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Happy Spring, Flight Opportunities Community!

Ronald Young, Program Manager

It's been a busy spring, with recent solicitation activities and three flight campaigns successfully executed, and plans for several summer flights well underway. We are also currently accepting proposals for Flight Opportunities solicitations that provide opportunities for you to advance your technologies.

This month we're covering:

- Details about **recent flights**, including campaigns with flight providers Masten Space Systems and Zero Gravity Corporation
- Information about World View Enterprise's **upcoming flight** to test its groundbreaking altitude control technology
- **Selections** from NASA's Tipping Point Technologies solicitation
- Upcoming **events**, both soon and toward the end of the year to help you plan ahead

Thank you as always for being part of this growing community!

Ron

Ronald Young, *Program Manager*
NASA's Flight Opportunities Program

Technology Selections

Announcing the Tipping Point Selections

NASA is partnering with six U.S. companies to advance small spacecraft and launch vehicle technologies that are on the verge of maturation and are likely to benefit both NASA and the commercial space market.

These partnerships are the result of the “Utilizing Public-Private Partnerships to Advance Tipping Point Technologies” solicitation released in August 2016 by NASA’s Space Technology Mission Directorate (STMD).

The selected technologies to receive awards for Small Launch Vehicle Technology Development are listed below.

- **Maturing the M10A 25,000-lbf Liquid Oxygen/Methane Broadsword Engine** (Masten Space Systems, Inc., Mojave, California)
- **Development and Flight-Testing of a High-Performance Electric Pump Fed Launch Vehicle** (Ventions, LLC, San Francisco, California)
- **Micro-Avionics Multi-Purpose Platform (MicroAMPP)**(Tyvak Nano-Satellite Systems, Inc., Irvine, California)
- **Additively Manufactured Ceramic Rocket Engine Components** (HRL Laboratories, LLC, Malibu, California)
- **Spyder: Critical Technology Demonstration Tests** (UP Aerospace, Inc., Littleton, Colorado)
- **Carbon Nanotube Infused Launch Vehicle Structures** (Orbital Sciences Corporation, Dulles, Virginia)

For more information about these selections, read the **full NASA press release**.

COBALT Flight Demonstrations Fuse Technologies to Gain Precision Landing Results

Many regions in the solar system beckon for exploration, but they are considered unreachable due to technology gaps in current landing systems. The CoOperative Blending of Autonomous Landing Technologies (COBALT) project, conducted by NASA's Space Technology Mission Directorate (STMD) and Human Exploration and Operations Mission Directorate (HEOMD), could change that. The technologies within COBALT could provide the guidance, navigation and the control capabilities to enable precision landing for future exploration missions.

Members from the NASA COBALT project and Masten Xodiac teams hold a pre-campaign technical interchange meeting in preparation for the COBALT payload integration onto Xodiac. (This image is in the Masten Xodiac hangar with Xodiac in the background and the COBALT payload atop Xodiac in the payload frame.)

"COBALT will allow us to reduce the risk in developing future landing systems and will benefit robotic landers to planetary surfaces by allowing for autonomous precision landing," said LaNetra Tate, STMD's Game Changing Development (GCD) program executive. "This will definitely become a game-changing technology."

The COBALT system pairs new landing sensor technologies that promise to yield the highest precision navigation solution ever tested for NASA space landing applications. The technologies included a navigation doppler lidar (NDL), which provides ultra-precise velocity and line-of-sight range measurements, and the Lander Vision System (LVS), which provides terrain-relative navigation.

Through flight campaigns conducted in March and April aboard Masten Space Systems' Xodiac, a rocket-powered vertical takeoff, vertical landing (VTVL) platform, the COBALT system was flight tested to collect sensor performance data for NDL and LVS and to check the integration and communication between COBALT and the rocket. The flight tests provided excellent performance data for both sensors, as well as valuable information on the integrated performance with the rocket that will be used for subsequent COBALT modifications prior to follow-on flight tests.

"The knowledge from these flights will lead into the development of systems for deployment in future NASA landing missions to Mars and the moon," said John M. Carson III, COBALT project manager.

To learn more, read the **full NASA web feature**.

Payloads from NASA's JPL and University Teams Test and Validate Performance on Parabolic Flights

Several payload proposals selected from NASA's Research Announcement: Space Technology Research, Development, Demonstration, and Infusion (REDDI) 2016 solicitation flew as part of a Zero Gravity Corporation (ZERO-G) parabolic flight campaign during two weeks in March.

Flight Opportunities REDDI awards allowed researchers to purchase research flights. The first week of these ZERO-G flights included two technologies from NASA's Jet Propulsion Laboratory (JPL):

- **Microgravity Testing of Comet Surface Sample Return (CSSR) Sample Verification System** (**T0164-P**):
  Researchers leveraged these flights to test the performance of the fiberscope sample imaging (**FiSI**) verification system in microgravity. This will ensure that the system is capable of supporting the objectives of the CSSR mission, to "acquire and return to Earth for laboratory analysis a macroscopic (≥500 cm3) comet nucleus surface sample."
- **Evaluation of the Biosleeve Gesture Control Interface for Telerobotics in Microgravity** (**T0161-P**):
  This team was seeking to understand the gesture recognition performance of the Biosleeve in a microgravity environment. They collected operational data that will influence the future design, development, and test program for the interface as it advances toward multiple flight opportunities, including testing on the International Space Station (ISS).

During the second week, four university research teams leveraged their REDDI grant awards to fly their technologies. With flights previously completed with Flight Opportunities funding, these teams were able to further their research with this latest round of parabolic flight tests.

- **A Revolutionary Approach for Efficient Microgravity Transfer Line Chilldown** (**T0172-P**) (University of Florida):
  The research team has developed a special coating for the inside of a propellant transfer pipe to enable faster cooling and minimize cryogen loss--a key capability for long-duration space travel that will require the use of liquid oxygen and hydrogen cryogens as rocket propellant. The parabolic flight verified the integrity and viability of the system in extreme temperature changes and microgravity.
- **Measuring Propellant Levels in Low Gravity** (**T0160-P**) (Carthage College):
  The research team's Modal Propellant Gauging (MPG) project is a non-invasive, real-time, cost-effective method of measuring liquid propellant volume by analyzing sound waves produced by vibrations applied to propellant tanks. The technology has shown a vast improvement in the margin of error over current methods of gauging spacecraft propellant in low gravity--helping to address a challenge for NASA's goal of sustained human presence in space.
- **Creating Reliable Models for the Effects of Gravity on Flow Boiling Heat Transfer** (**T0170-P**) (University of Maryland):
  The research team has created and tested a heat transfer database and models for heat removal from two-phase thermal systems--an important component for future space missions that will require lighter, smaller, more powerful spacecraft. The team is collecting data to determine how wall heat flux, inlet subcooling, and flow rate are affected by varied gravity environments in preparation for an ISS flight experiment.
- **MOJO-Micro: Multi-Orthogonal Jaunting Robot in Microgravity** (**T0163-P**) (Massachusetts Institute of Technology):
  MIT's experiment is a robotic system specifically designed to traverse and inspect a three-dimensional, reversibly assembled discrete lattice structure. Optimized to operate within a periodic lattice structure, the robot offers simplification over current state-of-the-art structure-traversing robots. The recent flight tests aimed to assess the impact that microgravity has on the robot's energy consumption, reliability, and maximum traversal speed and explore specific adaptations that may improve its performance in microgravity.

World View to Flight Test Groundbreaking Altitude Control Technology

The new advancement for the company's Stratollite system promises station-keeping capabilities and longer stratospheric missions.

World View's Stratollite now includes an advanced altitude control system, scheduled for flight testing in June 2017.

Long-duration stratospheric research missions could allow scientists to collect vast amounts of continuous data for their payloads--with benefits for NASA missions as well as potential for storm monitoring, forest fire tracking, and more. However, technological challenges have limited the duration of balloon flights in the stratosphere due to the lack of trajectory control necessary for longer flights.

Next month, World View Enterprises is planning to perform groundbreaking flight tests that put the company one step closer to shifting this status quo. World View plans to test its novel altitude control technology, which was selected to receive funding for a flight test through NASA's Research Announcement: Space Technology Research, Development, Demonstration, and Infusion (REDDI) 2016 solicitation. The system promises the capability to perform large altitude changes for the purpose of achieving meaningful trajectory control of stratospheric balloon flights.

The altitude control technology is just one component in a complex network of advances making up the company's Stratollite system.

"The Stratollite basically acts as a satellite for the stratosphere but actually gives you more coverage," said World View's Iain Beveridge, principal investigator. "During large portions of the year, we're able to sustain coverage within about 100 miles of a target to keep our instruments looking at that specific point."

Another advantage of the system is the vast altitude range for station keeping. "Based on our previous testing, it does look like our system will go 90K feet or above and then still be able to perform down to the 50K- to 60K-foot range," Beveridge said.

"In this upcoming series of flights, we will be expanding our flight envelope from days to weeks to months of flight, but the end goal is to be able to fly these for 6, 9, even 12 months at a time," Beveridge said. "So, researchers can gather 6 months of data and have a very high level of confidence that their system is going to work."

The implications for scientific payload testing are significant. "The operational cost of these flights in less than 1% of the cost of sending those payloads to space," explained Beveridge.

The testing of World View's altitude control technology moves this theoretical application one step closer to reality. The test flight planned for late June builds on multiple stratospheric flights of a functional prototype and will verify the operational system testing that has been conducted in an altitude control chamber.

"This next flight is considered World View's number one priority right now, so everyone is working around the clock to get the system ready to go," Beveridge said. "We're currently in the final stages of putting it all together and doing system level testing. And then we'll be putting it on the vehicle and getting ready for flight."

For more information, visit **worldview.space**.

Flight Provider Profile

Zero Gravity Corporation

ZERO-G's G-FORCE ONE aircraft is a Boeing 727-200F modified for reduced gravity environments.

Headquartered in Arlington, VA, Zero Gravity Corporation (ZERO-G) flew its first research flights for Flight Opportunities in 2011. Originating from Orlando Sanford International Airport in Florida, these missions enable researchers to achieve a reduced-gravity environment for scientific payloads. G-FORCE ONE, a specially modified 727 aircraft, does this by flying through a series of parabolic maneuvers, resulting in short periods of microgravity. The length of these reduced-gravity periods depends on the g-level required for the specific test. The g-levels available include Martian, lunar, and of course, zero gravity. Typical research missions on G-FORCE ONE consist of 30 parabolic maneuvers and offer the reduced gravity needed to achieve a near-space environment. In addition to flights for researchers, ZERO-G also offers flights to the general public from airports across the country.

Available Flight Platform

ZERO-G's aircraft, G-FORCE ONE, is a Boeing 727-200F--a three-engine aircraft modified for reduced-gravity environments. The aircraft:

- Contains up to 34 seats for researchers
- Includes an open research area approximately 67 feet long
- Permits both free-float and structurally integrated research equipment
- Accommodates experiments requiring overboard venting and a variety of electrical requirements
- Provides flight durations of approximately 2 hours

Notable Flights

In addition to the **flight campaigns completed in March 2017**, ZERO-G also conducted three flight campaigns in 2016 to support technologies selected via the SpaceTech-REDDI solicitation process. Since February 2016, ZERO-G has provided flights for 11 REDDI technologies, working directly with principal investigators to test their payloads. In addition, five of these technologies have flown as part of multiple campaigns, enabling investigators to leverage what they learned from the first campaign to advance the technology, and then test those improvements in a second campaign. Technology payloads have covered a broad range of technical areas. Notable recent payloads include:

- **MOJO-Micro: Multi-Orthogonal Jaunting rObot in Microgravity** (**T0163-P**) from Massachusetts Institute of Technology (MIT), a robotic system specifically designed to aid automated assembly of large space structures
- **Water Capture Device (WCD)** (**T0167-P**), from Orbital Technologies Corporation (ORBITEC), a concept technology that uses unique microgravity-specific phenomena in a novel way to create an efficient means of capturing, transporting, and collecting sparse airborne liquid droplets
- **Evolved Medical Microgravity Suction Device** (**T0162-P**), from Orbital Medicine, Inc., a medical device that can be used to extract blood and air when treating a collapsed lung of an injured astronaut

ZERO-G is slated to conduct more campaigns for Flight Opportunities throughout 2017 and beyond. For more information, contact **Michelle Peters** and visit: **www.gozerog.com**

Opportunities

SpaceTech REDDI-2017 F1(A) Solicitations

The SpaceTech-REDDI program seeks proposals to demonstrate cross-cutting space technologies in relevant space-like environments using currently available U.S. commercial reduced-gravity, high-altitude balloon, and suborbital reusable flight opportunities. The most recent solicitation, SpaceTech-REDDI 2017 F1(A), closed on June 2, 2017, with selections expected later this year. More information can be found on **NSPIRES**.

NASA Internal Call for Payloads

The most recent **NASA Internal Call for Payloads** closed on May 19, 2017. Reviews are underway and selections will be announced later this year. Researchers interested in participating in future calls can read up on valuable resources for putting together a successful proposal by **perusing our prior presentations online or emailing us** for more information.

Upcoming Conferences & Events

Don't forget to check out these upcoming events...

- Jun. 26-29: **Commercial and Government Responsive Access to Space Technology Exchange (CRASTE) 2017**
- Jun. 27-29: **NewSpace 2017**
- Aug. 5-10: **Small Satellite Conference 2017**
- Sep. 12-14: **American Institute of Aeronautics and Astronautics (AIAA) Space 2017**
- Oct. 11-12: **International Symposium For Personal And Commercial Spaceflight (ISPCS) 2017**
- Dec. 18-20: **Next-Generation Suborbital Researchers Conference (NSRC)**

Have ideas or feedback for the Flight Opportunitiesnewsletter?
Drop us a line at: NASA-FlightOpportunities@mail.nasa.gov

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