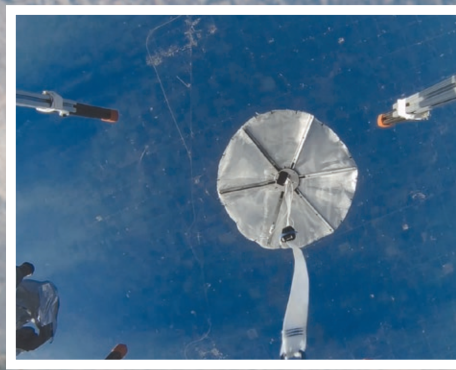
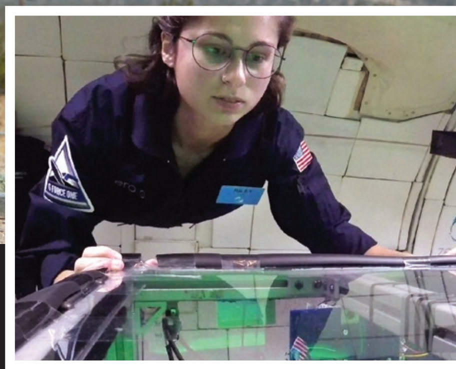
National Aeronautics and Space Administration

SPACE TECHNOLOGY MISSION DIRECTORATE

Flight Opportunities





2019 Accomplishments

Contents

Credit: Blue Origin

Flight Opportunities Mission

NASA's Flight Opportunities program facilitates rapid demonstration of promising technologies for space exploration and the expansion of space commerce through suborbital testing with industry flight providers. The program matures capabilities needed for NASA missions and commercial applications while strategically investing in the growth of the U.S. commercial spaceflight industry. These flight tests take technologies from ground-based laboratories into relevant environments to increase technology readiness and validate feasibility while reducing the costs and technical risks of future missions.

Awards and agreements for flight tests are open to researchers from industry, academia, non-profit research institutes, and government organizations. These investments help advance technologies of interest to NASA while supporting commercial flight providers and expanding space-based applications and commerce.

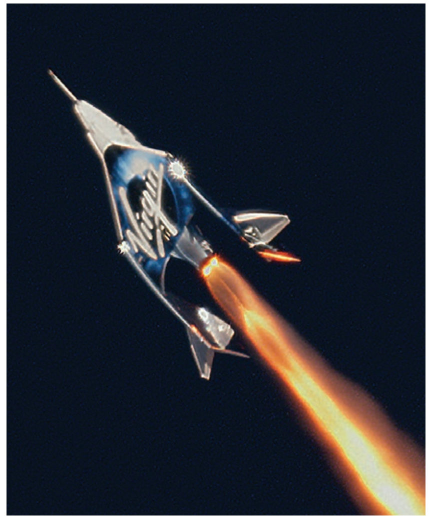
FY2019 QUICK LOOK

Payloads tested in flight	47
Successful flights	15
Active commercial flight providers	10
Technologies selected for future flight tests	25

Flight Highlights

Testing performed with commercial flight providers in fiscal year 2019 (FY2019) highlights the impact that rapid testing and reflight can have on increasing the speed and effectiveness of the technology development process. In addition, many technologies that are poised to help NASA achieve key mission goals were able to achieve notable maturation milestones during their flights this year.

LEVERAGING NEW VEHICLES FOR RAPID TESTING AND REFLIGHT



Vehicles from Virgin Galactic and Blue Origin demonstrated rapid testing and reflight for several Flight Opportunities–supported technologies on three successive launches over three months in early FY2019. Credits: Blue Origin (left), Virgin Galactic (right)

Between December 2018 and February 2019, 17 Flight Opportunities–supported payloads were tested on three flights conducted by Virgin Galactic and Blue Origin. These three successful flights in a short three-month timeframe represent the long-awaited emergence of two high-fidelity commercial suborbital platforms for testing program-supported payloads. Notably, these flights included:

- Virgin Galactic's first two flights for Flight Opportunities, both on SpaceShipTwo
- Blue Origin's first dedicated launch of its New Shepard rocket for NASA payloads

The flights carried a series of space exploration and utilization technologies, including research that could aid the ability of future missions to mitigate the impact of lunar surface dust on humans and equipment, separate gas and liquid for *in situ* resource processing and on-orbit fuel transfer, and understand how to help plants thrive in space as a resource for sustained human activity on the Moon and beyond. Many of the payloads were flown multiple times and on both vehicles, underscoring the benefit of gathering data on different flight platforms and exhibiting the potential for rapid testing and reflight of technologies.

ENABLING SAFE AND PRECISE PAYLOAD RECOVERY

A guided parafoil system for payload recovery was successfully tested in FY2019. Credit: Airborne Systems North America

Airborne Systems North America tested a precision payload recovery experiment on two high-altitude balloon flights from World View Enterprises on April 9 and September 22, 2019. The flights demonstrated the ability of a guided parafoil to navigate to a logistically accessible recovery zone and potentially improve midair retrieval of reusable rocket components and payloads returning to Earth.

FACILITATING RAPID SAMPLE RETURN FROM LOW-EARTH ORBIT

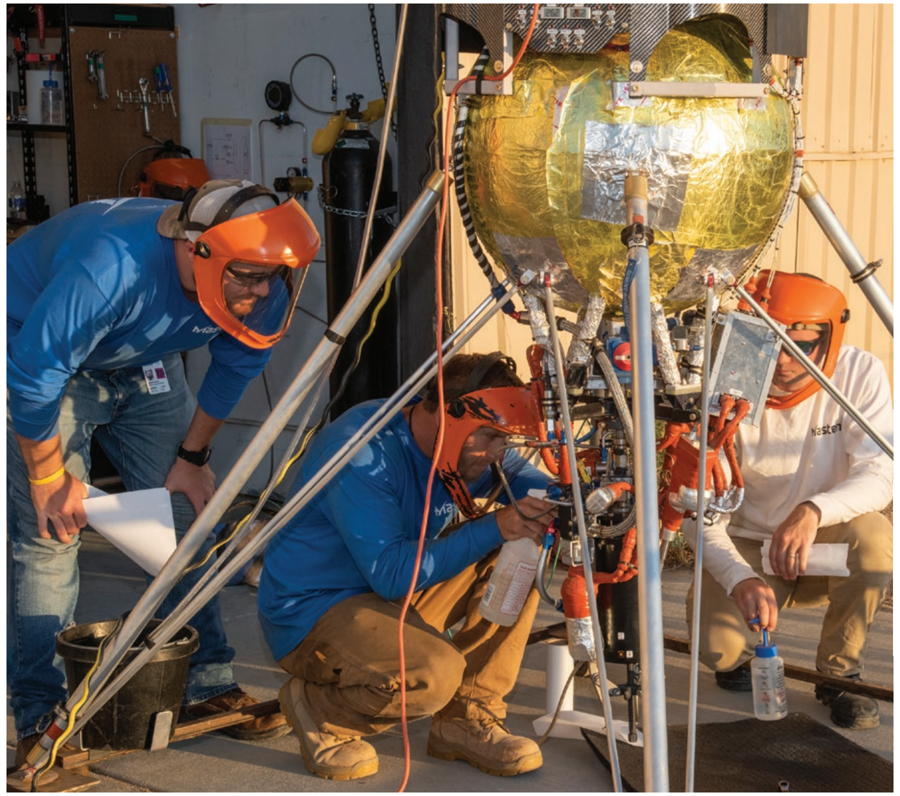
Raven Aerostar conducted its first flight for a Flight Opportunities–supported technology in FY2019. Credit: NASA

On August 29, 2019, NASA's Ames Research Center tested its exo-atmospheric aerobrake technology on a high-altitude balloon flight from Raven Aerostar above Sioux Falls, South Dakota. The payload is a passive re-entry/deorbit device designed to enable quick sample return from the International Space Station and other orbital outposts. Notably, the flight marked the first for Raven as a commercial provider for Flight Opportunities.

"Suborbital flights enable researchers to quickly and iteratively test technologies with the opportunity to make adjustments between flights. The ultimate goal is to change the pace of technology development and drastically shorten the time it takes to bring an idea from the lab to orbit or to the Moon."

— Christopher Baker, Program Executive, Flight Opportunities

ADVANCING LUNAR AND PLANETARY NAVIGATION



A successful test of Draper's terrain-relative navigation system on Masten Space Systems' Xodiac rocket has made the system one of several navigation tools in consideration for future missions to the Moon through NASA's Artemis program. Credit: NASA

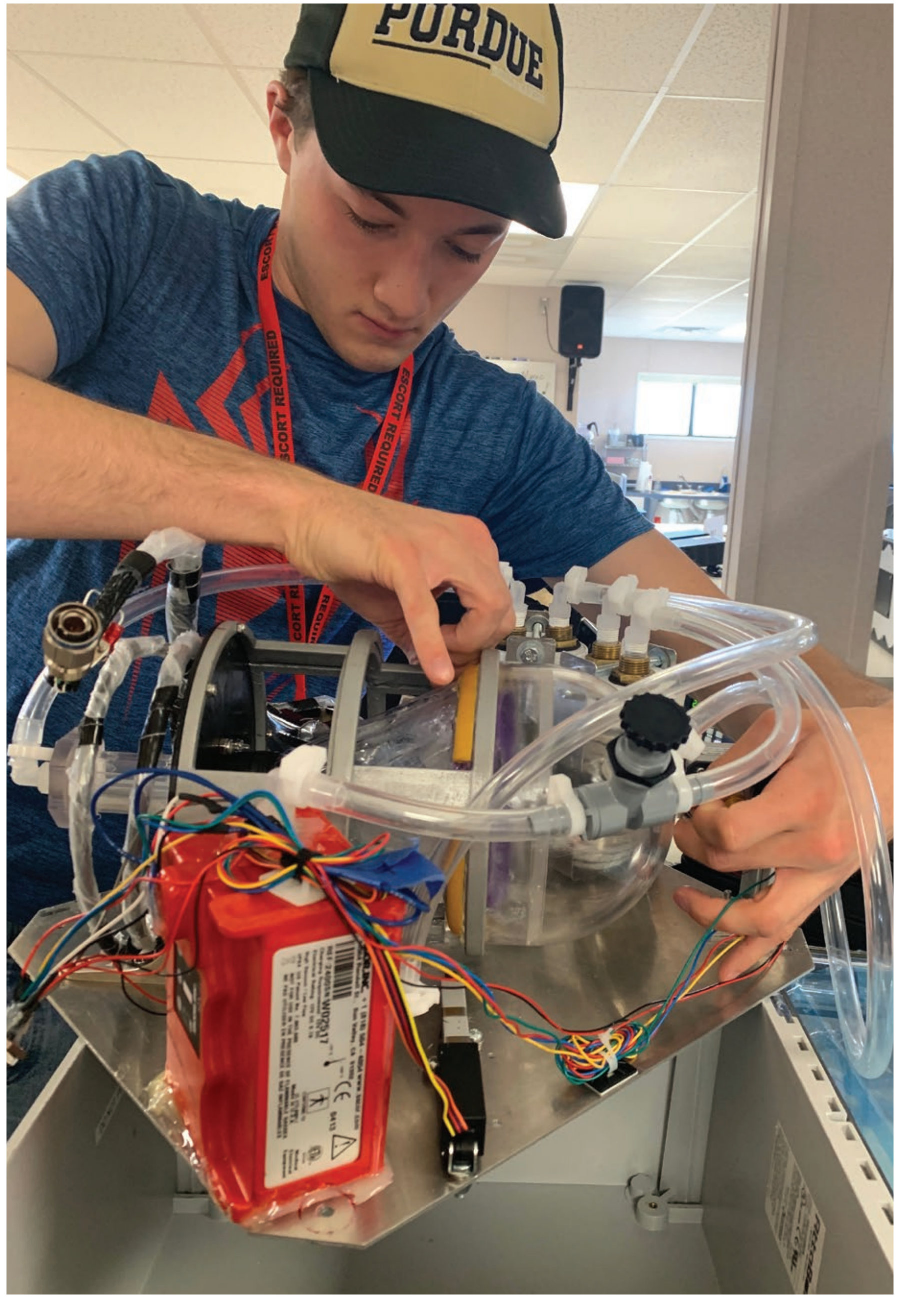
"If we didn't have these integrated field tests, a lot of new precision landing technologies might still be sitting in a lab or on paper, being deemed too risky for flight. This gives us the very necessary opportunity to get the data we need, make revisions, and build insight and confidence into how these technologies will perform on a spacecraft."

— John M. Carson III, SPLICE project principal investigator, NASA's Johnson Space Center

On September 11, 2019, Draper tested the performance of a terrain-relative navigation system on Masten Space Systems' Xodiac rocket. The goal: to demonstrate the technology's ability to identify land features in real time and characterize navigation performance, which will be critical for landing on the Moon or Mars. This capability would improve a lander's knowledge of where it is and where there is a safe place to touch down. NASA's work to develop this and related technologies falls under the Safe and Precise Landing–Integrated Capabilities Evolution (SPLICE) project.

Draper also leveraged balloon flights with World View Enterprises on April 9 and September 22, 2019, to gather valuable data in the high-altitude descent regime for another aspect of its portfolio of entry, descent, and landing (EDL) technologies: a vision navigation solution known as the Draper Multi-Environment Navigator. Draper has leveraged NASA-sponsored flights on several vehicles through Flight Opportunities, enabling researchers to test their EDL technologies at a variety of altitudes and conditions to help ensure that the systems can successfully execute a landing on the Moon or Mars. Draper's work resulted in the selection of its Navigation Doppler Lidar technology to fly to the Moon on a future NASA Commercial Lunar Payload Services (CLPS) flight.

MATURING LIFE-SAVING MEDICAL TECHNOLOGIES FOR ON-ORBIT EMERGENCIES



On May 2, 2019, Blue Origin conducted a successful suborbital flight of its New Shepard rocket with 38 payloads on board, including nine that were developed or sponsored by NASA. The payloads included a gravity-independent chest tube drainage system from Orbital Medicine that could be used to treat a collapsed lung in space (a potentially fatal injury likely to occur during a decompression event). This technology could also be applied in military or civilian medevac or other emergency medical situations where current gravity-dependent systems are in danger of being knocked over.

Orbital Medicine's Evolved Medical Microgravity Suction Device is prepared for a flight test to help mature the technology aboard Blue Origin's New Shepard rocket. Credit: Blue Origin

Technology Transitions

As technologies are matured through flight tests, they climb the technology readiness ladder, often transitioning to orbital testing opportunities or inclusion in NASA missions. In FY2019, several Flight Opportunities–supported technologies realized such success.

ARTEMIS AND COMMERCIAL LUNAR PAYLOAD SERVICES SELECTIONS

In FY2019, NASA selected science and technology experiments to fly to the Moon on future NASA Commercial Lunar Payload Services (CLPS) flights in support of the Artemis program. The technologies highlighted below* were matured in part through commercial flight tests facilitated by Flight Opportunities.

In addition, three Flight Opportunities participants are eligible to bid on NASA delivery services to the lunar surface through CLPS contracts: Astrobotic Technology, Blue Origin, and Masten Space Systems.

SwRI investigators tested methods for conducting electric and magnetic field measurements of planetary interiors on commercial flights, including the one shown here on a World View Enterprises balloon. These tests helped the SwRI team develop a new instrument that was selected for Artemis. Credit: Earth Science Systems

Lunar Magnetotelluric Sounder

Southwest Research Institute (SwRI) (PI: Robert Grimm)

Based on technology tested through the Flight Opportunities program, SwRI's sounder is designed to characterize the structure and composition of the Moon's mantle by studying its electric and magnetic fields. Selected by NASA for a lunar investigation, the sounder will employ a flight-spare magnetometer, originally made for the MAVEN spacecraft, which is currently orbiting Mars.

*Draper's Navigation Doppler Lidar technology was also selected for a future CLPS flight. See story on page 4.

Successful Flight Opportunities–supported tests of PlanetVac, which is designed to attach to the leg of a lander vehicle (as shown here), helped the technology be selected for Artemis as part of a CLPS mission. Credit: Honeybee Robotics

PlanetVac

Honeybee Robotics (PI: Kris Zacny)

PlanetVac—a pneumatic suction device designed to collect regolith for subsequent analysis—will be used on one of the landers being developed under the CLPS contracts. The device's ability to quickly and efficiently gather regolith was well demonstrated on flights facilitated by Flight Opportunities.

Flights facilitated by Flight Opportunities, including on high-altitude balloons and rockets, helped mature the RadSat technology (shown at the recovery stage after a World View Enterprises balloon flight) for Artemis selection. Credit: World View Enterprises

Reconfigurable, Radiation-Tolerant Computer System

Montana State University (PI: Brock LaMeres)

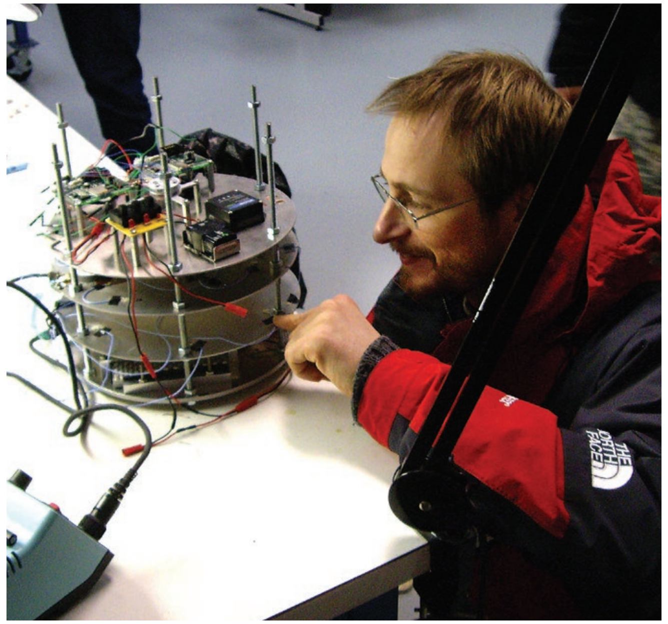
Radiation-tolerant computing will be needed on the Moon, where the lack of atmosphere as well as the magnetic field and radiation from the Sun will be a challenge for most terrestrial electronics. This lunar demonstration will further test the computer system matured in part through Flight Opportunities and will also help characterize the radiation effects on the Moon's surface—a critical need for understanding long-term impact on human explorers and equipment.

Read more about the selections online

Visit *https://go.usa.gov/xdBRK* and *https://go.usa.gov/xdBR5*

MATERIALS INTERNATIONAL SPACE STATION EXPERIMENT SELECTIONS

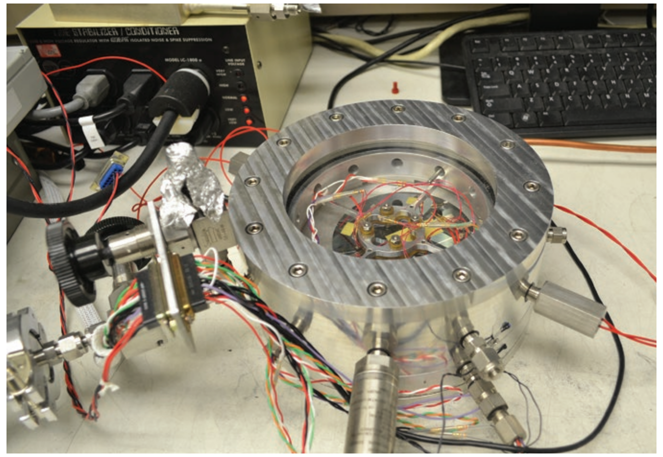
The Structural Health Monitoring for Commercial Space Vehicles technology from the New Mexico Institute of Mining and Technology (Andrei Zagrai and Anders Jorgensen, co-investigators) was selected for NASA's next Materials International Space Station Experiment (MISSE) mission. MISSE sends material samples to the International Space Station for a minimum research period of one year, enabling materials under investigation for long-term use in space to be exposed to the harsh space environment for testing and evaluation. This selected technology is designed to provide an integral part of a flight information recorder (commonly known as the black box), gathering and storing data on its structural integrity during all stages of spaceflight.



The Structural Health Monitoring for Commercial Space Vehicles technology was matured in part by flights facilitated by Flight Opportunities, including on UP Aerospace's SpaceLoft rocket, as shown here. Credit: UP Aerospace

OTHER MISSIONS AND COLLABORATIVE EXPERIMENTS

Several technologies matured through Flight Opportunities received additional NASA funding for further suborbital or orbital testing beyond the program, including experiments on the International Space Station, and on both NASA and commercial vehicles. Recent highlights of these types of infusions include:



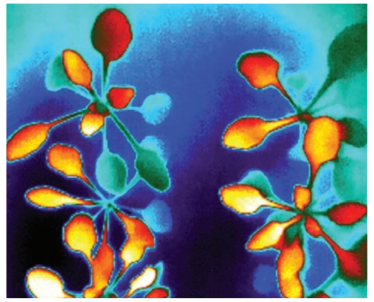
Flights on commercial vehicles, including ZERO-G's parabolic aircraft, helped prepare this thermal management experiment for an International Space Station mission. Credit: Worcester Polytechnic Institute

Investigation of Gravity Effects on Electrically Driven Liquid Film Boiling

Worcester Polytechnic Institute (PI: Jamal Yagoobi)

Data from multiple commercial suborbital flights is helping inform the experiment design for a NASA-funded long-term investigation on the International Space Station as early as 2021. Researchers are hoping to develop enhanced thermal management capabilities by investigating the effects of gravity on the electric forces governing heat flux acquisition and fluid management.

University of Florida investigators have been conducting biological investigations on plants in microgravity for 20 years, including on many parabolic flights such as the one shown here. Credit: NASA

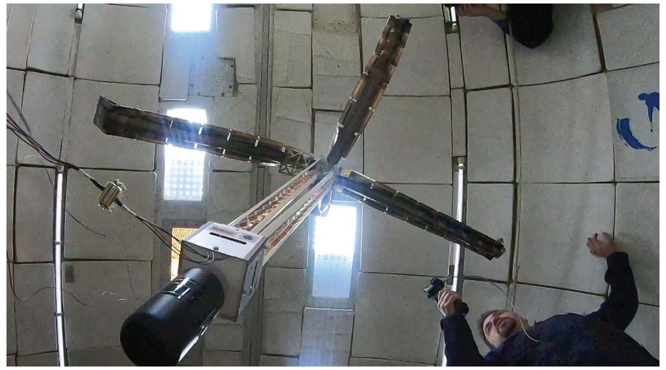


Fluorescent imaging hardware tested on plants is now being used in other collaborative science studies. Credit: University of Florida

Telemetric Hardware for Biological Imaging in Suborbital Applications

University of Florida (PI: Robert Ferl)

University of Florida investigators received NASA funding to use their imaging hardware on a biological sciences experiment from the University of Wisconsin. The collaboration is funded by NASA's Division of Space Life and Physical Sciences Research and Applications through a Research Opportunities in Space Biology award. The experiment is funded for one test flight on a commercial vehicle, slated for 2020.



Parabolic flights have helped ready this advanced solar technology for an orbital mission. Credit: NeXolve Corporation

Lightweight Integrated Solar Array and Antenna (LISA-T)

NeXolve Corporation (PI: Brandon Farmer)

LISA-T provides power to CubeSats with specific power generating and stowage requirements. The technology was selected for demonstration in 2021 as part of NASA's Pathfinder Technology Demonstrator project, which will test the operation of a variety of novel CubeSat technologies in low-Earth orbit.

Technologies Tested in FY2019

Flight Date	Flight Provider and Vehicle	Principal Investigator	Organization	Technology
October 15, 2018	Near Space Corporation ››› *Small Balloon System*	Andres Martinez	NASA's Ames Research Center	T0199 - Animal Tracker Ground Station - Tag Testing
November 13, 2018	Zero Gravity Corporation ››› *G-FORCE ONE*	Josh Colwell	University of Central Florida	T0154 - Miniaturized and Reusable Asteroid Regolith Microgravity Experiment
		Jacob Chung	University of Florida - Gainesville	T0189 - Optimal Childdown Methods for Cryogenic Propellant Tanks
		Jungho Kim	University of Maryland	T0190 - Gravity Effects on Flow Boiling Heat Transfer Using Temperature-Sensitive Paints
		Kevin Crosby	Carthage College	T0191 - Microgravity Propellant Gauging Using Modal Analysis: Phase III
		Karen Daniels	North Carolina State University	T0197 - Ejecta-Minimizing Protocols for Applications Needing Anchoring or Digging on Asteroids
		Mark Pankow	North Carolina State University	T0205 - Lightweight Strain-Energy Deployed Spacecraft Booms
		Steven Collicott	Purdue University	T0206 - Small-sat Propellant Management Technology
November 18, 2018	Near Space Corporation ››› *Small Balloon System*	Russell Dewey	GSSL, Inc.	T0099 - Satellite-Based ADS-B
December 13, 2018	Virgin Galactic ››› *SpaceShipTwo*	Kathryn Hurlbert	NASA's Johnson Space Center	T0020 - Microgravity Multi-Phase Flow Experiment for Suborbital Testing
		Josh Colwell	University of Central Florida	T0036 - Collisions Into Dust Experiment
		Robert Ferl	University of Florida - Gainesville	T0053 - Telemetric Hardware for Biological Imaging
		Scott Green	Controlled Dynamics, Inc.	T0077 - Facility for Microgravity Research and Submicroradian Stabilization Using sRLVs
January 23, 2019	Blue Origin ››› *New Shepard*	H. Todd Smith	Johns Hopkins University	T0015 - Electromagnetic Field Measurements on sRLVs
		Josh Colwell	University of Central Florida	T0036 - Collisions Into Dust Experiment
		Josh Colwell	University of Central Florida	T0052 - Collection of Regolith Experiment
		Robert Ferl	University of Florida - Gainesville	T0053 - Telemetric Hardware for Biological Imaging
		Scott Green	Controlled Dynamics, Inc.	T0077 - Facility for Microgravity Research and Submicroradian Stabilization Using sRLVs
		Kevin Crosby	Carthage College	T0123 - Microgravity Propellant Gauging Using Modal Analysis
		Steven Collicott	Purdue University	T0128 - Zero-gravity Green Propellant Management Technology
		Franklin Robinson	NASA's Goddard Space Flight Center	T0173 - Flow Boiling in Microgap Coolers - Embedded Thermal Management
January 29, 2019	Black Sky	Justin Lee	The Aerospace Corporation	T0177 - Rapid Calibration of Space Solar Cells
February 22, 2019	Virgin Galactic ››› *SpaceShipTwo*	H. Todd Smith	Johns Hopkins University	T0015 - Electromagnetic Field Measurements on sRLVs
		Kathryn Hurlbert	NASA's Johnson Space Center	T0020 - Microgravity Multi-Phase Flow Experiment for Suborbital Testing
		Josh Colwell	University of Central Florida	T0036 - Collisions Into Dust Experiment
		Scott Green	Controlled Dynamics, Inc.	T0077 - Facility for Microgravity Research and Submicroradian Stabilization Using sRLVs
April 9, 2019	World View Enterprises ››› *Tycho-20*	Garrett Dunker	Airborne Systems North America	T0186 - Guided Parafoil High Altitude Research II
		Brett Streetman	Draper	T0195 - Draper Multi-Environment Navigator
May 2, 2019	Blue Origin ››› *New Shepard*	C. Marsh Cuttino	Orbital Medicine	T0162 - Evolved Medical Microgravity Suction Device
		Kathryn Hurlbert	NASA's Johnson Space Center	T0168 - Suborbital Flight Experiment Monitor-2
		Franklin Robinson	NASA's Goddard Space Flight Center	T0173 - Flow Boiling in Microgap Coolers - Embedded Thermal Management
		Suzanne Smith	University of Kentucky	T0178 - Characterization of 3D Printing Processes Under Microgravity Conditions
		Sam Wald	Nanoracks	T0180 - Developing a Centrifuge for New Shepard
		Daniel O'Connell	HNU Photonics	T0181 - BioChip SubOrbitalLab: Microfluidic Imaging Platform for Live-Cell Investigations
		Adrienne Dove	University of Central Florida	T0182 - Strata-S1 - Testbed to Evaluate Regolith Behavior
		Steven Collicott	Purdue University	T0192 - Cryogenic Gauging Technology Geometry Development
		Elizabeth Kennick	Teachers in Space	T0193 - Stratospheric and Suborbital Flight Experiments and Equipment
August 29, 2019	Raven Aerostar	Marcus Murbach	NASA's Ames Research Center	T0075 - Exo-atmospheric Aerobrake
September 11, 2019	Masten Space Systems ››› *Xodiac*	Matt Fritz	Draper	T0198 - Terrain Relative Navigation System for Landing Applications
September 22, 2019	World View Enterprises ››› *Tycho-20*	Garrett Dunker	Airborne Systems North America	T0186 - Guided Parafoil High Altitude Research II
		Brett Streetman	Draper	T0195 - Draper Multi-Environment Navigator
		Brock LaMeres	Montana State University	T0210 - Using Single Event Effects to Generate Truly Random Numbers for Encryption Keys

New Technology Selections

The Flight Opportunities "Tech Flights 2019" solicitation was released on February 19, 2019, to provide funding to industry and academia for the suborbital testing and demonstration of technologies that address two topic areas in line with current NASA priorities. The program selected 25 promising space technologies for testing aboard parabolic aircraft, high-altitude balloons, and suborbital rockets.

TOPIC 1: SUPPORTING SUSTAINABLE LUNAR EXPLORATION AND THE EXPANSION OF ECONOMIC ACTIVITY INTO CISLUNAR SPACE

Carthage College
Advancements that address the need for accurately measuring propellant levels on spacecraft during dynamic events in zero gravity, such as engine burns

Draper
A navigation system designed to give crewed missions precise location and navigation data needed for safe and accurate lunar and planetary landings

Honeybee Robotics
A planetary sample capture device featuring a footpad-integrated sampling tube and sample sorting station to collect surface soil, or regolith, on another planetary body that could be returned to Earth for analysis

IMEC USA Nanoelectronics Design Center
A diagnostic and bioanalytical monitoring solution for astronauts aboard deep space exploration missions

Johns Hopkins University
A complete lunar radiation hazard characterization and monitoring system

Masten Space Systems
- A commercialized terrestrial version of a NASA navigation system that has been adapted for space with lower size, mass, and power consumption than the previous versions
- A laser instrument that measures density and particle size of lunar lander plume ejecta
- A high-fidelity landing simulator combined with a regolith sample collection device

Montana State University
A computer technology based on cost-effective, off-the-shelf parts that is designed to recover in the event of a system failure caused by radiation

North Carolina State University
Large-scale deployable solar arrays constructed with a hinge mechanism that allows folding into origami-like shapes for improved packing

Southwest Research Institute
A device to improve the transfer and delivery of cryogenic fluids by reliably removing vapor bubbles

University of Central Florida
An experiment to characterize the charging behavior of dust in lunar-like environments to understand how dust interacts with other particles and surfaces

University of Colorado
Testing of a 3D printer to determine the effect of reduced gravity on the fabrication of components, including elements of life support systems that could be required to remove carbon dioxide from a crew-occupied cabin

University of Florida
- Enhancement of a flight-proven imaging concept and hardware system to characterize biological responses to changes in gravity levels during spaceflight
- A cryogenic boil-off experiment to collect information and advance the long-term storage of propellant in space

Learn more about these technologies

Visit https://go.usa.gov/xdBGA

TOPIC 2: FOSTERING THE COMMERCIALIZATION OF LOW-EARTH ORBIT AND UTILIZATION OF SUBORBITAL SPACE

GSSL
A modified drone shuttle system designed to return large amounts of data from high-altitude balloons, allowing unprocessed science data to be retrieved before the end of a balloon flight

Johns Hopkins University
- An ultraviolet remote imaging system that can fly externally on suborbital rockets, enabling new science measurements at altitudes of up to 100 km in the absence of ozone
- Deployment and re-entry of miniaturized satellites, known as ChipSats, to evaluate the capability of the technology to enable inexpensive study of difficult-to-explore regions of Earth's upper atmosphere as well as the atmospheres and surfaces of other planets or moons

Mayo Clinic
Real-time testing of biological changes during suborbital launch and landing conditions and hyper/microgravity

Night Crew Labs
Adaptation of a satellite remote sensing technique that detects changes in Global Navigation Satellite System radio signals as they pass through Earth's atmosphere to a balloon-based system that provides on-demand and persistent coverage over regions of strong interest during high-impact weather events

Purdue University
A payload designed to observe fuel behavior and its effect on spacecraft pointing

Southwest Research Institute
A novel anchoring and sampling architecture for the surfaces of small asteroids, enabling regolith collection from multiple sites

Space Environment Technologies
Long-duration regional monitoring and identification of harmful radiation sources

University of Kentucky
Lightweight, compact, and low-cost instrumentation designed to examine potential long-range gust and turbulence detection at high altitudes, with benefits for suborbital and low-Earth orbit vehicles as well as general aviation

Vanderbilt University
Testing of a small system designed to enable complex biological and chemical experiments as well as new capabilities for synthesizing chemicals, including pharmaceuticals

Flight Providers

Flight Opportunities supports the testing of technologies in a wide variety of relevant environments. Flights from commercial providers offer access to many vehicle types, each with its own unique environment and capabilities for testing. The following information highlights the general categories of vehicles available for testing and the commercial providers that were active in FY2019.

A high-altitude balloon is prepared for flight. Credit: Near Space Corporation

HIGH-ALTITUDE BALLOONS

Large balloon systems reach altitudes of 30 km and beyond and can also typically sustain the longest duration of the suborbital vehicles—hours, days, or even weeks at a time. This makes them ideal for payloads that benefit from extended periods of data collection.

- BlackSky Aerospace
- Near Space Corporation
- Raven Aerostar
- World View Enterprises

A spacecraft boom is deployed during a parabolic flight. Credit: North Carolina State University

PARABOLIC AIRCRAFT

These specialized airplanes achieve brief periods of variable gravity through a series of maneuvers called parabolas. They can be used for demonstrating technologies that need to operate in the absence of gravity.

- Zero Gravity Corporation

ROCKET-POWERED VEHICLES

These vehicles include both suborbital reusable launch vehicles that reach high altitudes as well as lander vehicles that specialize in entry, descent, and landing technologies. Both of these classes of vehicles are typically recoverable and reusable after launch.

- Blue Origin
- EXOS Aerospace
- Masten Space Systems
- UP Aerospace
- Virgin Galactic

The Xodiac rocket lifts off the launchpad at the Mojave Air and Space Port in California. Credit: Masten Space Systems

UP Aerospace's SpaceLoft rocket, prepared for launch. Credit: NASA

Learn more about available vehicles

Visit Flight Opportunities online to view information about all currently active commercial flight providers for the program: *https://go.usa.gov/xdBPY*

CURRENT TECHNOLOGY PORTFOLIO

Number	PI	Organization	Title	NASA TX Number
T0003	Sathya Gangadharan	Embry-Riddle Aeronautical University	Determining Rotational Stability of On-Orbit Propellant Storage and Transfer Systems	TX01: Propulsion Systems
T0024	Gregory A. Zimmerli	NASA GRC	Radio Frequency Gauging of the Liquid Oxygen Tank on an sRLV	TX01: Propulsion Systems
T0191	Kevin Crosby	Carthage College	Microgravity Propellant Gauging Using Modal Analysis: Phase III	TX01: Propulsion Systems
T0192	Steven Collicott	Purdue University	Cryogenic Gauging Technology Geometry Development	TX01: Propulsion Systems
T0202	Kevin Supak	Southwest Research Institute	Liquid Acquisition Devices for Cryogenic Fluid Management	TX01: Propulsion Systems
T0206	Steven Collicott	Purdue University	Small-sat Propellant Management Technology	TX01: Propulsion Systems
T0215	Alina Alexeenko	Purdue University	FEMTA Micropropulsion System for Interplanetary Smallsat	TX01: Propulsion Systems
T0216	Steven Collicott	Purdue University	Zero g Slosh Model Technology	TX01: Propulsion Systems
T0218	Kevin Crosby	Carthage College	Magneto-Active Slosh Control System	TX01: Propulsion Systems
T0200	Austin Williams	Tyvak Nano-Satellite Systems LLC	Micro-Avionics Multipurpose Platform	TX02: Flight Computing and Avionics
T0177	Justin Lee	The Aerospace Corporation	Rapid Calibration of Space Solar Cells in Suborbital Environments	TX03: Aerospace Power and Energy Storage
T0203	Greg Laue	NeXolve Corporation	Lightweight Integrated Solar Array and Antenna	TX03: Aerospace Power and Energy Storage
T0222	Meyya Meyyappan	NASA ARC	Triboelectric Nano Generator (TENG) for Mars Exploration and High Altitude Power Generation on Earth	TX03: Aerospace Power and Energy Storage
T0197	Karen Daniels	North Carolina State University	Ejecta-Minimizing Protocols for Applications Needing Anchoring or Digging on Asteroids	TX04: Robotic Systems
T0053	Rob Ferl	University of Florida - Gainesville	Telemetric Imaging Hardware for Suborbital Biological Imaging	TX06: Human Health, Life Support, and Habitation Systems
T0155	George Pantalos	University of Louisville	Aqueous Immersion Surgical System for Reduced Gravity	TX06: Human Health, Life Support, and Habitation Systems
T0181	Daniel O'Connell	HNU Photonics LLC	BioChip SubOrbitalLab: Microfluidic Imaging Platform for Live-Cell Investigations	TX06: Human Health, Life Support, and Habitation Systems
T0187	Peter Lee	Ohio State University	Gravity Sensing Mechanisms in Tissue-Engineered Skeletal Muscle	TX06: Human Health, Life Support, and Habitation Systems
T0188	Meghan Downs	NASA JSC	Novel Muskuloskeletal Loading System	TX06: Human Health, Life Support, and Habitation Systems
T0201	Rob Ferl	University of Florida - Gainesville	Human Tended Space Biology: Enabling Suborbital Genomics and Gene Expression	TX06: Human Health, Life Support, and Habitation Systems
T0209	Michael Menze	University of Louisville	Preserved Blood for Transfusion Therapy in Reduced Gravity	TX06: Human Health, Life Support, and Habitation Systems
T0219	Amir Hirsa	Rensselaer Polytechnic Institute	Adapting Ring-sheared Drop Technology As a Bioreactor	TX06: Human Health, Life Support, and Habitation Systems
T0221	Kent Tobiska	Space Environment Technologies	Automated Radiation Measurements for Aerospace Safety - Suborbital	TX06: Human Health, Life Support, and Habitation Systems
T0220	Christine Escibar	Space Lab Technologies	Microgravity Investigation for Thin Film Hydroponics	TX06: Human Health, Life Support, and Habitation Systems
T0052	Josh Colwell	University of Central Florida	Collection of Regolith Experiment	TX07: Exploration Destination Systems

Number	PI	Organization	Title	NASA TX Number
T0036	Josh Colwell	University of Central Florida	Collisions Into Dust Experiment	TX07: Exploration Destination Systems
T0015	H. Todd Smith	Johns Hopkins University	Electromagnetic Field Measurements on sRLVs	TX08: Sensors and Instruments
T0022	H. Todd Smith	Johns Hopkins University	Environment Monitoring Suite on sRLVs	TX08: Sensors and Instruments
T0023	Sean Casey	Silicon Valley Space Center	Measurement of the Atmospheric Background in the Mesosphere	TX08: Sensors and Instruments
T0085	Craig DeForest	Southwest Research Institute	Solar Instrument Pointing Platform	TX08: Sensors and Instruments
T0114	H. Todd Smith	Johns Hopkins University	Graphene Ion Membranes for Earth and Space Applications	TX08: Sensors and Instruments
T0196	H. Todd Smith	Johns Hopkins University	External Environment Payload Accommodation	TX08: Sensors and Instruments
T0204	Julie Brisset	University of Central Florida	Dust In-situ Manipulation System	TX08: Sensors and Instruments
T0217	Karl Hibbitts	Johns Hopkins University	Integrated Remote Imaging System	TX08: Sensors and Instruments
T0156	Julie Brisset	University of Central Florida	Suborbital Particle Aggregation and Collision Experiment 2 (SPACE-2)	TX11: Software, Modeling, Simulation, and Information Processing
T0182	Adrienne Dove	University of Central Florida	Strata-S1 - Testbed to Evaluate Regolith Behavior	TX11: Software, Modeling, Simulation, and Information Processing
T0076	H. Todd Smith	Johns Hopkins University	Vertically Aligned Carbon Nanotubes for Earth Climate Remote Sensing	TX12: Materials, Structures, Mechanical Systems & Manufacturing
T0178	Suzanne Smith	University of Kentucky	Characterization of 3D Printing Processes Under Microgravity Conditions	TX12: Materials, Structures, Mechanical Systems & Manufacturing
T0205	Mark Pankow	North Carolina State University	Lightweight Strain-Energy Deployed Spacecraft Booms	TX12: Materials, Structures, Mechanical Systems & Manufacturing
T0207	David Miles	University of Iowa - Iowa City	CubeSat Articulated Boom Option Optimization in Microgravity	TX12: Materials, Structures, Mechanical Systems & Manufacturing
T0212	Konstantinos Sierros	West Virginia University	3D Printing of Hierarchical Foams in Microgravity	TX12: Materials, Structures, Mechanical Systems & Manufacturing
T0159	Nick Demidovich	FAA	1090 MHz ADS-B Demo	TX13: Ground, Test, and Surface Systems
T0173	Franklin Robinson	NASA GSFC	Flow Boiling in Microgap Coolers - Embedded Thermal Management for Space Applications	TX14: Thermal Management Systems
T0189	Jacob Chung	University of Florida - Gainesville	Optimal Chilldown Methods for Cryogenic Propellant Tanks	TX14: Thermal Management Systems
T0208	Jamal Yagoobi	Worcester Polytechnic Institute	Investigation of Gravity Effects on Electrically Driven Liquid Film Boiling	TX14: Thermal Management Systems
T0213	Richard Banish	University of Alabama	Transport Properties of Fluids for Exploration	TX14: Thermal Management Systems
T0165	Lisa Valencia	NASA KSC	Autonomous Flight Termination System	TX15: Flight Vehicle Systems
T0194	Thomas Lambot	NASA ARC	Suborbital Flight Experiment Monitor-3	TX15: Flight Vehicle Systems
T0214	Alexandre Martin	University of Kentucky	KRUPS Capsule for Heat Shield Validation	TX16: Air Traffic Management and Range Tracking Systems

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