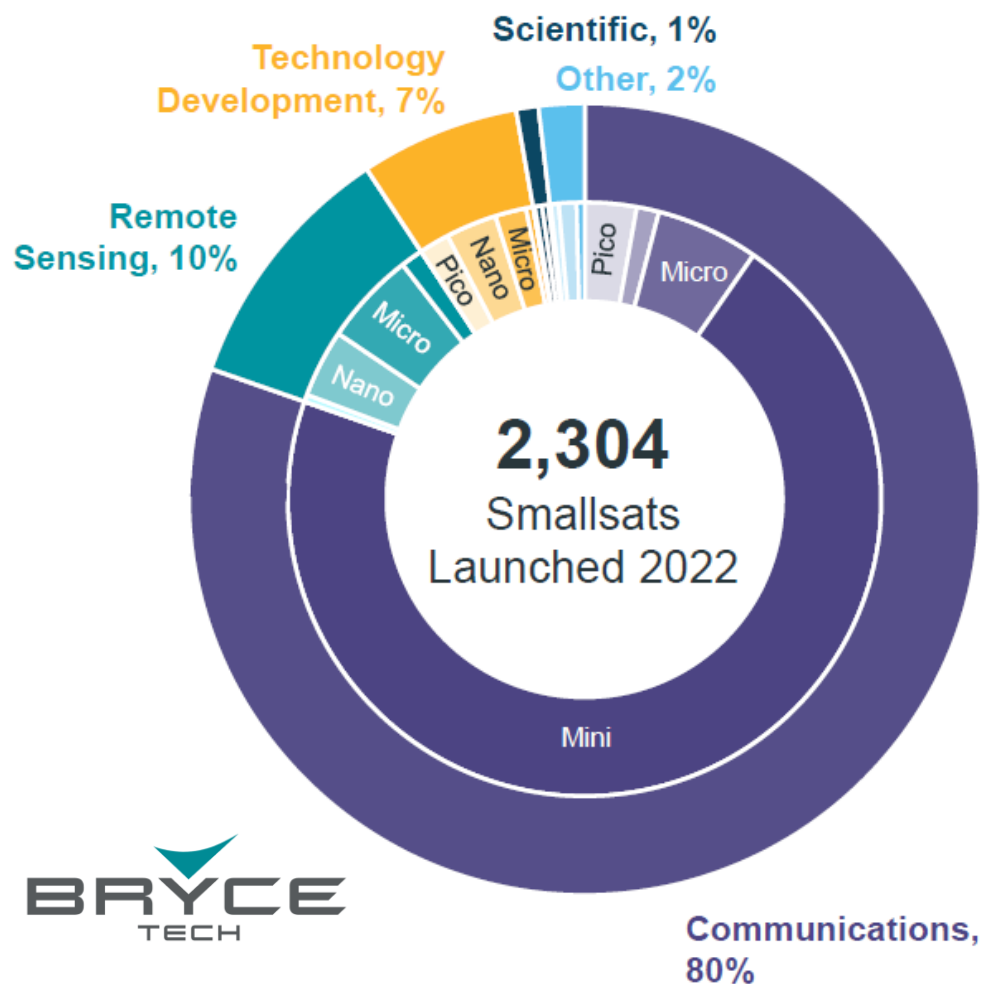
Smallsats in Context

Spacecraft Launched 2013 – 2022, by Mass Class

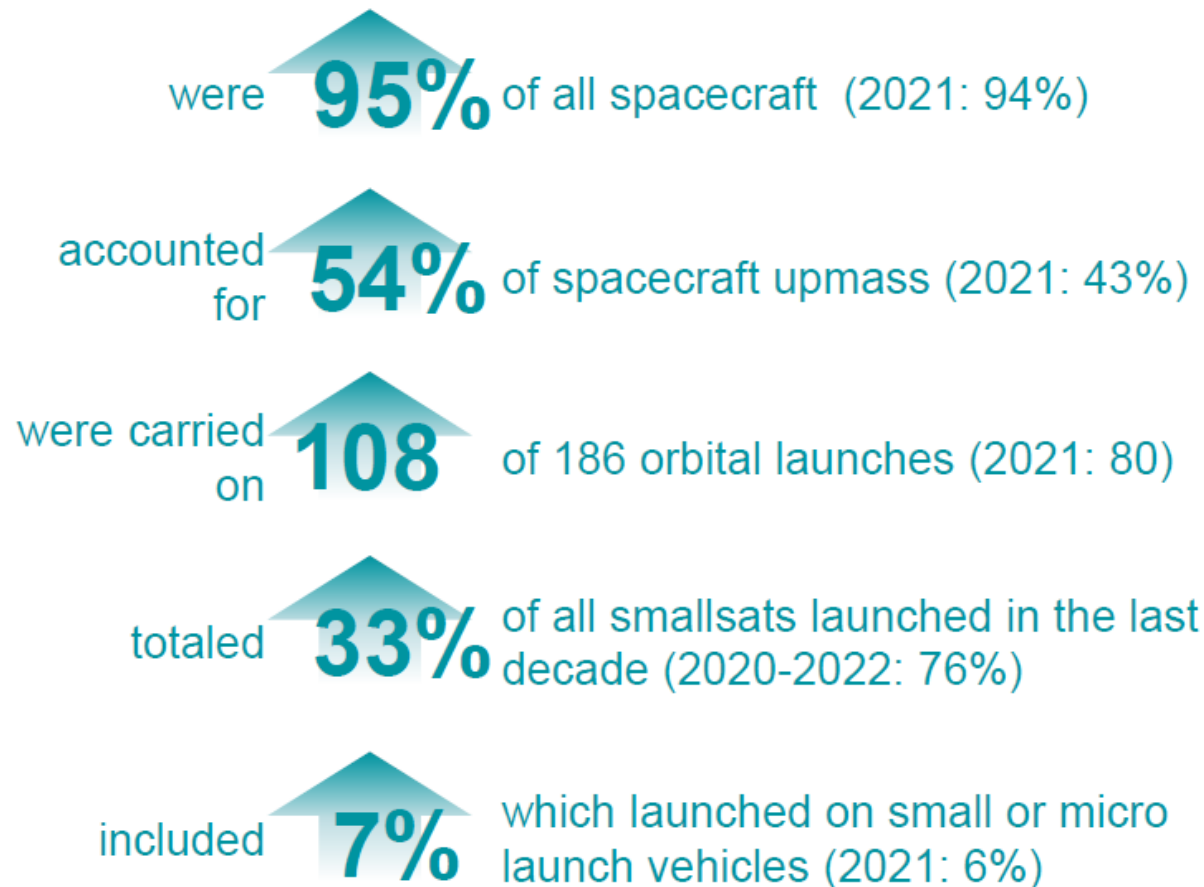


brycetech.com/reports

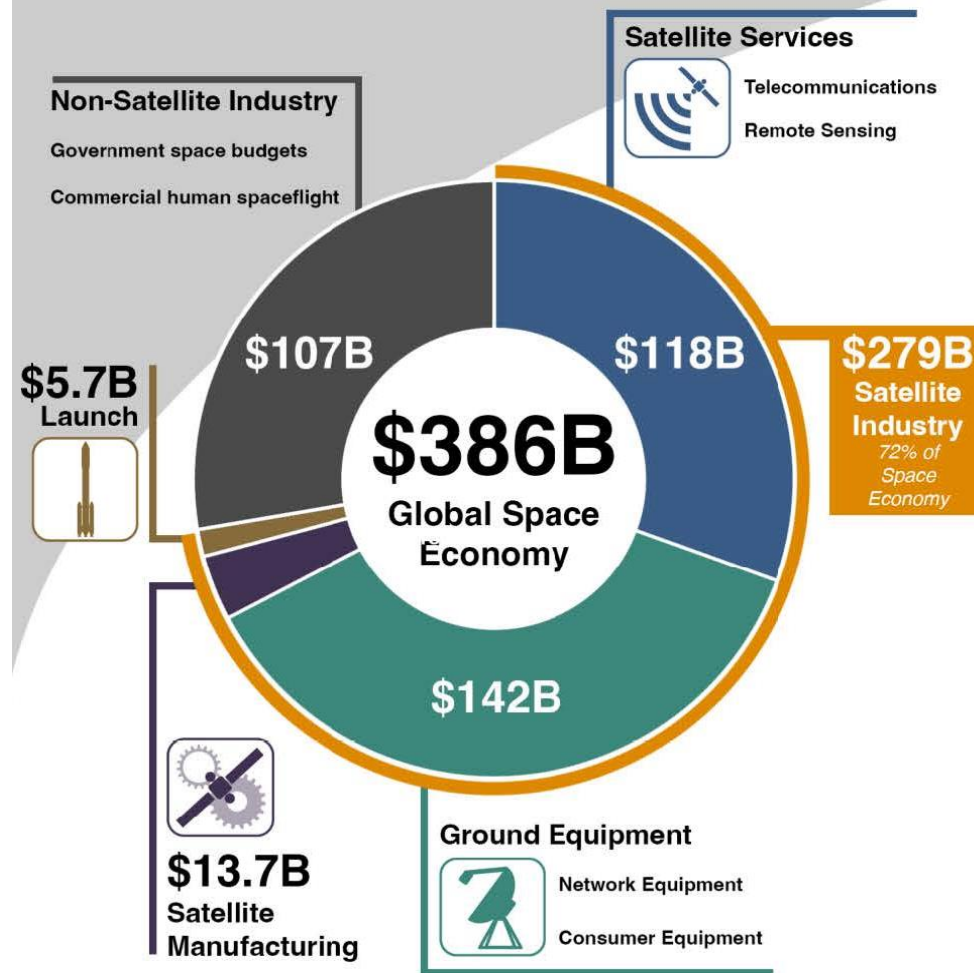
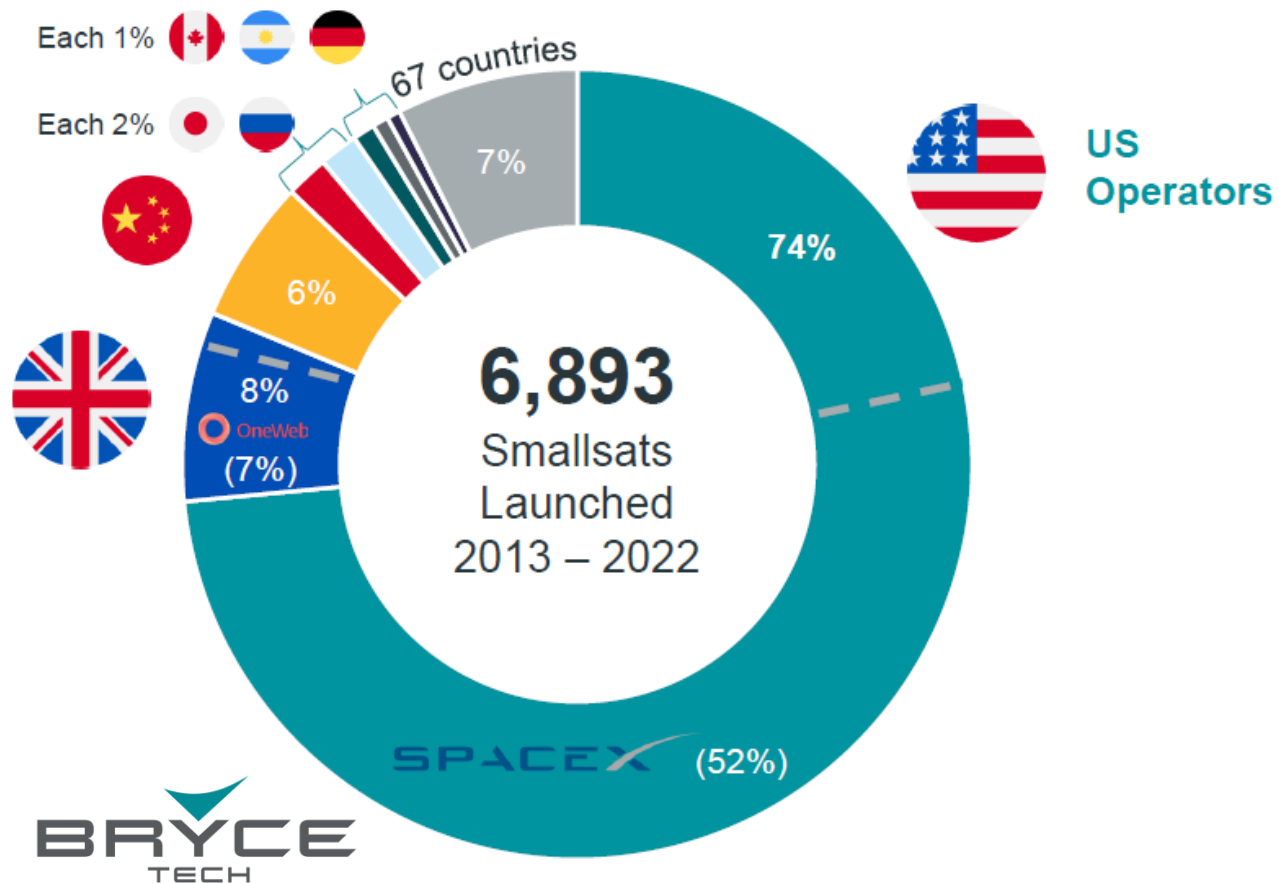
UNP 2022 Smallsat Highlights



Smallsats launched in 2022:



brycetech.com/reports

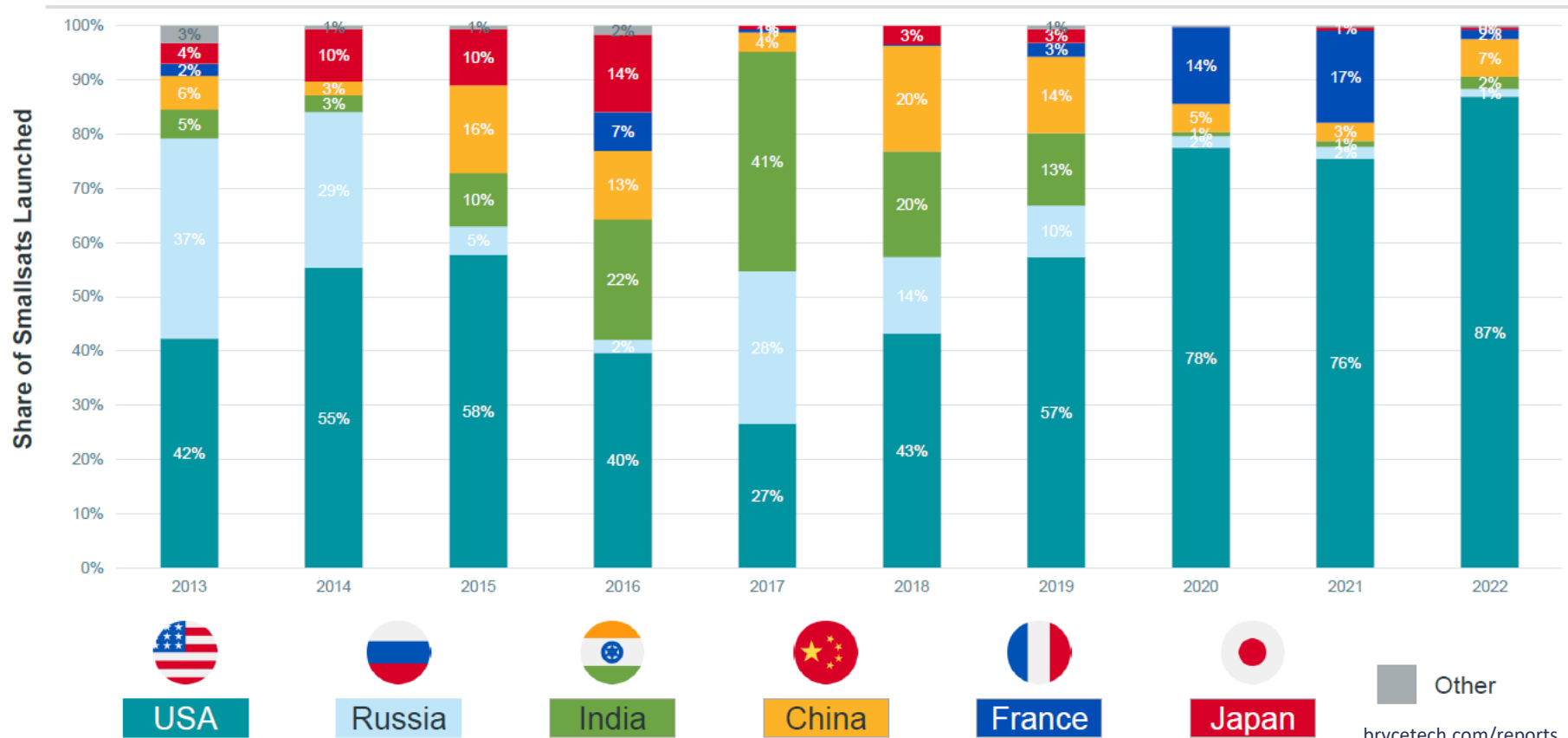


brycetech.com/reports



Smallsat Launch Trends

Smallsats 2013 – 2022, by Country of Launch Provider

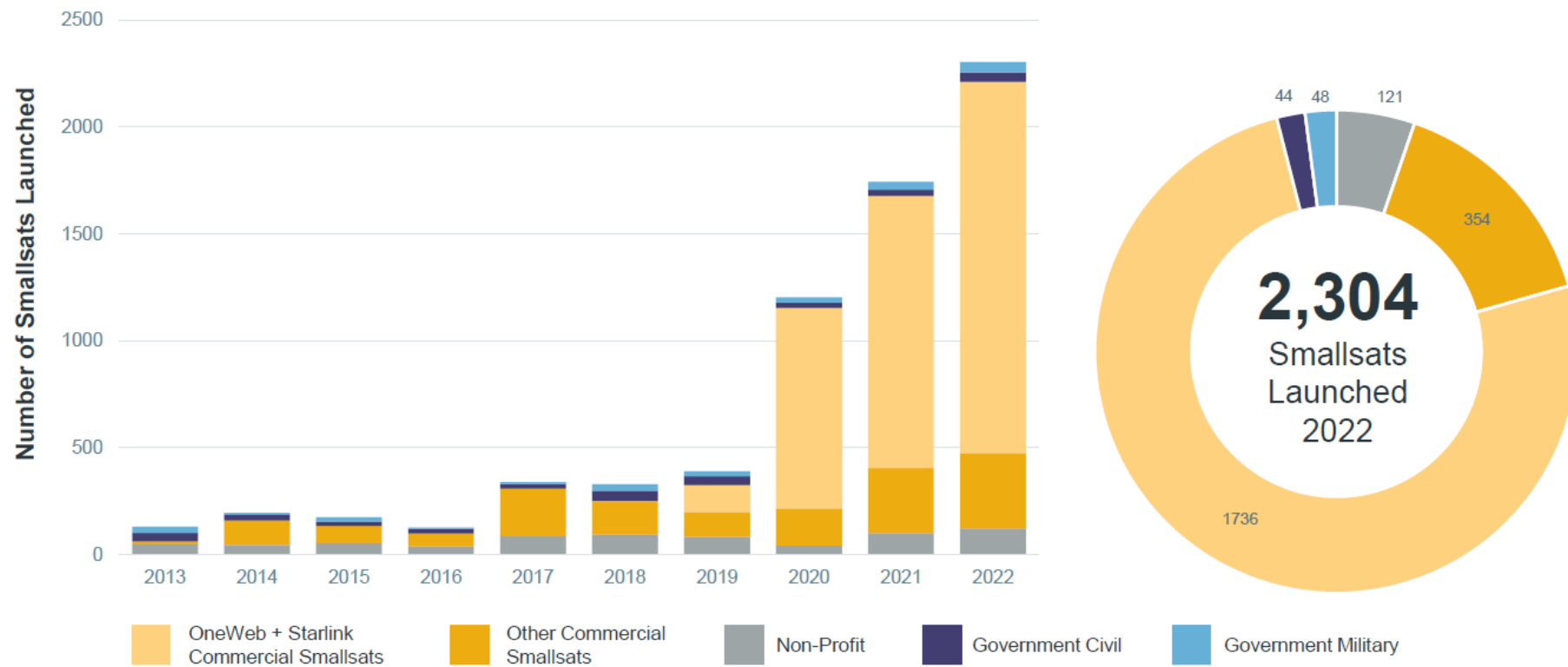


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Operator and Mission Type Trends

Number of Smallsats 2013 – 2022, by Operator Type



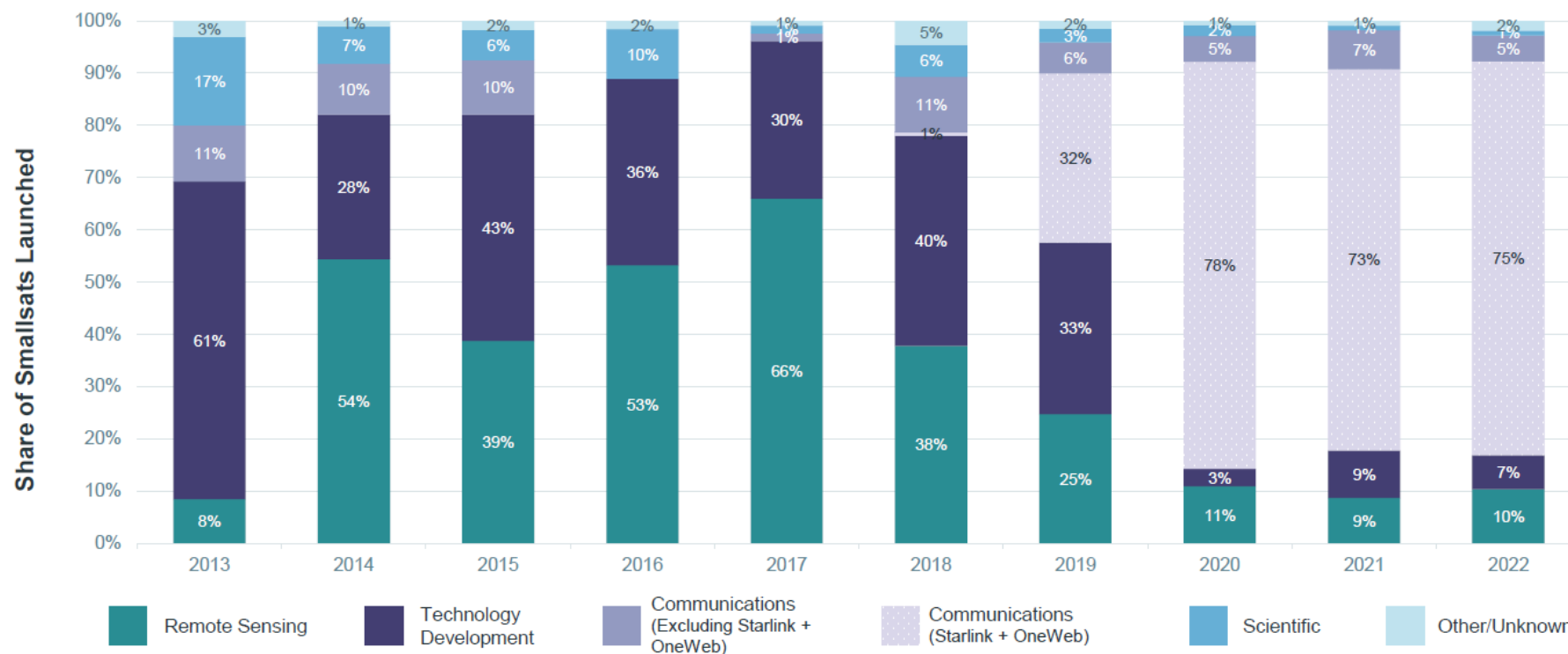
brycetech.com/reports

Number of commercial smallsats launched increased from 14 smallsats in 2013 to 2,090 in 2022



Operator and Mission Type Trends

Smallsats 2013 – 2022, by Application, Including Starlink and OneWeb



brycetek.com/reports

Communications satellites constitute the largest share of smallsats in 2022. Relative share of remote sensing and technology development smallsats has decreased due to launch of LEO communication smallsats

UNP Space Vital to Economic and National Security



Vital to way of life



Vital to modern warfare



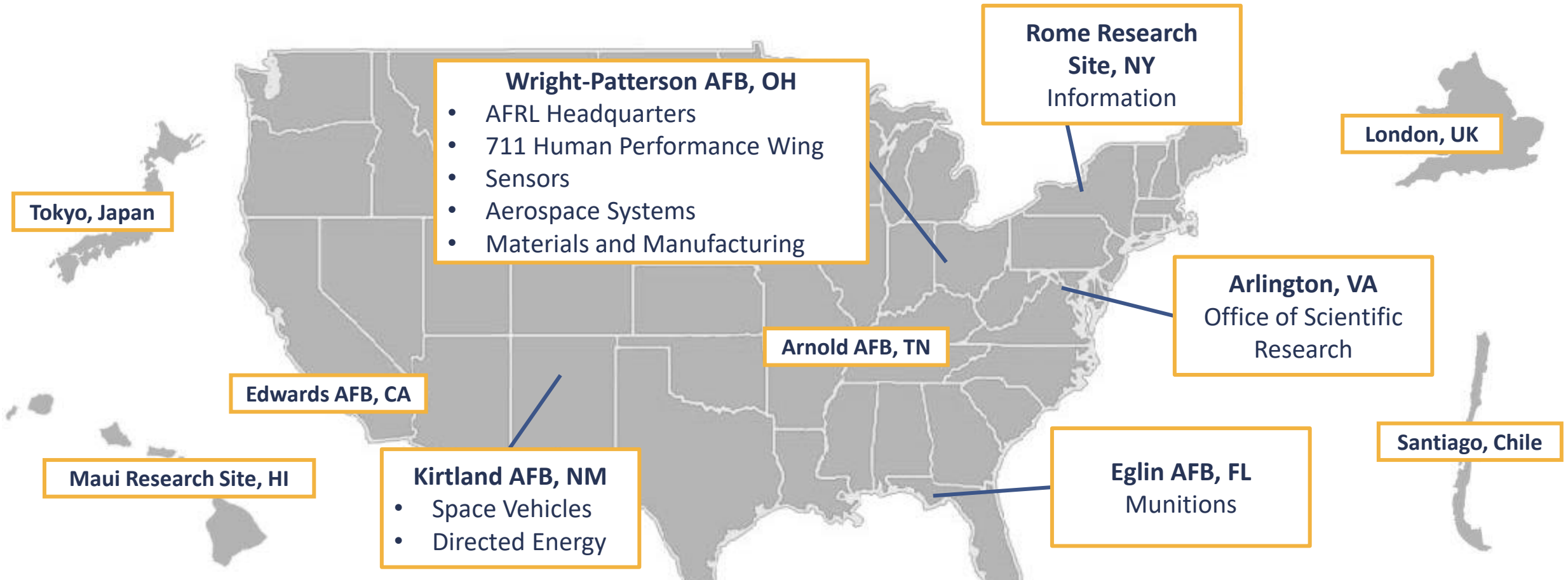
U.S. utilizes space every day for communications, global markets, weather, scientific exploration, and more

Global space economy expected to grow to \$1 Trillion by 2040

Adversaries recognize space advantages and U.S. military dependence and are rapidly developing space capabilities

In a conflict, adversaries intend to degrade U.S. space capabilities, reducing military effectiveness and degrading way of life

The U.S. Space Force is dedicated to accessing, protecting, and defending the space domain



AFRL total: 10,000+ personnel (military, civilian, and contractors); AFRL New Mexico: 2,000+ personnel

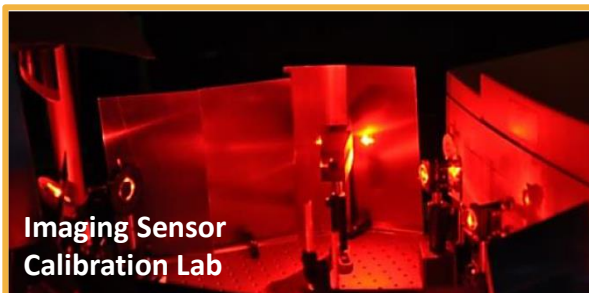
UNP AFRL Space Vehicles Directorate (AFRL/RV)



Quantum Sensing

Satellite Communication and PNT

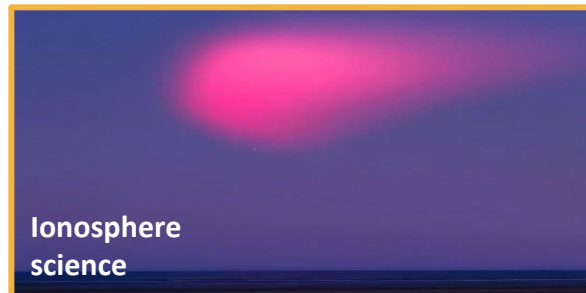
- Robust and resilient PNT
- Wide and narrow band comm
- Quantum sensing and timing



Imaging Sensor Calibration Lab

Missile Warning and Tactical ISR

- Novel detectors and materials
- Data processing and algorithms
- Infrared radiation effects lab



Ionosphere science

Space Environment

- Wave impacts on radiation belt
- Effects on systems and services
- Monitor, forecast, and mitigate



Roll-Out Solar Array

Pervasive Technologies

- Power, structures, electronics
- Space logistics and maneuver
- Size, weight, power, and cost



Oracle Spacecraft

Space Control

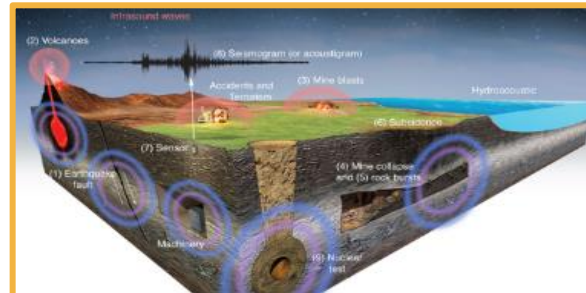
- Cislunar domain awareness
- Multi-agent autonomous ops
- Cyber protection, hardening



XVI Antenna

Small Satellite Portfolio

- Proving CubeSat military use
- Cost efficient tech experiments
- University Nanosat Program



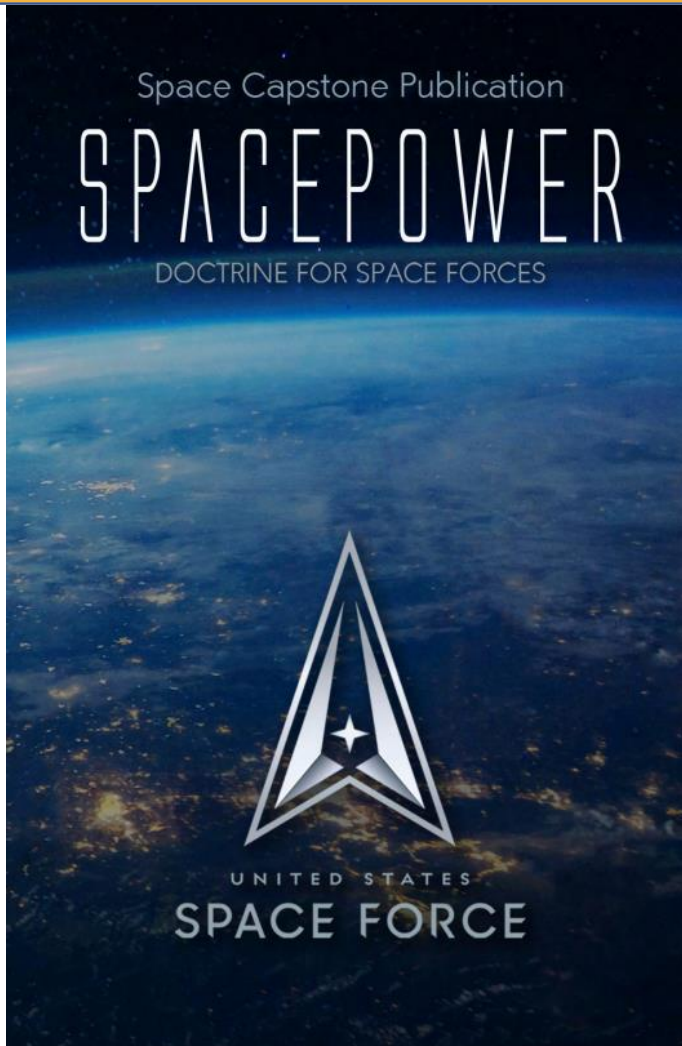
Nuclear Deterrence Operations

- Inertial navigation systems
- Nuclear explosion monitoring
- Hypersonic modeling and sim



Agile Software Operations

- Software factory, SecDevOps
- Unified data library market
- User interfaces, decision aids



Space Security

Combat Power Projection

Space mobility and logistics

Information mobility

Space domain awareness

UNP AFRL/RV Prioritized Initiatives

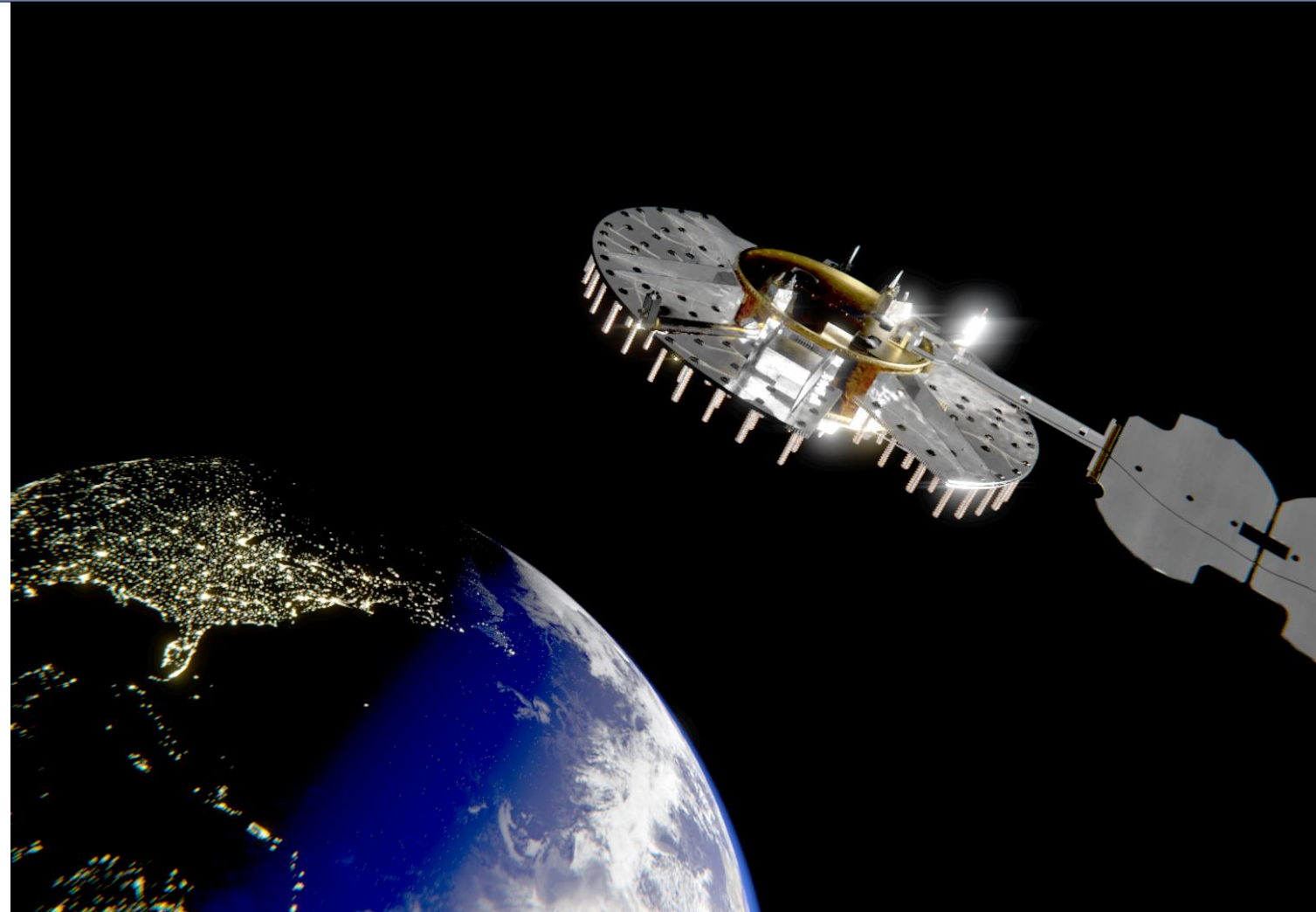


1. Path agnostic communication
2. Managing hybrid architectures
3. Low-cost satellite protection technologies
4. Autonomy, Artificial Intelligence, and multi agent collaboration
5. Space cyber hardening and protection
6. LEO to cislunar space domain awareness
7. Modeling and simulation concept analysis for data driven decision making
8. Space logistics, e.g., servicing/upgrade, assembly, and manufacturing
9. Space to surface sensing
10. Clean sheet command, control, and communications architecture
11. Space environment
12. Space based terrestrial environmental monitoring

UNP Navigation Technology Satellite 3 (NTS-3)



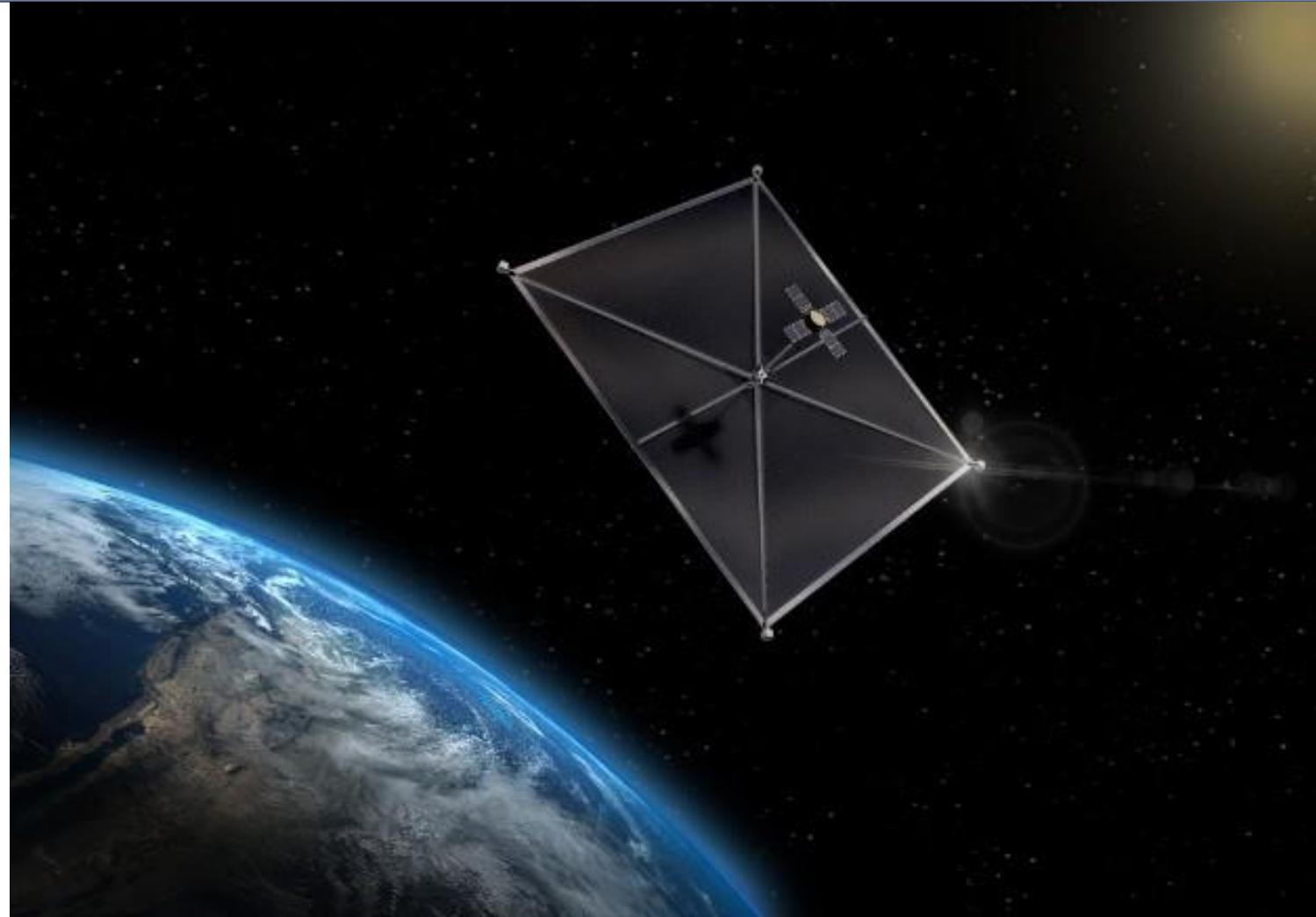
- Position, navigation, and timing (PNT) experiment
 - Global utility: air traffic control, banking, farming, search and rescue, cellular networks,
- First U.S. DoD experimental navigation satellite in 45 years
 - NTS-2 followed by 40+ years of GPS
- Testing new technologies
 - Reprogrammable signals
 - Reprogrammable receivers – user equipment
 - Flexible timekeeping – improved time
 - Advanced electronically scanned array antennas
 - Responsive ground control



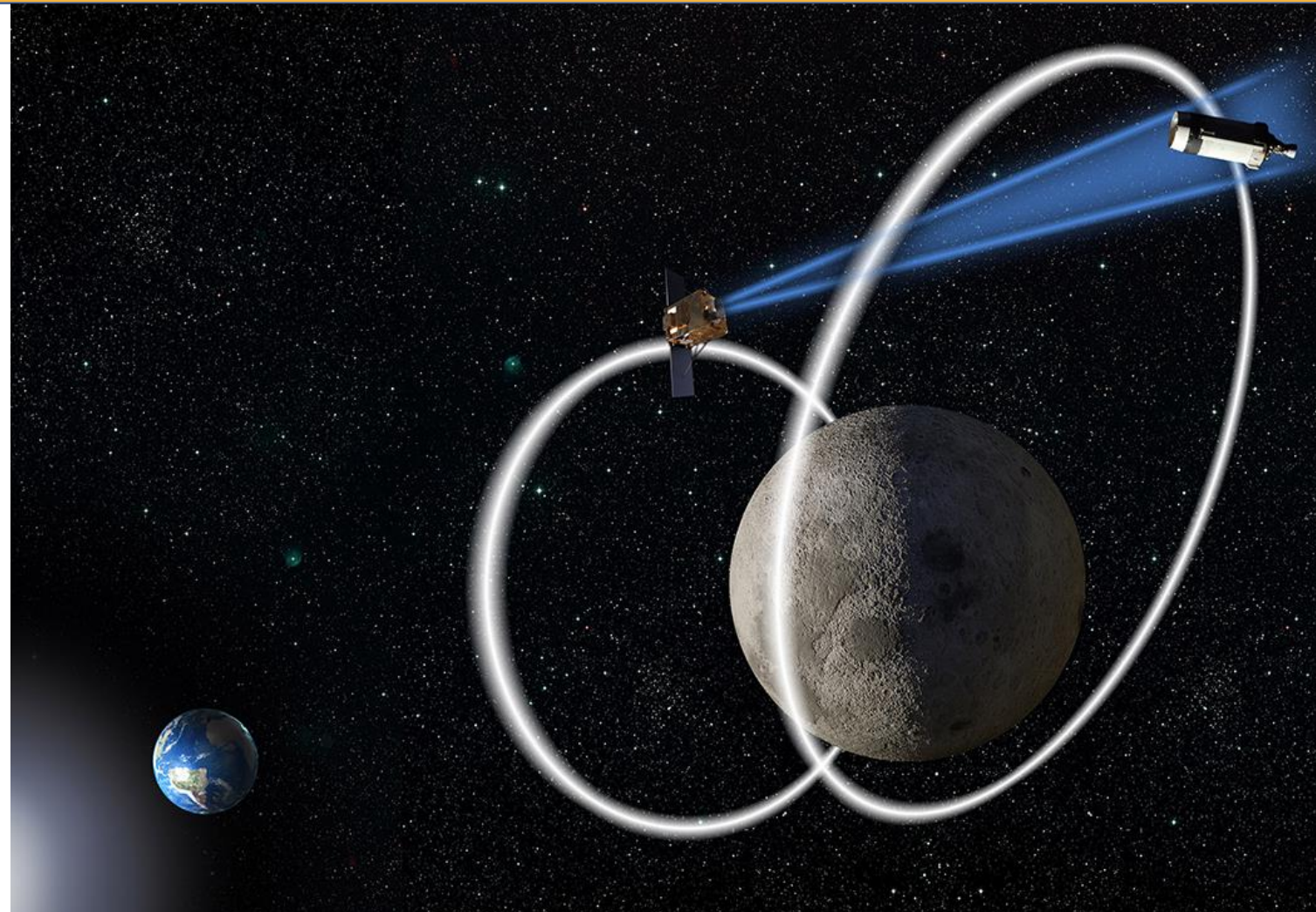
UNP Space Solar Power Incremental Demonstrations and Research (SSPIDR)



- Reduces logistics burden
- Minimizes energy resupply risks
- Transitions away from fossil fuels
- Increases energy architecture flexibility
- Allows for new operational concepts



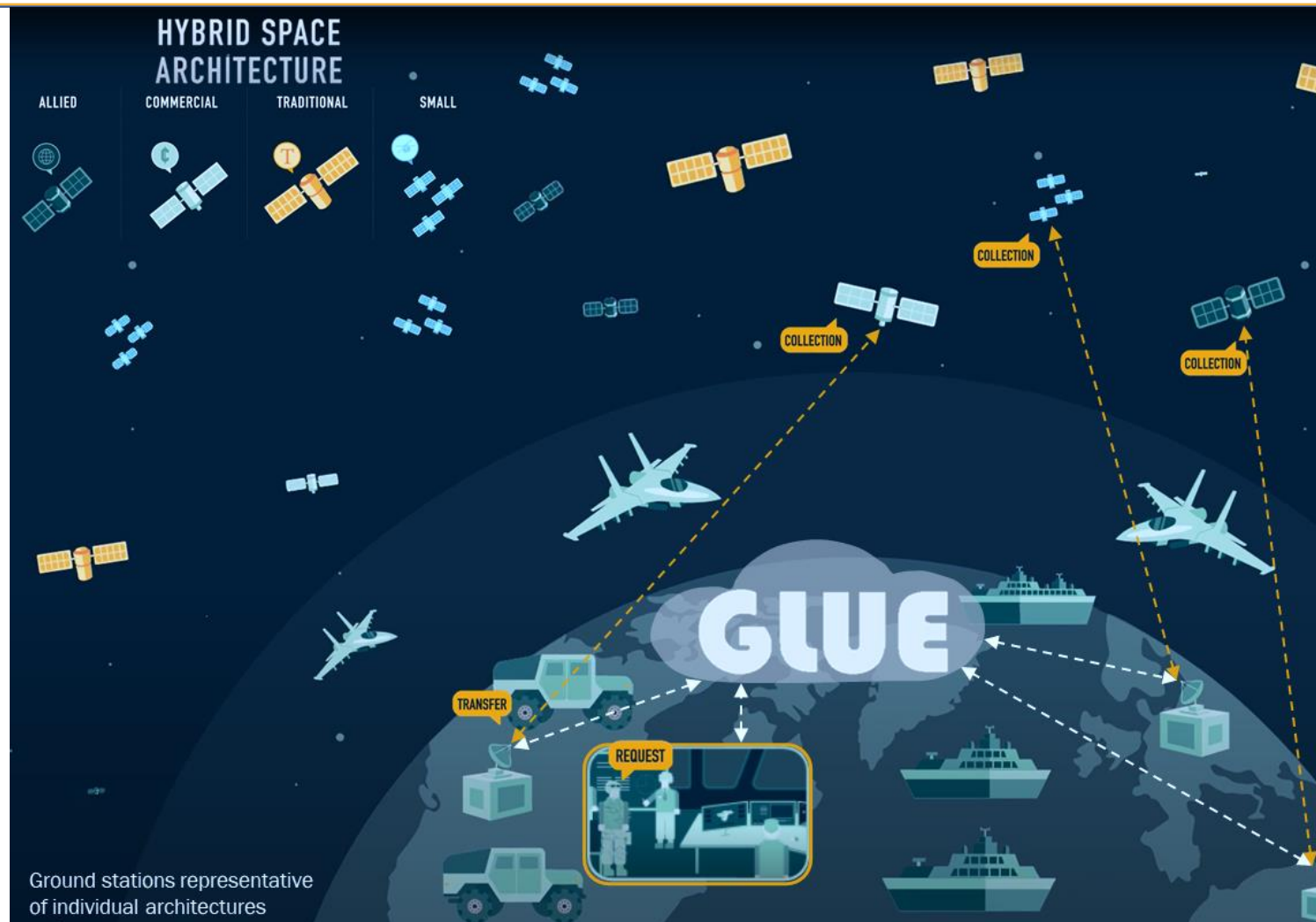
- Find, fix, and track objects in the cislunar environment
- Demo tip and cue with existing ground and space assets
- Explore new orbit determination methods on objects in cislunar space
- Assess novel navigation techniques in 3-body space



UNP Hybrid Architecture Demonstration (HAD)

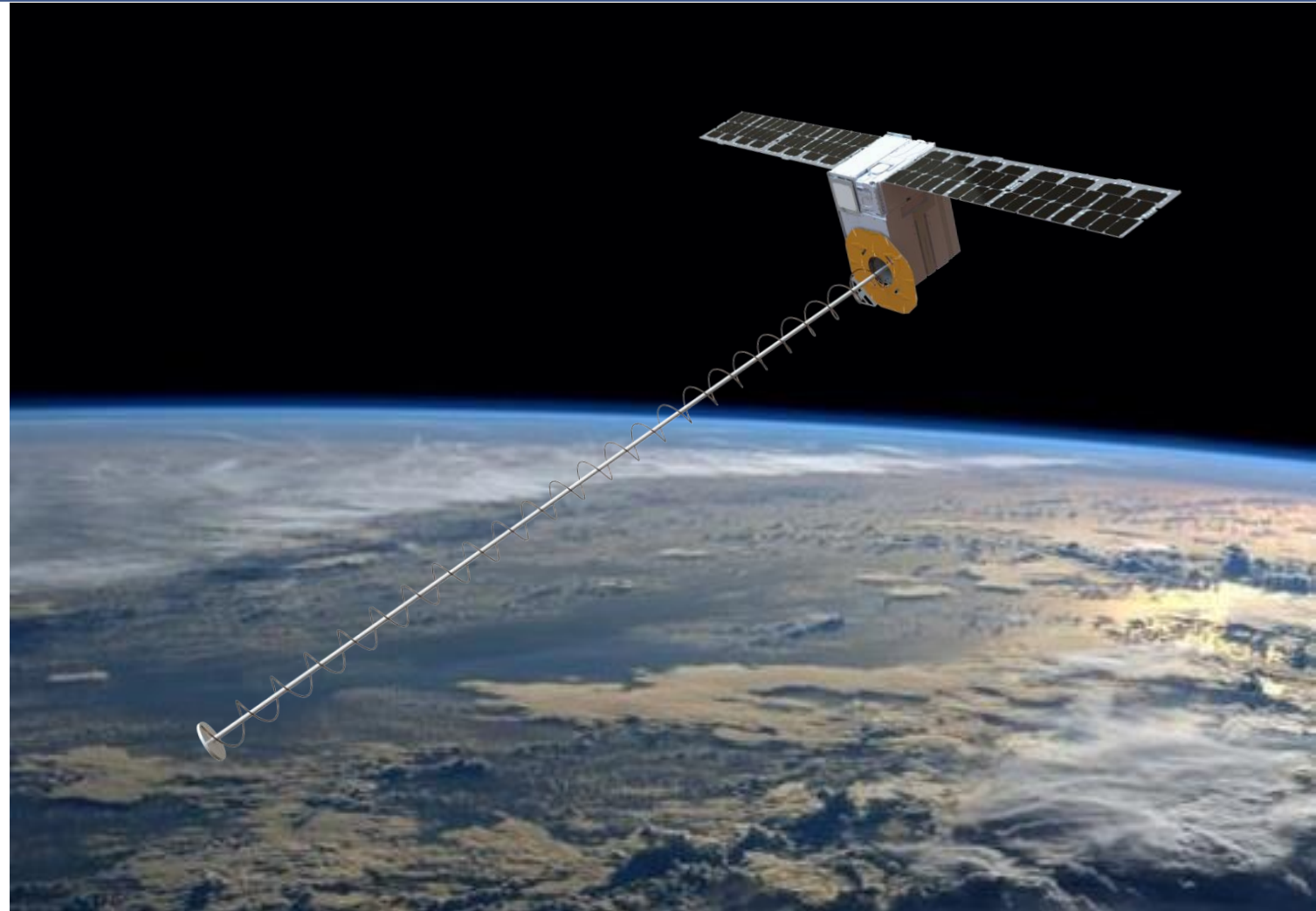


- Assessing the military utility of commercial and allied Intelligence, surveillance and reconnaissance capabilities
- Developing tools to leverage those capabilities



Ground stations representative of individual architectures

- Proving Link-16 tactical data link from space with unmodified terrestrial users
- Commercially provided CubeSat
- Software modified Link-16 radio
- Multi-domain command and control



UNP Current UNP University Mission Areas



High data rate, laser, and path agnostic communications

GPS-denied position, navigation, and timing via pulsars and chip scale atomic clocks

On-board image and event processing, recognition, and exploitation

Space domain awareness via RF, glint, and event imager measurements

Slosh and thruster plume data collection and mitigation

Technology demonstrations in laser comm, propulsion, and quantum key distribution

