



EXPLORE SPACE TECH

Advancing Space Technologies Through Suborbital and Orbital Flight

Dr. Nettie Roozeboom | Technologist, NASA's Flight Opportunities Program

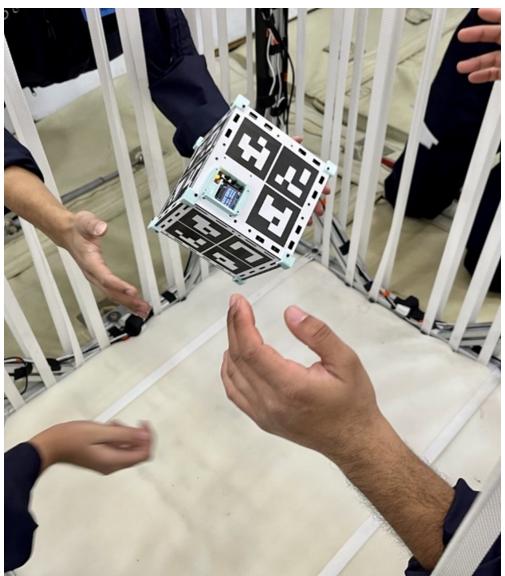
Bruce Yost | Director, Small Spacecraft Systems Virtual Institute

January 10, 2024

NASA'S FLIGHT OPPORTUNITIES PROGRAM



- Opportunities for external researchers via TechFlights solicitation and NASA TechLeap Prize
- Rolling opportunities for NASA-funded research – including SBIR awardees – and researchers from other government agencies
- Part of the Space Technology Mission Directorate
- Based at NASA Armstrong



SMALL SPACECRAFT TECHNOLOGY & FLIGHT OPPORTUNITIES PORTFOLIO

Flight Opportunities and Small Spacecraft Technology seek to **change the pace of space exploration, discovery and space commerce.**

Portfolio speed, flexibility, and access to a wide array of commercial suborbital / orbital capabilities provides opportunity to rapidly address technology gaps and emerging needs.

WHY?

To ensure **American leadership** in space...

...and **increase the rate of scientific discoveries** within our lifetimes.



COMMERCIAL VEHICLES MAKE FLIGHT OPPORTUNITIES POSSIBLE



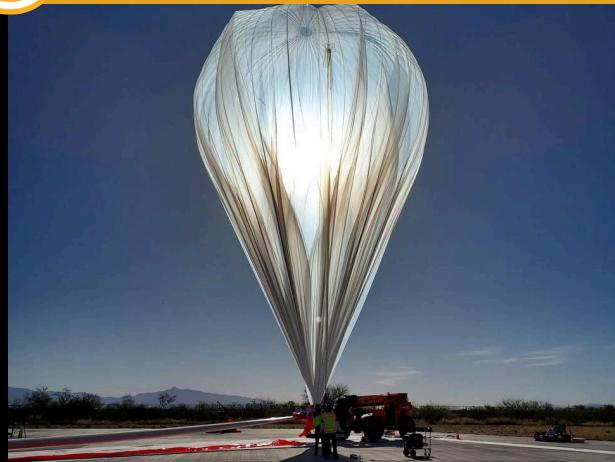
Rocket-Powered Vehicles



Credits: NASA



High-Altitude Balloons



Credits: World View Enterprises



Parabolic Flights



Credits: University of California, Berkeley



Vertical Takeoff Vertical Landing (VTVL) Vehicles



Credits: Lauren Hughes/NASA



Orbital Platforms Hosting Payloads



Credits: Firefly (formerly Spaceflight, Inc.)

WHAT DOES FLIGHT OPPORTUNITIES SUPPORT?

Innovators from:

- Universities
- Industry
- Non-profit research institutes
- NASA
- Other government agencies



Cryogenic Fluid Management



Advanced Materials,
Structures, and
Construction



Entry, Descent, and
Landing (EDL) and
Precision Landing



Advanced Habitation
Systems



Thermal Protection
Systems and
Thermal Management



Advanced
Manufacturing



In-Situ Resource
Utilization (ISRU)



Small Spacecraft
Systems

FLIGHT OPPORTUNITIES



Includes topic areas that address agency and mission goals; up to \$1M to purchase flights on suborbital or hosted orbital platforms directly from any eligible U.S. commercial flight provider



Challenges addressing specific NASA technology needs; previous awards have been up to \$650K to build payloads, plus access to a suborbital flight test



Competition to inspire the next generation of space researchers; offers hands-on insight into the design and test process used by NASA-supported researchers



Through collaborative internal and external relationships, the program takes advantage of opportunities to flight test valuable space technologies



To increase access to test opportunities in relevant environments, Flight Opportunities collaborates with other NASA initiatives like **SMD's ROSES** and **SOMD's SubC** to help them leverage the commercial flight ecosystem

Flights of Opportunity Examples:

- In-Space Manufacturing/ ISS Program Office
- SBIR/STTR
- Intergovernmental support (Department of Defense, USDA)
- TechFlights Reflights



**Match your
solution to
available funding
opportunities:**

[techport.nasa.gov/
opportunities](http://techport.nasa.gov/opportunities)



Flight Opportunities and Small Spacecraft Technology utilize a variety of mechanisms to mature innovative solutions from **proof-of-concept, to benchtop, to flight**.

We want to work with **academia, non-profit research institutes, and industry, as well as entrepreneurs, small businesses, and students** in order to close our technology gaps.



LSP CubeSat
Launch Initiative



STMD Tipping
Point Awards



Announcements
of Collaboration
Opportunity



Missions of
Opportunity



Flights of
Opportunity

Pathways to flight test for
researchers with existing support:
Contact the programs directly.

NOW OPEN: NASA TECHLEAP UNIVERSAL PAYLOAD INTERFACE CHALLENGE

- The process to ensure payloads can properly interface with a host vehicle is currently complex, time-consuming, and can vary greatly from vehicle to vehicle, as well as between suborbital flights, orbital flights, and beyond.
- This challenge seeks interface systems that can efficiently integrate diverse payloads onto a range of flight vehicles, including suborbital, orbital, and planetary lander vehicles.
- Open to businesses, academic institutions, entrepreneurs, and other innovators.
- A maximum of 3 winners will receive up to \$650K in prizes and an opportunity to flight test their system.

E-mail us: questions@NASATechLeap.org

Register for the challenge and sign-up for the webinars at www.upic.nasatechleap.org

Register by Thursday, February 1, 2024 at 5 pm ET

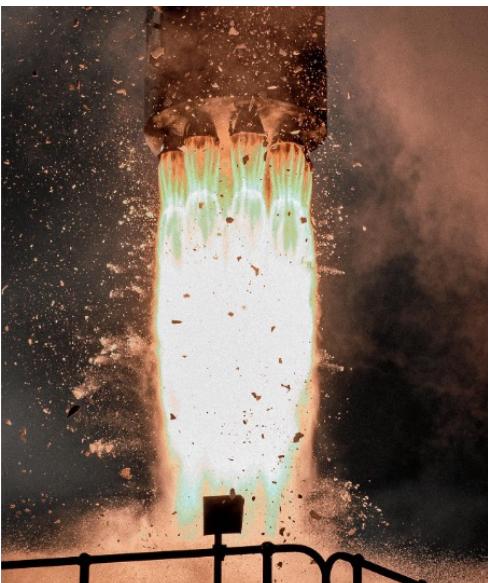
Applications due Thursday, February 22, 2024 at 5 pm ET

[Share the challenge with your networks!](#)



www.upic.nasatechleap.org

FLIGHT OPPORTUNITIES IMPACT HIGHLIGHTS



Improving Storm Prediction via Small Spacecraft Constellations

TROPICS: Dual-spinning CubeSat bus uses microwave radiometer technology developed by MIT for small spacecraft

Tested in its early stages on parabolic flights in 2013

Launched May 2023 to gather data to understand the evolution of tropical cyclone intensity



Miniature Robots for the Lunar Surface

MIT's AstroAnt: Designed to support autonomous vehicle inspection and maintenance

Matured through a series of parabolic flights in 2021

Will be deployed on a CLPS mission to lunar South Pole



Wearable Vision-Aided Moonwalks

DMEN: Designed to provide terrain-relative navigation for landings in challenging space environments

Matured through flight tests on high-altitude balloons and suborbital rockets

Integrated with wearable kinematics tech for 2022 fields tests to collect data that will support the agency's moonwalking preparations



Optical Fiber Production on the International Space Station

Both Mercury Systems and FOMS, Inc. used parabolic flights to validate their technologies ahead of ISS demonstrations

Collaboration with NASA Johnson's In-Space Production Applications (InSPA) project

SUPPORTING THE FLIGHT TEST COMMUNITY

Community of Practice Webinars

Designed to distill and share most important lessons learned by suborbital researchers.

First Wednesday of each month 10 am PT



October 6, 2021 Community of Practice -
An Open Conversation About Suborbital Flight Testing

Flight Opportunities Newsletter

www.nasa.gov/flightopportunities

The image shows the cover of the Flight Opportunities newsletter. The top half features a collage of three images: a NASA logo, a white rocket launching, a large white balloon being inflated, and a woman working in a lab. Below the collage, the title "Flight Opportunities" is written in a large, bold, white font. Underneath the title, it says "ISSUE: 43 | May 2021". A section titled "In This Issue:" lists several bullet points about recent flights, community practice webinars, opportunities, and events. At the bottom, it says "Enjoy! The Flight Opportunities team". A red banner at the bottom reads "Recent Flights". Below the banner is a photo of a launch team at a site with a large red balloon.

Flight Opportunities

ISSUE: 43 | May 2021

In This Issue:

- Recent Flights: Big Goals, Small Package: Enabling Compact Deliveries from Space; Parabolic Flights Provide Relevant Environment for Testing Flight Opportunities-Supported Technologies
- Community of Practice: June webinar: From the Mojave Desert to Jezero Crater; Introducing Lessons from the Launchpad – a new monthly column featuring trusted tips for successful flights
- Opportunities: Recently announced: CASIS Research Announcement for Technology Advancements; Upcoming: Tech Flights 2021 solicitation, Two new NASA prize-based competitions; Closing soon: CASIS Research Announcement for In-Space Production Applications
- Events: Join Flight Opportunities Chief Technologist Stephan Ord for CRASSTE next month

Enjoy!
The Flight Opportunities team

Recent Flights

The Near Space Corporation launch team completes pre-flight rigging and checks at the Madras Municipal Airport in Madras, Oregon. Credits: Near Space Corporation

LESSONS LEARNED LIBRARY

An ongoing collection of best practices and suggestions to help researchers optimize their flight test outcomes

Designed to support researchers as they move through each part of the flight testing process:

- Getting involved with the program
- Preparing proposals
- Step-by-step suggestions for getting ready to fly
- Best practices for payload design
- Top tips for each type of flight platform

Practical tips are linked to helpful clips from the program's monthly Community of Practice webinar.

The screenshot shows the homepage of the Lessons Learned Library. At the top, there is a dark header bar with a search input field, the NASA logo, and navigation links for "News & Events" and "Multimedia". Below the header, the main title "Lessons Learned Library" is displayed in a large, bold, black font. To the right of the title, there is a "QUICK TIPS" section with a blue lightbulb icon. The text in this section encourages users to contact flight providers early in the process to strengthen their proposal. At the bottom of the page, there is a note about the library being updated frequently.

Search...

NASA

News & Events ▾ Multimedia

/ Lessons Learned Library

Home About News Work with Us ▾ Resources ▾ Tech Portfolio ▾ Images

Lessons Learned Library

QUICK TIPS

Contact flight providers – either those that have flown with Flight Opportunities in the past or other vendors that meet the requirements – early in the process to strengthen your proposal.

Over the years, Flight Opportunities participants have identified dozens of suggestions to help researchers be more successful in their flight testing. The Lessons Learned Library presents these suggestions – many of which were shared in the program's Community of Practice webinars. (Access more information about these webinars under the Resources menu above.)

Check back often as Flight Opportunities is always adding to this library

STAY ENGAGED:

NASA.GOV/FLIGHTOPPORTUNITIES

NASA.GOV/SMALLSPACECRAFT

Visit our websites for more information and resources, including our newsletter and monthly Community of Practice webinars.

Reach out:

NASA-FlightOpportunities@mail.nasa.gov





NASA Small Spacecraft Technology Program & Small Spacecraft Systems Virtual Institute

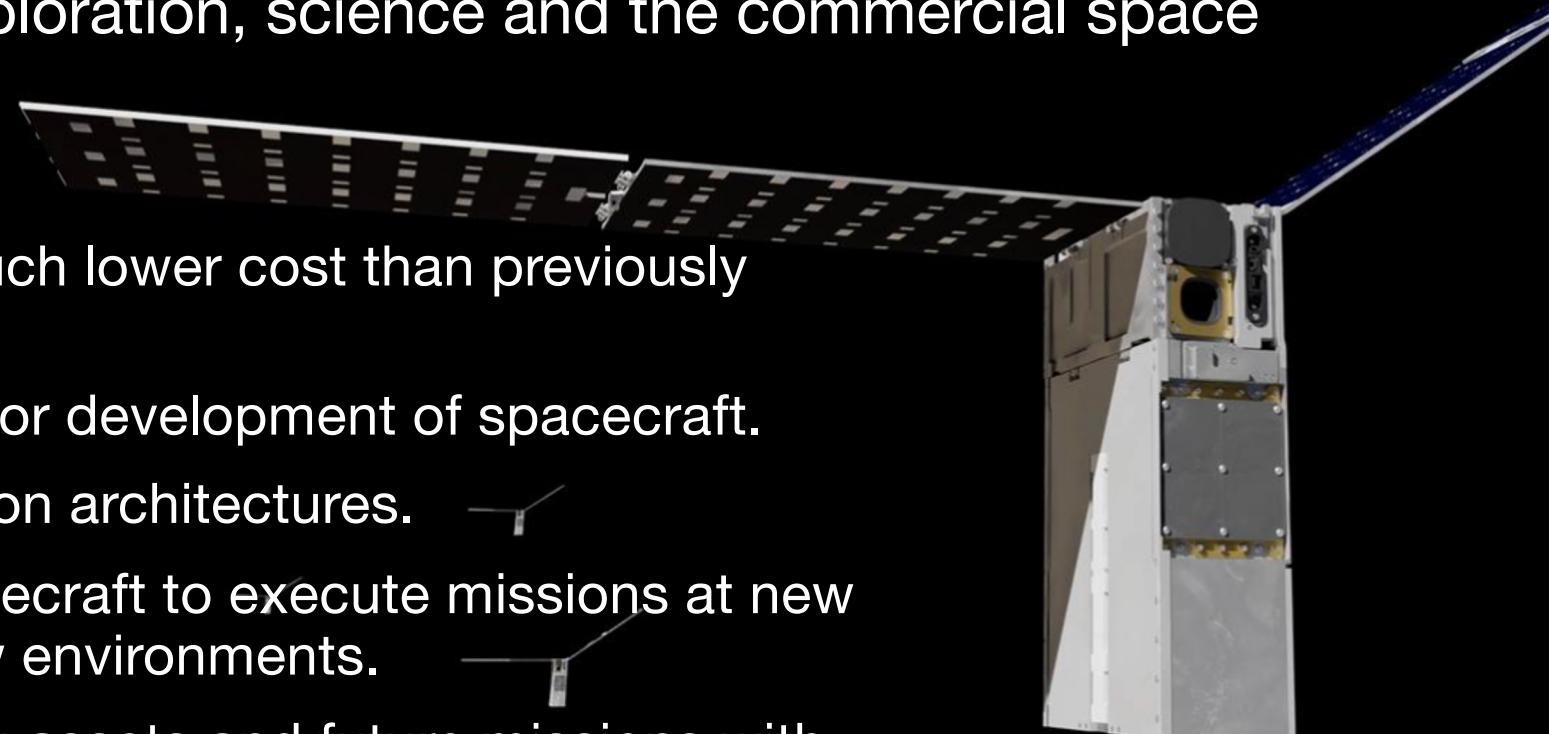
Bruce D. Yost
*Director, Small Spacecraft
Systems Virtual Institute
(S3VI)*

2024 AIAA SciTech Forum

SMALL SPACECRAFT TECHNOLOGY PROGRAM OBJECTIVES

The Small Spacecraft Technology program expands U.S. capability to execute unique missions through rapid development and demonstration of capabilities for small spacecraft applicable to exploration, science and the commercial space sector.

- Enable execution of missions at much lower cost than previously possible.
- Substantially reduce time required for development of spacecraft.
- Enable and demonstrate new mission architectures.
- Expand the capability of small spacecraft to execute missions at new destinations and in challenging new environments.
- Enable the augmentation of existing assets and future missions with supporting small spacecraft.



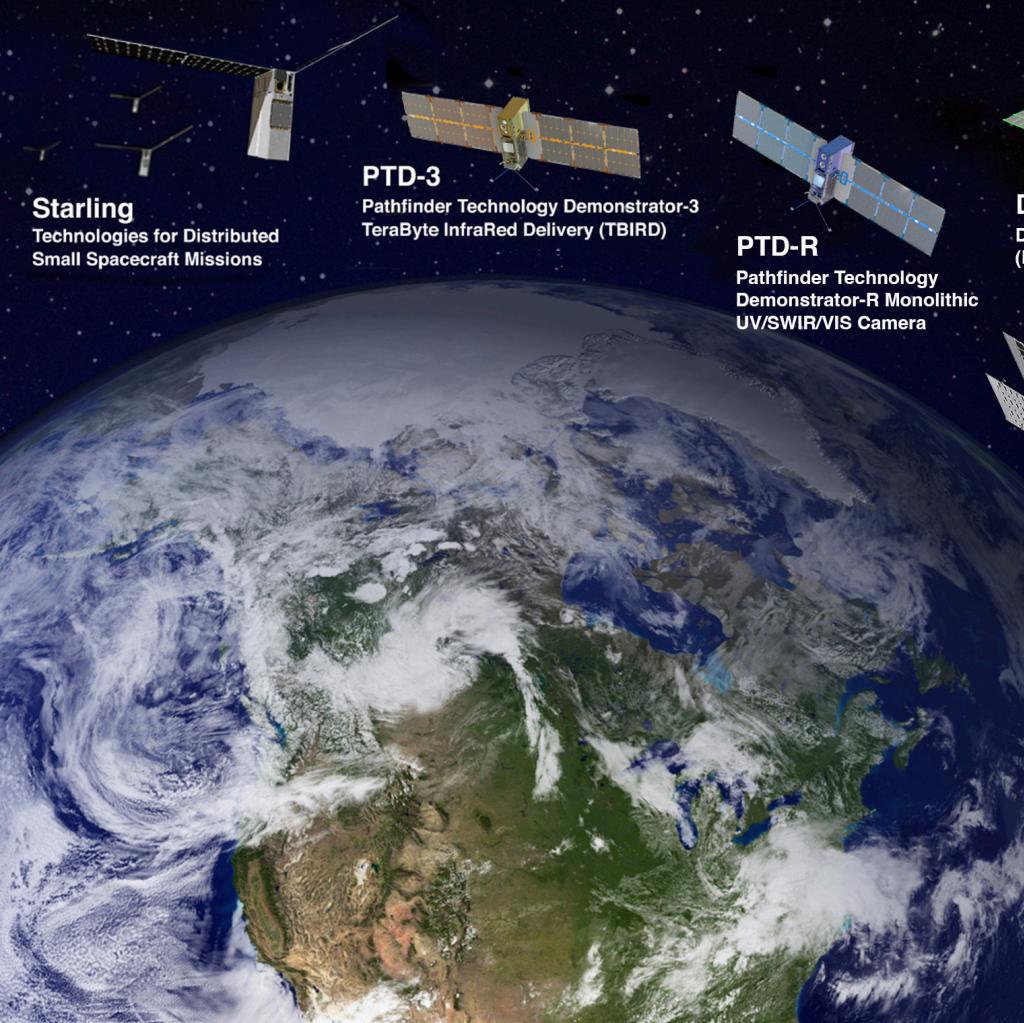
Starling Spacecraft
Image Credit: NASA



Small Spacecraft Technology Program

SPACE TECHNOLOGY MISSION DIRECTORATE

Expanding NASA's ability to execute unique missions through rapid development and demonstration of capabilities for small spacecraft applicable to exploration, science and the commercial space sector.



Starling

Technologies for Distributed Small Spacecraft Missions

PTD-3

Pathfinder Technology Demonstrator-3
TeraByte InfraRed Delivery (TBIRD)

PTD-R

Pathfinder Technology Demonstrator-R Monolithic
UV/SWIR/VIS Camera

DUPLEX

Dual Propulsion Experiment
(DUPLEX) CubeSat

Credit:
CU Aerospace,
LLC.

GPDM

Green Propulsion
Dual Mode

CLICK

CubeSat Laser
Infrared Crosslink

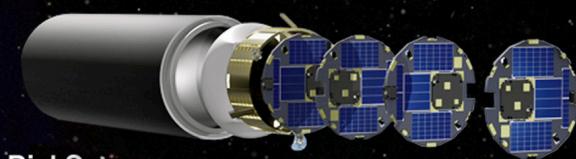
PY4

Four-CubeSat Swarm of
PyCubed-Based Spacecraft



PTD-4

Pathfinder Technology Demonstrator-4
Lightweight Integrated Solar Array
and anTenna (LISA-T)



DiskSat

Two-Dimensional; High-Power,
High-Aperture, Maneuverable Spacecraft



R5

Rapid Technology Maturation



CAPSTONE

Cislunar Autonomous
Positioning System
Technology Operations
and Navigation Experiment



Courier

Solar Electric Propulsion Module

www.nasa.gov/nasasmallspacecraft



ACS3

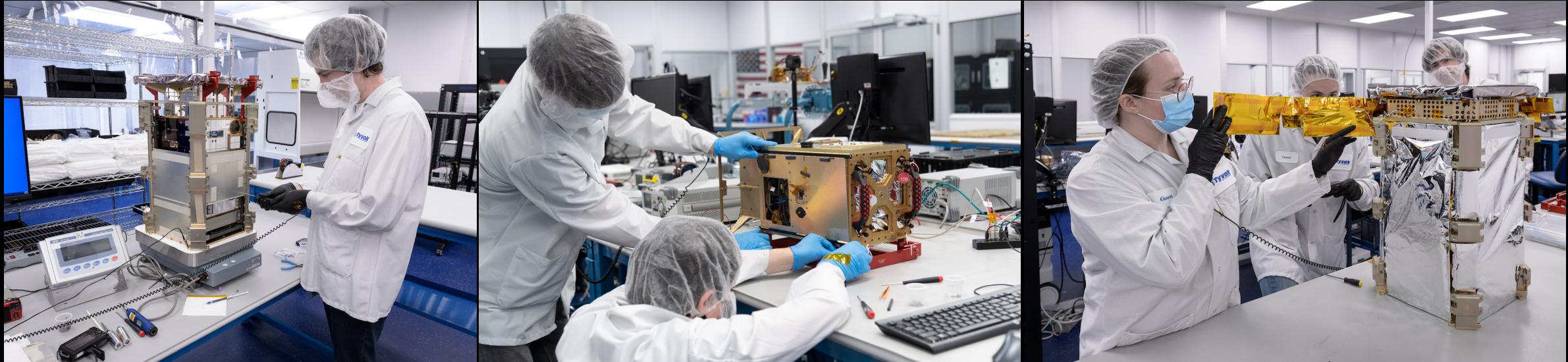
Advanced Composite
Solar Sail System

CAPSTONE - LAUNCHED JUNE 28, 2022 – CURRENTLY IN LUNAR ORBIT



Demonstrated ability to enter and maintain a near rectilinear halo orbit around the Moon. Demonstrated one & two way ranging and autonomous spacecraft navigation.

CAPSTONE INDUSTRY AND ACADEMIC PARTNERS

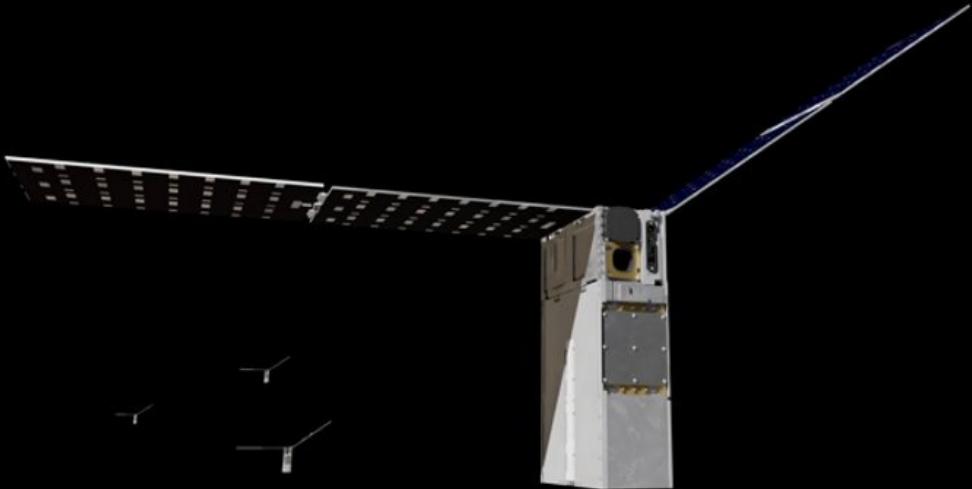


CAPSTONE represents an innovative collaboration between NASA and its partners to provide rapid results and feedback to inform future exploration and science missions.

- Advanced Space of Westminster, Colorado, developed and is operating CAPSTONE.
- Terran Orbital Corporation, of Irvine, California, designed and built the CubeSat platform.
- Stellar Exploration, Inc. of San Luis Obispo, California, provided the propulsion system.
- Rocket Lab USA, Inc., of Long Beach, California, provided the launch service.

The mission is also supported by the Space Dynamics Laboratory, Orion Space Solutions, Tethers Unlimited, Inc., and Morehead State University.

STARLING 1.0 – LAUNCHED JULY 17, 2023 – ENGAGED IN ON-ORBIT OPERATIONS



Starling's mission includes four main demonstrations: swarm maneuver planning and execution, communications networking, relative navigation, and autonomous coordination between spacecraft.

Technology Demonstrations Include:

- Cluster flight control algorithms: (*ROMEO – Onboard Cluster Flight Control*)
- Network communication protocols: (*MANET – Crosslink/Networking*)
- Relative navigation algorithms: (*StarFOX –Relative Navigation*)
- Autonomous reactive operations software: (*DSA – Distributed Spacecraft Autonomy*)

NASA STARLING 1.0/*1.5 INDUSTRY & ACADEMIC PARTNERS



NASA partners with the following industry and academic entities for Starling's demonstrations:

- Blue Canyon Technologies of Boulder, Colorado, designed and manufactured the spacecraft buses and provides mission operations support
- Rocket Lab USA, Inc., provided launch and integration services

Partners supporting Starling's payload experiments include:

- Stanford University's Space Rendezvous Lab in California
- Emergent Space Technologies of Laurel, Maryland
- CesiumAstro of Austin, Texas
- L3Harris Technologies, Inc., of Melbourne, Florida
- NASA Ames – with funding support by NASA's Game Changing Development program within STMD

*The Starling 1.5 extended mission is developing technology and operational protocols for autonomous maneuvering coordination between spacecraft constellations to enable nascent space traffic management capabilities. Among other partners, SpaceX is an industry partner for this demonstration.

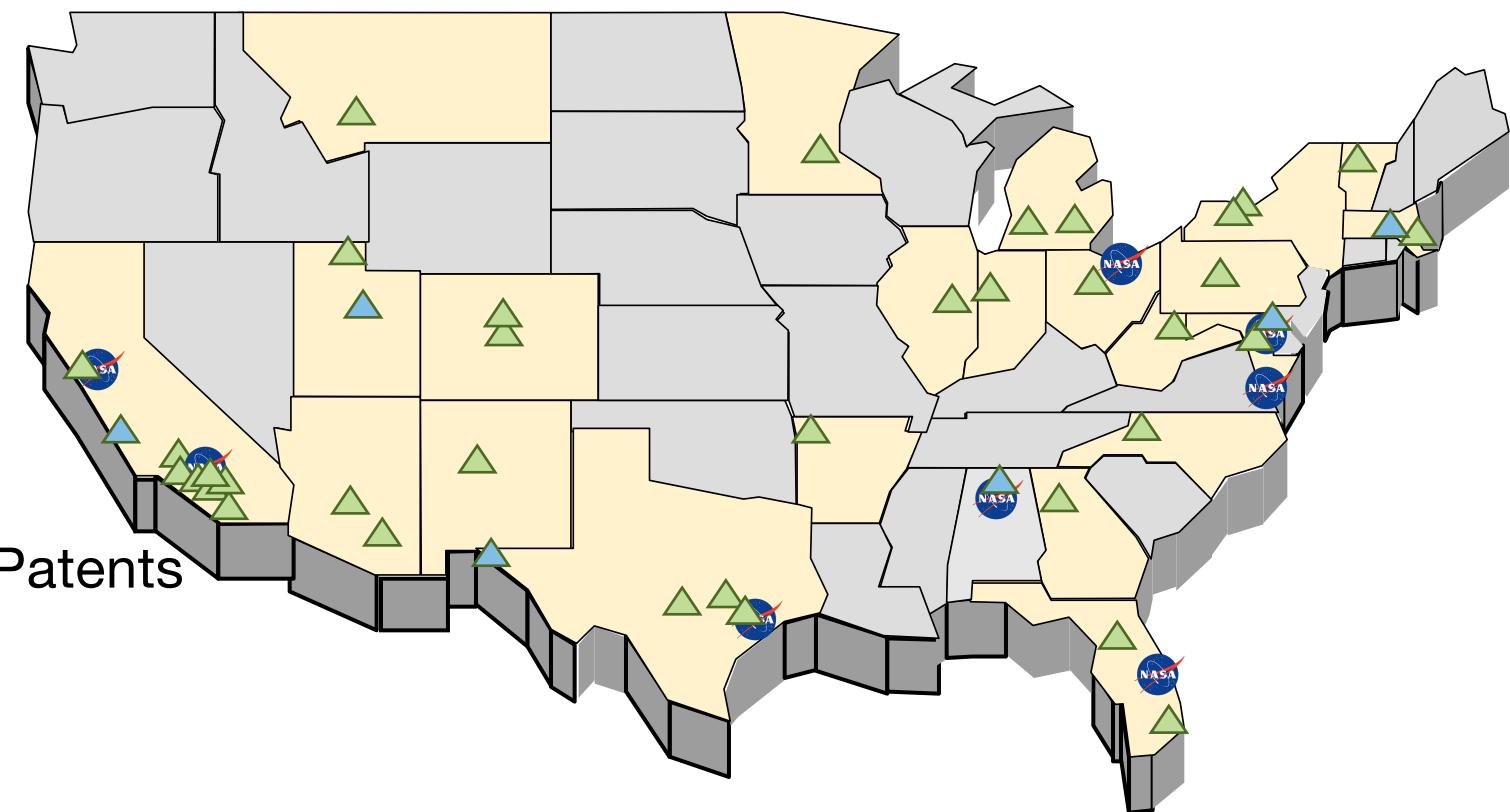
UNIVERSITY SMALLSAT TECHNOLOGY PARTNERSHIP SUCCESSES TO DATE

- **Investments:**
 - Over \$30,000,000 awarded
 - 54 partnerships in 6 cohort years
 - 36 universities in 22 states (+6 supporting collaborators in 6 states)
 - 8 of 10 NASA centers partnered

- **Results:**
 - 24 flight demonstrations performed/planned
 - 1 Intersatellite Network Planning/ Routing tool software open-sourced

- Numerous New Technology Reports/Patents
- 30+ conference presentations
- 50+ papers published
- 100+ students involved
- Many technology readiness levels (TRL) raised

- ▲ **36 Universities in 22 States**
- **8 NASA Centers (including JPL FFRDC)**
- ▲ **6 Supporting University Collaborators in 6 States**



Small Spacecraft Systems Virtual Institute (S3VI)



Promoting Innovative Concepts

Building Community through:

Sharing Knowledge

- SmallSat LEARN Forum
- Community of Practice
- Mission Accomplished Webinar Series
- Access to Space Announcements
- S3VI Quarterly Newsletter
- CubeSat 201

Community of Practice Webinar Series

Pathfinder for Autonomous Navigation: Flight Demonstration of Commercial Off-the-Shelf Technologies for Spacecraft Rendezvous and Docking

Mason Peck
Associate Professor, Mason Peck, Kyle Kinn, NASA SoftTech Forum

Small Spacecraft Reliability Initiative Knowledge Base

Explore > Interactive Tree

- Hover over or click a **section** node to expand its children
- Hover over or click a **topic** node to preview the topic and click to open

```

CONCEPTUAL DESIGN ○
PLANNING AND MANAGEMENT ○
DETAILED DESIGN AND ANALYSIS ○
MANUFACTURING ○
INTEGRATION AND TEST ○
LAUNCH ○
OPERATIONS ○
INTEGRATION ○
DAY-IN-THE-LIFE TESTING ○
EMI/EMC TESTING ○
ACCELERATED LIFE TESTING ○
ELECTRONICS FUNCTIONAL TESTING ○
BAKE OUT ○
RAILATION TESTING ○
LAUNCH ENVIRONMENT TESTING ○
  
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Identifying Emerging Technology Opportunities

Building Tools

- Small Spacecraft Reliability Initiative Knowledge Base Tool
- Small Spacecraft Information Search
- State of the Art Report
- Space Mission Design Tools Collection
- Anomaly Alert Reporting System

Connecting People and Ideas

- Industry Days Webinar Series
- SmallSat Technology Partnerships – TechExpo
- Cross-Agency Collaboration



www.nasa.gov/smallsat-institute

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Small Spacecraft Information Search

SMALLSAT INFORMATION SEARCH

Search smallsat information...

Select Search...

S3VI Web Portal

Small Satellite Missions Blog

Small Spacecraft Systems Virtual Institute

Recent SmallSat News

Small Satellites News Archive

S3VI Newsletter

In This Issue - February 2022

Upcoming Opportunity Due Dates & Events / Released Small Satellite Information System (S3IS) Database

Community Engagement

RELEASED! Small Spacecraft Reliability Initiative Knowledge Base Tool v2.0

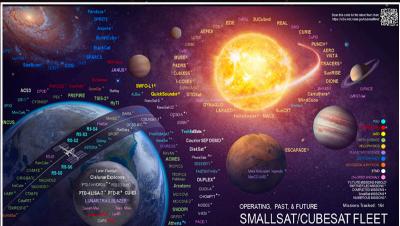
New Space Mission Design

Upcoming Opportunity Due Dates & Events

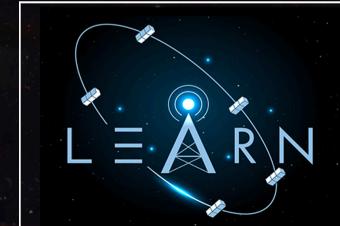
Recent SmallSat News

Small Satellites News Archive

SmallSat / CubeSat Fleet Chart



NASA SmallSat LEARN Forum



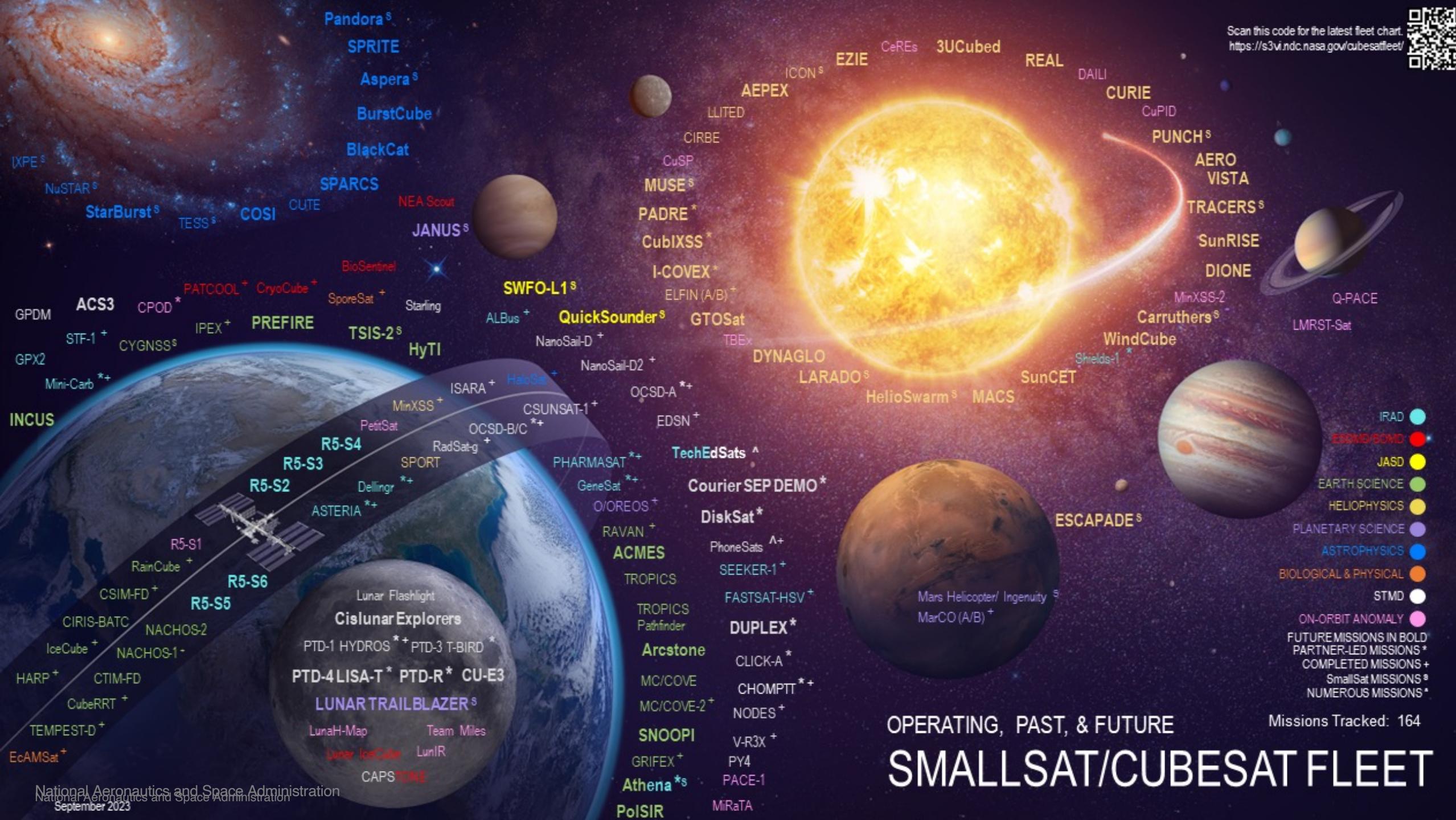
LaunchPortal: Potential Rideshare Opportunities

Mission Name	Launch Date (NET)	Primary Orbit	Apogee (km)	Perigee (km)	Inclination (deg)	Insertion	Rideshare Adapter
JPSS-2	11/1/22	SSO, Polar	810	810		1325 LTAN	None: ULA C-4 adapters surrounding LOFTID secondary payload. (no rideshare opportunities available)
IMAP	2/1/25	L1			28	C3 max <-0.5	ESPA Grande (no rideshare opportunities available)
SPIREX	2/28/25	SSO	650	650		6am MLTAN	For ULA, no additional opportunities available
JPSR-3	2025-2027	SSO					
COSI	2025/09	LEO	550	550	5	TBD	
SENTINEL 6B	2025/11	LEO	1336	1336	66	TBD	
NEON	2026/05	L1			C3 (bd)	TBD	
SURVEYOR							
MUST	2027/04	LEO	620	620	97.9	6am MLTAN	
PERITAS	2029/05	Venus				C3-17	TBD
Impeccable	2029/05	LEO	400	400			

Scan this code for the latest fleet chart.
<https://s3vindc.nasa.gov/cubesatfleet/>



OPERATING, PAST, & FUTURE SMALLSAT/CUBESAT FLEET



S3VI RESOURCES AVAILABLE TO ALL

The S3VI provides the US SmallSat research community with access to mission enabling information and maintains engagement with small spacecraft stakeholders in industry, government and academia.

The S3VI resources listed below are available to all at: <https://www.nasa.gov/smallsat-institute/>

Contact us at: agency-smallsat-institute@mail.nasa.gov

Community of Practice Webinar Series

Small Spacecraft Reliability Initiative Knowledge Base Tool

LaunchPortal

Small Spacecraft Guidebooks

United Nations Office of Outer Space (UNOOSA) Systems Engineering Webinar Series

NASA Small Spacecraft State of the Art Report

S3VI WebPortal

Quarterly S3VI Newsletter

Small Spacecraft Information Search

Space Mission Design Tool Catalog

S3VI is sponsored by NASA's Space Technology Mission Directorate

