

ACCESS TO SPACE FOR ALL: AN INITIATIVE OF THE UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS

L. ST-PIERRE, J. DEL RIO VERA and H. MORI

*Space Applications Section, United Nations Office for Outer Space Affairs,
Vienna, Austria*

E-mail: luc.st-pierre@un.org

E-mail: jorge.delriovera@un.org

E-mail: hazuki.mori@un.org

Abstract: The Office for Outer Space Affairs manages and implements the program on the peaceful uses of outer space, which is aimed at strengthening international cooperation in space activities and in the use of space science and technology for achieving sustainable development, and represents the United Nations in promoting international cooperation in the exploration and peaceful uses of outer space for economic, social and scientific development, in particular for the benefit of developing countries. The Office discharges these responsibilities by, among other duties, implementing the Program on Space Applications, which has been created in 1971. The program was created to increase awareness about the benefits to be derived from the applications of space technology and today provides capacity-building in the form of conferences, training courses, advisory services, fellowships, and hands-on opportunities.

The Office for Outer Space Affairs launched the Access to Space for All Initiative in 2018 providing research and orbital opportunities for United Nations Member States to Access Space. Under the Initiative, the Office for Outer Space Affairs has been collaborating with spacefaring governmental, intergovernmental, and private sector entities to open ground- and space-based facilities to all Member States of the United Nations for micro- and hypergravity experiments, space missions, and human spaceflight-related activities.

This report presents the objective of the Initiative and the specific achievements of its different opportunities as of end of 2020. Lessons learnt also guide the development of new actions for future cycles and new partnerships.

Keywords: Smallsat, microgravity, hypergravity, exploration, United Nations

1. ACCESS TO SPACE FOR ALL INITIATIVE

The goal of the Access to Space for All Initiative is to provide research and orbital opportunities for United Nations Member States to access space and to ensure that the benefits of space, for sustainable development, are truly accessible

to all. To fulfil this goal, the opportunities have been organized in three different tracks which enable progressive capacity development:

- Hypergravity and Microgravity Track,
- Satellite Development Track, and
- Exploration Track.

As opposed to individual opportunities, The Tracks have been created to deliver progressive sustainable and responsible hands-on capacity on space technology development from start to the end, by grouping existing opportunities and identifying gaps that the Office is striving to close.

Partnership is a distinctive feature of the Initiative. The Access to Space for All Initiative is only possible owing to the partnerships with various public and private actors, who are contributing to the Initiative in various manners. New contributions to the Initiative are possible and encouraged.

The number of opportunities is different from track to track. The Hypergravity and Microgravity Track currently has the highest number of opportunities available, with five programmes. The requirements for applicants vary from opportunity to opportunity, although, in general terms, the Initiative is mainly addressed to developing countries, rendering accessible opportunities that otherwise would be difficult to access or too costly and to provide the building blocks to start building capacity towards more complex experimentations in a structured manner. To that effect, the Hypergravity and Microgravity Track has been designed to provide a full range of facilities, from ground to orbit, to help acquiring the skills and knowledge to develop experiments in orbit, while the Satellite Development Track currently provides two opportunities which require a different degree of expertise and enable the deployment of different sizes of CubeSats. The Office has also identified the Exploration Track to provide hands-on opportunities for space technology development related to space exploration. Currently there are no opportunities under the Exploration Track, but the Office is already discussing with some potential partners to fill this gap.

The Office for Outer Space Affairs strives to support the monitoring and achievement of the 17 Sustainable Development Goals (SDGs), part of the 2030 Agenda for Sustainable Development and requires that applicants make the link between what they try to achieve and the SDGs. In the years that the Initiative has been active, the Office has received applications relevant to all the targets of the SDGs, including developments for improving the communications in areas subject to disasters using CubeSats, cancer prevention and treatment, or the development of high efficiency solar cells. Therefore, the importance of the Access to Space for All Initiative transcends the development of space capabilities, as the skills that are acquired through the participation in the opportunities are multi-purpose and can be used in a wide range of other fields.

2. AREAS OF RESEARCH CONDUCTED UNDER THE INITIATIVE

The Office has offered opportunities since 2010, however, it is only in 2018 when the Access to Space for All Initiative was launched. Considering the opportunities provided under programs that are still active and now under the Initiative, there have been winners from 28 different countries, and of one organization that groups 8 countries.

The areas of interest are varied, covering many different aspects of space science and technology, such as:

- Three projects in biology, microbiology, biotechnology, and biophysics have direct or indirect application in food supply for space exploration, agriculture and food security on Earth, medicine, epidemiology, and public health.
- Eight projects are innovative in physics and chemistry studies, including in material science, fluid dynamics, thermodynamics, or nuclear physics.
- Ten engineering and technology experiments have applications in space exploration, satellite development and operations such as Earth observation and telecommunication, 3D printing in space and others.
- Two projects in astronomy and five with applications to monitor climate change impacts and other indicators of development.

Many of the winning projects are cross-sectoral and can deliver results of interests in other areas of applications.

Scientific selection committees of each opportunity approved projects from high schools, colleges and universities, national and regional research and development institutes and agencies, space agencies, societies, and research councils in all three Tracks.

The following sections provide an overview of the highlights for each Track during 2020 and associated opportunities during 2020.

3. HYPERGRAVITY AND MICROGRAVITY TRACK

The objective of this Track is the development of hands-on capacity to develop experiments under different gravity conditions.

Hypergravity is when the acceleration force is larger than the gravitational force equivalent of 1g, while microgravity is when the acceleration forces are of the order of 1 millionths of the Earth gravity (mg). Experiments under varying gravity can help to prove theories, reveal unexplained phenomena, and develop new technology.

Through the opportunities offered in the Hypergravity and Microgravity Track, in partnership with different entities, teams from all over the world have been able to run experiments on engineering, such as the development of mechanisms to damp oscillations of tethers in satellites or understanding the behavior of a reduced-scale robotic arm manipulator. There have also been experiments in material science, such as the analysis of the mechanical features of nitinol alloy, a

biocompatible material, super elastic, and intelligent material with “shape-memory”, and experiments related to medicine and microbiology, such as the one on a method to develop increased antimicrobial activity in medicine droplets. To complement the experiments, the Office provides theoretical knowledge to ease access for countries with no capacity related to hypergravity/microgravity experimentation.

3.1. DROPTES¹

3.1.1. PROJECT OUTLINE

The Drop Tower Experiment Series (DropTES) program is done in partnership with the Centre of Applied Space Technology and Microgravity (ZARM) and the German Aerospace Centre (DLR). DropTES allows student teams from non-spacefaring countries to learn and study microgravity science first-hand by performing experiments at the Bremen Drop Tower in Germany. This drop tower is a ground-based laboratory with a drop tube of a height of 146 meters, which can enable short microgravity experiments to be performed in various scientific fields, such as fluid physics, combustion, thermodynamics, and material science. Each experiment consists of four drops or catapult launches within a one-week period. The entire program is aimed at contributing to the promotion of space education and research in microgravity.

3.1.2. IMPLEMENTATION

Six rounds have been successfully implemented and the winning teams between 2013 and 2019 were from Jordan, Bolivia, Costa Rica, Poland, Romania, and Italy. The experiments conducted range from technology demonstration to medical science and material science. The seventh-round winning team selected in April 2020 is from Universidad Católica de Bolivia, with an experiment to analyze the feasibility of a new 3D printing extruding technique in microgravity. The series of experiments has been postponed to 2022 due to the COVID-19 pandemic.

3.2. CHINA SPACE STATION²

3.2.1. PROJECT OUTLINE

The Cooperation on the Utilization of the China Space Station (CSS) is done in partnership with the China Manned Space Agency (CMSA). This program provides scientists from around the world with an opportunity to conduct their own

¹ United Nations Office for Outer Space Affairs, Fellowship Programme for "Drop Tower Experiment Series" (DropTES), <https://www.unoosa.org/oosa/en/ourwork/psa/hsti/capacity-building/droptes.html>

² United Nations Office for Outer Space Affairs, The United Nations/China Cooperation on the Utilization of the China Space Station (CSS), https://www.unoosa.org/oosa/en/ourwork/psa/hsti/chinaspacestation/ao_main.html

experiments on board CSS. There are three ways to conduct experiments in this program; the first is conducting experiments inside the CSS by utilizing experiment payloads to be designed and developed by the selected applicants, the second is conducting experiments inside the CSS by utilizing experiment payloads already provided by CSS, and finally, conducting exposed experiments outside the CSS by utilizing exposed experiment payloads. It is an innovative and future-focused program to open up space exploration to all nations and to create a new paradigm in building capabilities in space science and technology.

3.2.2. IMPLEMENTATION

A total of forty-two applications from organizations in twenty-seven countries were received and nine experiment projects were selected in the first round in June 2019. This program was innovative in a way that many projects were submitted by multi-national teams. The Office for Outer Space Affairs and CMSA are working together to organize a second round for this opportunity.

3.3. HYPERGES³

3.3.1. PROJECT OUTLINE

The Fellowship Program on the Large Diameter Centrifuge Hypergravity Experiment Series (HyperGES) is done in partnership with the European Space Agency (ESA). The fellowship program aims at providing opportunities for scientists and researchers with a team of students from Member States of the United Nations, with particular attention to developing countries, to conduct their own hypergravity experiment series at the large diameter centrifuge facility located at the European Space Research and Technology Centre (ESTEC) of ESA in Noordwijk, the Netherlands. The entire program is aimed at contributing to the promotion of space education and research to understand and describe the influence of gravity systems.

3.3.2. IMPLEMENTATION

The first cycle for HyperGES opened in the second half of 2019 with the selection of the winner taking place in the beginning of 2020. The winner of this cycle is a team from the Faculty of Science of the Mahidol University, Thailand, with a proposal to study the effect of hypergravity on *wolffia*, commonly known as watermeal or duckweed, a type of aquatic plant, with the aim at using it as a source of food and oxygen for space exploration. The experiment has been postponed to 2022 due to the COVID-19 pandemic.

³ United Nations Office for Outer Space Affairs, United Nations/European Space Agency (ESA) Fellowship Programme on the Large Diameter Centrifuge Hypergravity Experiment Series (HyperGES), https://www.unoosa.org/oosa/en/ourwork/psa/hsti/lde_hyperges/ao_main.html

3.4. BARTOLOMEO⁴

3.4.1. PROJECT OUTLINE

The opportunity to accommodate a payload on the Airbus Bartolomeo external platform aboard the International Space Station (ISS) and to have the All-in-One Mission Service is opened in partnership with Airbus Defence and Space GmbH. Bartolomeo is an external platform on the ISS European module. It allows the hosting of small and medium size payloads, with different viewing conditions, offering hosting that can point to Earth or to space. It provides the highest data downlink rate on the ISS and the payloads can be controlled and data retrieved through the Airbus Cloud.

3.4.2. IMPLEMENTATION

The opportunity opened in 2019 and was closed in April 2020 with the reception of proposals from eighteen countries and twenty-nine institutions. The selection process is ongoing at the date of the drafting of this report. The winner of the first round will be selected among the three higher-ranked proposals and will be announced in the last quarter of 2020.

3.5. DREAM CHASER⁵

3.5.1. PROJECT OUTLINE

The opportunity to participate in an orbital space mission utilizing the Dream Chaser® space vehicle of Sierra Nevada Corporation (SNC) is under preparation. The Dream Chaser is the only runway landing space vehicle actively in development is designed to launch on a variety of launch vehicles. It can carry experiments, payloads, or satellites provided by institutions in the participating countries.

3.5.2. IMPLEMENTATION

In 2017, a call for interest was launched to assess the feasibility of a free-flight mission and have a preliminary understanding of the types of payloads to plan for. The results exceeded the expectations with one hundred fifty responses from seventy-five countries. At the International Astronautical Congress of 2019 in Washington D.C., the United States of America, a call for interest for landing sites was launched. The call was open until the end of April 2020. Applications from seven countries have been received. This marks a milestone in the effort of the

⁴ United Nations Office for Outer Space Affairs, Accessing Space with the ISS Bartolomeo Platform, <https://www.unoosa.org/oosa/en/ourwork/psa/hsti/orbitalmission/bartolomeo/index.html>

⁵ United Nations Office for Outer Space Affairs, Orbital Space Mission, https://www.unoosa.org/oosa/en/ourwork/psa/hsti/FreeFlyer_Orbital_Mission.html

Office for Outer Space Affairs and SNC towards the opening the announcement of opportunity for the utilization of the Dream Chaser.

4. SATELLITE DEVELOPMENT TRACK

The objective of this Track is the development of hands-on capacity for satellite development.

Despite being as small as 10 cm x 10 cm x 10 cm, CubeSats have a large variety of uses. They can capture images of Earth; they can be used as testbeds for new technologies or help us understand the space environment, among many other applications. They may also allow and encourage a country to establish the essential mechanisms for a larger space program in compliance with international law and regulations and develop engineering and human capacity and getting acquainted with the space systems engineering processes and necessary tools within the development cycle.

As many of their components are readily available, CubeSats are affordable to develop, therefore a very accessible entry point. In this line, the Committee on Space Research (COSPAR) has identified several recommendations concerning small satellites, noting that scientific communities from small countries may benefit from investing their budgets in small satellites.

To complement the experiments, the Office provides theoretical knowledge to ease access for countries with no capacity related to developing CubeSats through webinars, symposiums, and fellowship programs. In 2018, the Office co-organized with the Government of Brazil to hold the “United Nations/Brazil Symposium on Basic Space Technology: Creating Novel Opportunities with Small Satellite Space Missions” which reviewed the status of capacity building for small satellites, examined issues relevant to the implementation of small satellite programs, and elaborated on regulatory and legal issues on the space technology development programs. Currently, the Office and the Government of Japan in cooperation with the Kyushu Institute of Technology (Kyutech) have established a United Nations/Japan Long-term Fellowship Program on Nano-Satellite Technologies for nationals of developing countries or non-spacefaring nations. The Program provides extensive research opportunities in nano-satellite systems using the nano-satellite development and testing facilities available at Kyutech.

The following section provides a list of the opportunities available under this track and the progress in 2020.

4.1. KIBOCUBE⁶

4.1.1. PROJECT OUTLINE

The Cooperation Program on CubeSat Deployment from the International Space Station (ISS) Japanese Experiment Module (Kibo) "KiboCUBE" is offered in partnership with the Japan Aerospace Exploration Agency (JAXA). KiboCUBE provides educational and research institutions from developing countries with the opportunity to develop a CubeSat and have it deployed from the Japanese module "Kibo" of the International Space Station. Thanks to the lower vibration and more benign environment during launch, KiboCUBE lowers the threshold for countries to enter space activities and contributes to national capacity development in spacecraft engineering, design and construction, inspiring new generations of scientists and engineers.

4.1.2. IMPLEMENTATION

The Central American Integration System (SICA) was selected as the winner of the fifth round, with a proposal of a communications satellite for emergency situations. Besides SICA, there are three CubeSats, from Indonesia, Mauritius and Moldova respectively, that are currently in development. In April 2020, the second-round winner Guatemala deployed Quetzal-1, the first satellite of the country into orbit. The deployment ceremony was conducted online on 28 April due to the COVID-19 pandemic and was covered by national and international media. It is also worth noting that the first satellite deployed thanks to KiboCUBE, from Kenya, 1KUNS-PF, re-entered the atmosphere in June 2020 after having successfully completed more than ten thousand orbits. It produced many beautiful images and temperature/ velocity data from the on-board components.

4.2. VEGA C⁷

4.2.1. PROJECT OUTLINE

The Cooperation Program on Access to Space by utilization of the Vega C launcher is offered in partnership with Avio S.p.A. This opportunity will put into orbit a CubeSat or aggregates of CubeSats of maximum 3U developed at educational or research institutions from developing countries which are United Nations Member States.

⁶ United Nations Office for Outer Space Affairs, The United Nations/Japan Cooperation Programme on CubeSat Deployment from the International Space Station (ISS) Japanese Experiment Module (Kibo) "KiboCUBE", <https://www.unoosa.org/oosa/en/ourwork/psa/hsti/kibocube.html>

⁷ United Nations Office for Outer Space Affairs, Accessing Space with VEGA-C, <https://www.unoosa.org/oosa/en/ourwork/psa/hsti/vegac.html>

4.2.2. IMPLEMENTATION

The Office and Avio S.p.A conducted a webinar in July 2020 to raise awareness of the opportunity and another webinar in October 2020 to announce the opening of the Announcement of Opportunity. To ease the process of partnership development, the Office made available an innovative matchmaking tool so interested institutions can advertise their interest in partnering and the type of partner they look for in the context of this opportunity.

5. EXPLORATION TRACK

The Office is interested in developing capacity related to exploration missions, both on ground through opening access to analogue facilities, and in exploration missions beyond the geostationary orbit with the objective of developing hands-on capacity in these areas. The Office is in initial discussion with potential partners.

6. GAPS

It is worth noting that the Tracks, in addition to provide a structured learning path, also allow to identify areas where the Initiative should expand in order to offer a gradual learning curve:

- Hyper and Microgravity Track: As an intermediate step to acquire experience in orbit experimentation, the Office is interested in developing capacity in parabolic and suborbital experimentation, to increase the experience of applicants before applying to an opportunity for developing an in-orbit experiment, as well as, in increasing access to facilities in ground.
- Satellite Development Track: The Office would like to develop capabilities related to CanSats as a starting point that will enable countries to advance their capabilities in space systems engineering. In addition, facilitating access to test facilities on ground, would be beneficial for participants.
- Exploration Track: The Office is interested in developing capacity related to exploration missions, both on ground through opening access to analogue facilities, and in exploration missions beyond the geostationary orbit.

7. CONCLUSION AND LESSONS LEARNT

The opportunities under the Access to Space for All Initiative continue to attract the interest of institutions from all over the world. This year new applications on a wide number of topics have been received. It is worth noting that, although the pandemic situation has created delays for the development of some of the

activities, due to the difficulty in importing components or due to the impact on the winning teams such as their access to their respective research facilities or because of travel restrictions, the different opportunities continue to move forward.

In 2020, through the Initiative, the Office achieved the following:

- selected a winner for the seventh-round for DropTES;
- deployed the second-round KiboCUBE winner Guatemala's first satellite into space and opened an announcement of opportunity for another round in December;
- opened an announcement of opportunity for the first-round for Avio;
- the Office also plans to announce the first-round winner for Bartolomeo in the last quarter of the year.

The Office for Outer Space Affairs complements the opportunities with other learning activities such as webinars. A series of webinars were offered to further the work on the Access to Space for All Initiative and continue to offer space-related opportunities as a source of inspiration and to attract students and professionals from different areas, fostering science, technology and innovation and preparing them for the jobs of the future. A total of ten webinars related to Access to Space for All have been organized during 2020 and two sessions of the same webinar were organized to accommodate different time zones.

The Office for Outer Space Affairs continues to work with partners to maintain and enhance the Access to Space for All Initiative, providing opportunities for universities and research institutions, and promoting international cooperation in the peaceful uses of outer space. Member States, private and public entities are encouraged to join the Access to Space for All Initiative.