National Aeronautics and Space Administration

Advancing Science and Technology for Planetary Exploration Through Testing with NASA's Flight Opportunities Program

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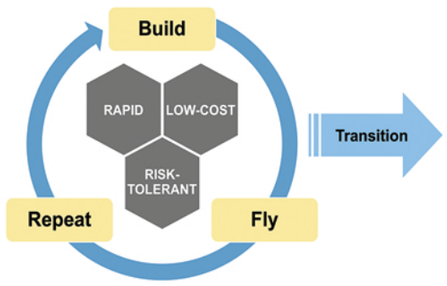
INTRODUCTION

NASA's Flight Opportunities program serves the agency by providing access to suborbital and hosted orbital flight tests with commercial providers as well as subject matter expertise on flight testing a range of payload types aboard a variety of platforms. Researchers across NASA, at other federal agencies, and in academia or industry can engage with the program to flight test their technologies, instruments, and experiments, moving beyond ground-based laboratories. Cost-effective and timely access to relevant environments for space travel can help advance technology readiness levels and reduce risk ahead of longer, more expensive missions, including to the Moon and Mars.

Since 2011, Flight Opportunities has supported hundreds of flights with more than 1,000 payload tests. These flight tests have supported the maturation of technologies and research with applications for lunar and planetary exploration.

The program achieves its objectives by:

- Minimizing NASA processes while leveraging agency expertise
- Leveraging commercial capabilities and best practices
- Embracing risk-informed decision making and risk tolerance
- Applying constraint-driven mission philosophy (cost/schedule)
- Rapidly moving from benchtop to flight test to de-risk technology
- Maintaining programmatic agility to ensure responsiveness to disruptive innovation and the changing geopolitical landscape



ACCESSING FLIGHT TESTS AND EXPERTISE

Flight Opportunities creatively uses a variety of funding mechanisms to mature innovative solutions for the nation's space technology needs, enabling government and non-government researchers to access flight tests.

Researchers currently funded by NASA or other government agencies (OGAs) can work with the program directly to **access commercial flight tests through the program's IDIQ** (Indefinite Delivery/Indefinite Quantity) contracts with more than a dozen flight providers. Non-government researchers can propose for payload development and flight test funding through the program's challenges and solicitations.

Flight Opportunities Provides

Relevant environments to:
- Test technologies
- Advance science
- Expand space commerce

Expertise in:
- Preparing payloads for flight tests
- Working with commercial flight providers
- Leveraging procurement and funding mechanisms

Challenges:

NASA TechLeap PRIZE

Open to U.S. commercial businesses, academic or non-profit research institutions, entrepreneurs, and independent innovators; provides funding and flight test opportunity.

Solicitations: Eligibility varies according to the solicitation.

SBIR·STTR America's Seed Fund

Tipping Points

ROSES (Research Opportunities in Space and Earth Science)

Announcements of Collaboration Opportunity

Flights of Opportunity:

- **Open to:**
  - — NASA personnel
  - — Competitively selected NASA-funded projects
  - — Other government agencies
- **Flight Opportunities experts help:**
  - — Identify appropriate vehicle platform to achieve a relevant test environment
  - — Establish mechanism/agreement to access flight provider
  - — Prepare for flight test

GETTING STARTED WITH FLIGHT OPPORTUNITIES

Interested researchers within and outside of NASA are encouraged to reach out to Flight Opportunities at any time. Researchers are also encouraged to subscribe to the program's newsletter to stay up to date on Flight Opportunities activities. In addition, several resources are available via the program's website, including a Community of Practice webinar series, a flight test lessons learned library, and one-on-one meetings with the program team and as well as a tool to prepare for these discussions.

Learn more, subscribe to the newsletter, access resources, and reach out to the program at nasa.gov/flightopportunities.

www.nasa.gov

LUNAR AND PLANETARY TECH TESTING HIGHLIGHTS

Flight Opportunities-supported flight tests across a variety of commercial platforms have advanced lunar and planetary science and technology, including:

Entry, descent, and landing systems
Dust mitigation techniques and tools
In situ resource utilization approaches
Advanced habitation systems
Communications and navigation technologies

Advancing Lunar and Planetary Technologies

In 2024 and 2025, 42 program-supported technologies were tested on parabolic flights. During brief periods of microgravity as well as lunar and Martian gravity, researchers collected data for projects that address several technology shortfalls across the civil space ecosystem.

- On flights in April 2024, NASA's Glenn Research Center tested a lunar excavation tool that uses resonant vibrations to fluidize soil around the leading edge of a probe or shovel. **Researchers collected data to help establish what magnitude of force reduction can be expected from an ultrasonic tool on the Moon and Mars**, enabling the tool's mass reduction and thereby reducing launch costs. Supported by NASA's Game Changing Development program, this technology for extraterrestrial mining or prospecting machinery could enable commodity production on the lunar surface.
- During lunar landings the rocket plume disturbs regolith, which can result in cratering, severe dust blowing, and particle ejecting. Aboard parabolic flights in March and April 2024, Auburn University researchers gathered data on **plume-surface interaction in reduced- and lunar-gravity conditions** to better understand the underlying physics and enable safe landings.


Zero Gravity Corporation


Zero Gravity Corporation

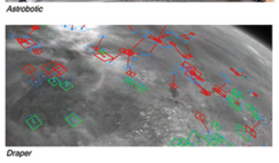
In addition, in Feb. 2025, the program supported the testing of 17 technologies aboard Blue Origin's suborbital rocket system, **which spun the payload capsule ~11 rpm after it detached from the booster to simulate lunar gravity for approximately two minutes.** The flight test allowed researchers to test and de-risk innovations that could address critical shortfalls for the Artemis program, planetary exploration, and commercial space missions.

Preparing Technologies for Lunar Landings

Flight Opportunities leveraged Astrobotic's Xodiac lander vehicle as well as their testbed of simulated lunar terrain in the Mojave Desert for the testing, refining, and de-risking of two technologies that will help guide upcoming missions to the Moon:


Astrobotic

Astrobotic's advanced hazard detection lidar sensor successfully captured high-precision data during a Nov. 2024 flight test supported by Flight Opportunities, **progressing to a new readiness level as it prepares to guide a safe and precise landing at the Moon's South Pole during the company's Griffin-1 mission.** The system processes 3D lidar (light detection and ranging) point cloud data into a terrain map to enhance hazard detection.


Draper

The Draper Multi-Environment Navigation (DMEN) technology, a vision-aided system to help spacecraft land with greater precision, took flight in Oct. 2024 aboard Xodiac as well as in Feb. 2025 aboard Blue Origin's suborbital rocket system and building on earlier high-altitude balloon tests – all supported by Flight Opportunities. **This iterative testing increased DMEN's technology readiness as Team Draper prepares to land at Schrödinger Basin on the Moon's far side.**

RELEVANT TEST ENVIRONMENTS

Flight Opportunities facilitates access to a variety of test environments that replicate conditions encountered on lunar and planetary missions. Relevant environment test conditions include, but are not limited to:

- Reduced gravity and weightlessness
- Challenging landing navigation
- High-altitude solar exposure
- Extreme temperatures and vacuum
- Atmospheric re-entry
- Radiation

Commercial flight providers utilize a variety of vehicles to provide these test profiles and support the advancement of investigators' research or technology development plans.


Astrobotic

Vertical Takeoff Vertical Landing (VTVL) Vehicles

These vehicles provide controlled descent and landing from various altitudes, often used to test of entry, descent, and landing technologies.


Zero Gravity Corporation

Parabolic Flights

These airplanes achieve brief periods of reduced gravity (lunar, Martian, and microgravity) through a series of maneuvers called parabolas. These flight profiles can be used for testing technologies that need to operate outside of Earth's gravity.


SpaceWorks Enterprises

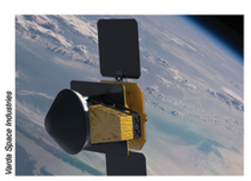
High-Altitude Balloons

These systems can reach altitudes of up to ~100,000 feet (or 30 km) and typically sustain flights of hours, days, or even weeks, offering exposure to relevant pressure, radiation, and thermal environments; external views of the Earth; and high-altitude drop of payloads.


Virgin Galactic

Suborbital Reusable Launch Vehicles

These vehicles reach high altitudes — nominally nearly 50 miles (or 80 kilometers) — providing two or more minutes of continuous reduced gravity and/or exposure to the space environment.


Varda Space Industries

Hosted Orbital Platforms

These platforms include small spacecraft, satellites, launch vehicle stages, or orbital spacecraft that provide power and communications to their hosted payloads and extended periods of microgravity.


NASA

Capability Enhancements

The program makes strategic investments and provides expertise to help flight providers develop enhanced flight test capabilities, such as Astrobotic's high-fidelity Lunar Surface Proving Ground and thermal protection materials for Varda's space capsule.

LUNAR INFUSION SUCCESS STORIES

Several technologies tested through the Flight Opportunities program have been infused into lunar, planetary, and other space missions. As described below, **seven went to the Moon through NASA's Commercial Lunar Payload Services (CLPS) initiative**, which supports the delivery of science and technology payloads to the Moon's surface for testing. Parabolic and suborbital flight tests helped research teams reduce their technologies' risks and prepare them for NASA CLPS deliveries.


Launch of the IM-1 CLPS mission Feb. 15, 2024. Credits: SpaceX

Intuitive Machines IM-1

In 2024, two technologies matured through Flight Opportunities flew aboard the Intuitive Machines IM-1 CLPS delivery, which was the first U.S. lunar landing in decades:

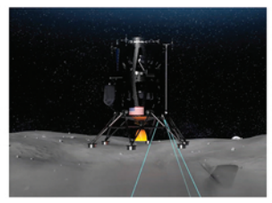
NASA's Radio Frequency Mass Gauge (RFMG)


In 2011, NASA tested the RFMG in microgravity on parabolic flights supported by Flight Opportunities. Credits: Devin Boldt

- Developed at NASA's Glenn Research Center, RFMG uses radio waves and antennae in a tank to measure how much propellant is available — a particularly challenging task in microgravity.
- **Parabolic flights in 2011 supported by Flight Opportunities helped advance RFMG and led to novel ideas for improving the gauging algorithm.** That progress helped RFMG secure a spot on the International Space Station for further testing, helping ready it for its demonstration on the CLPS mission.
- During the IM-1mission, **RFMG helped Intuitive Machines verify propellant levels in the lander.**

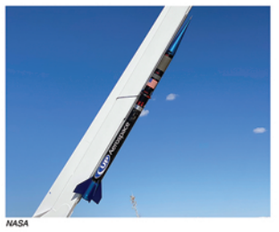
NASA's Navigation Doppler Lidar (NDL)

- NASA's NDL uses a laser to measure a spacecraft's velocity and altitude during descent and landing, providing a lighter and more accurate option than radar-based systems for precision navigation and tightly controlled landing on the Moon or other destinations in the solar system.
- Developed at NASA's Langley Research Center, NDL was tested on a commercial rocket-powered lander in 2017 via Flight Opportunities, **advancing it for use in a wide range of landing missions, including crewed lunar missions.**
- **NDL provided critical backup data** when the IM-1 lander's primary navigation system encountered an issue during descent.
- NASA's NDL technology is expected to fly to the Moon again aboard Astrobotic's Griffin Mission One to the lunar South Pole.
- Virginia-based Psionic licensed the technology from NASA and created a miniaturized commercial version of NDL, which also was tested through Flight Opportunities and now serves multiple markets.


Navigation Doppler Lidar (NDL) allows for extremely safe and precise landings of robotic and crewed vehicles on the Moon. Credits: Intuitive Machines

2025 CLPS Deliveries

The program also helped advance five technologies that were on two 2025 CLPS deliveries, having supported testing on high-altitude balloons, parabolic flights, and rocket-powered vehicles between 2014 and 2024:


NASA

The Lunar GNSS Receiver Experiment (LuGRE) from NASA and the Italian Space Agency acquired/tracked signals for the first time in lunar orbit — a new record.
- During a 2024 flight test supported by Flight Opportunities aboard an UP Aerospace sounding rocket, researchers demonstrated the effective use of a multi-constellation (GPS-Galileo) multi-frequency GNSS receiver on a launch vehicle. Researchers used flight data to perform experimental evaluations of the benefits of interoperability between GPS and Galileo constellations. **The effort with Flight Opportunities provided extremely valuable data to aid in ongoing research and optimization of the technology.**


Honeybee Robotics

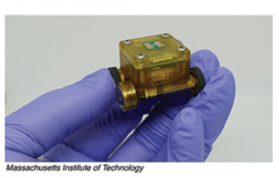
Lunar PlanetVac from Honeybee Robotics, a Blue Origin company, collected and sorted the Moon's soil.
- From 2018 to 2020, during tests supported by Flight Opportunities on Astrobotic's Xodiac VTVL vehicle, PlanetVac successfully collected more than 220 grams of simulated regolith. **Flight tests showed PlanetVac could survive launch/landing and successfully capture and deliver regolith samples, proving its worthiness for a lunar mission.**


Montana State University

Radiation Tolerant Computer (RadPC) from Montana State University successfully operated through VanAllen Belts and on the lunar surface.
- Flight Opportunities–supported testing began in 2014 aboard sounding rockets, including one flown by UP Aerospace, which helped **demonstrate that RadPC could withstand the forces of a rocket launch**. Aboard Aerostar International high-altitude balloons, RadPC flew for more than 100 hours above 75,000 feet — outside of the majority of Earth's atmosphere and thus exposed to space radiation — **enabling researchers to validate various subsystems.** These flight demonstrations were crucial to preparing RadPC for two demonstrations on the International Space Station in 2022 as well as selection for a CLPS mission.

Space Environment Technologies

Automated Radiation Measurement for Aerospace Safety (ARMAS) from Space Environment Technologies measured radiation both en route to the Moon and on the lunar surface to help protect on-board equipment.
- Multiple high-altitude balloon flights with World View Enterprises **helped researchers demonstrate the sensor's capabilities and identify areas of refinement**, and a flight test on Blue Origin's suborbital rocket system helped ready ARMAS to provide radiation measurements from outside the International Space Station in 2022.


Massachusetts Institute of Technology

The **AstroAnt miniature robot** from the MIT Media Lab Space Exploration Initiative was designed to provide diagnostics and servicing of rovers on the Moon.
- Flight Opportunities enabled testing of AstroAnt in 2021 in simulated lunar, Martian, and microgravity aboard a Zero Gravity Corporation aircraft flying a parabolic profile. **In these reduced gravity environments, researchers demonstrated rapid robot mobility and controlled traction for lunar spacecraft diagnostics and servicing.**