Access to Space for All initiative for Sustainability: Interview Series Article #7 November 2023

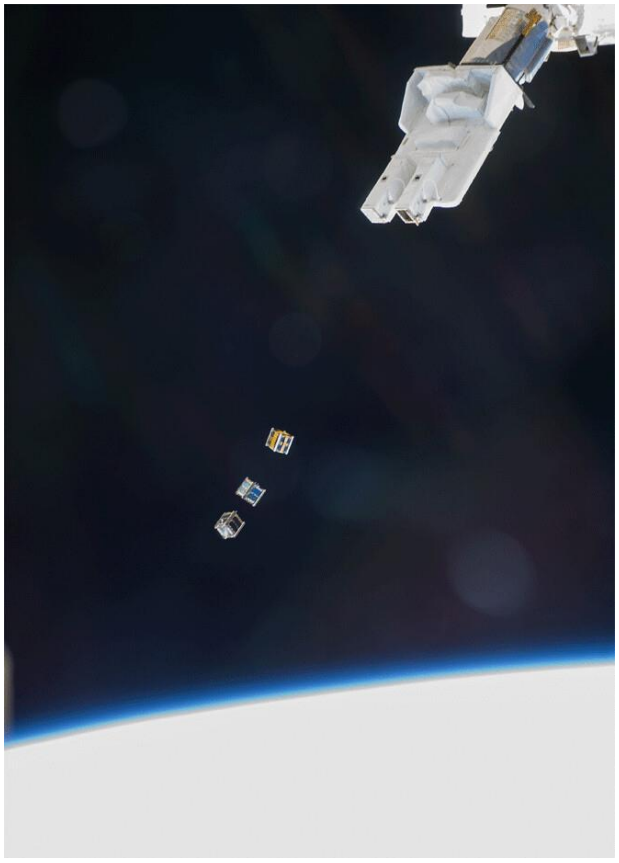
KiboCUBE: Bringing "Hope" to Countries with a Small Satellite

Interviewee:
Dr. Izumi Yoshizaki
Manager, Kibo Utilization Center, Human Spaceflight Technology Directorate, Japan Aerospace Exploration Agency (JAXA)
Dr. Viorel Bostan
Rector, Technical University of Moldova (TUM)

Date: Interview conducted with JAXA on 16 November and with TUM on 22 November 2023

Background:

The United Nations/Japan Cooperation Programme on CubeSat Deployment from the International Space Station (ISS) Japanese Experiment Module, better known as "KiboCUBE" is offered by the United Nations Office for Outer Space Affairs (UNOOSA) in collaboration with the Japan Aerospace Exploration Agency (JAXA) since 2015. It is a cornerstone programme of the Satellite Development Track of the Access to Space for All initiative, which provides an opportunity to deploy your own 10cm x 10cm x 10cm single-unit 1U Cube Satellite (CubeSat) from the ISS Japanese Experiment Module "Kibo". Through this opportunity, the selected teams will work closely with JAXA for the safety review process to bring their CubeSat up to the ISS. They will receive technical advice and support throughout this process. JAXA bears the launching and deployment cost of the CubeSat, which is usually the costliest part of getting a satellite into space. Adding to that, the CubeSat will be transported as cargo to the ISS, meaning the launch environment is much more benign than being flown as a piggy-back satellite on a launcher. With advantages like this, the selected teams can focus more on the development of their CubeSat and the necessary ground infrastructure for the operation.



Deployment of CubeSats from Kibo
©JAXA/NASA

KiboCUBE is not only an opportunity to build capacity in technology, but is also a chance to engage the policymakers and government in space activities and gain experience in legal and international relations-related matters. Launching a CubeSat into space requires coordination with international bodies such as the International Telecommunications Union (ITU) regarding radio regulations and with UNOOSA for the registration of the space object. To make sure that the launch of the CubeSat and related space activities are in line with international treaties, the government needs to regulate by establishing a space policy and law. There are guidelines in place that actors must respect, such as the Space Debris Mitigation Guidelines and the Guidelines for the Long-term Sustainability of Outer Space Activities. KiboCUBE offers a holistic activity that covers all of these activities which not only include the selected team itself but different stakeholders, meaning that the whole country gains experience and takes one step forward to accessing to space.

The 8th round of KiboCUBE is currently open for applications!
Make sure to read all the documents on the website and take a look at the KiboCUBE Academy webinars.
Press Release: New KiboCUBE opportunity announced by UNOOSA and JAXA (2 June 2023)
For more details: KiboCUBE Rounds, KiboCUBE Webinars, and KiboCUBE Academy
Information on Awardees: Awardees page

Interview: First, we talked with Izumi, who is the Manager at the Kibo Utilization Center at the Human Spaceflight Technology Directorate of Japan Aerospace Exploration Agency (JAXA).

Q: Why did you decide to undertake this space project? What benefits do you see in the space environment?

Izumi has been working on scientific experiments on the ISS and space shuttle missions for more than 20 years. ©JAXA

The Japanese experiment module on the ISS which we call "Kibo" (which also means hope in Japanese) has a very unique capability. It has an airlock system and a robotic arm. By setting the CubeSat deployer to the robotic arm from inside the space station and sending it out from the airlock, JAXA can freely deploy CubeSats into space from Kibo. JAXA started this deploying service in 2012 and was the first to offer this solution on the ISS. We saw that there was a strong need from many entities for this capability and we wanted to provide easy access to space through Kibo. CubeSats nowadays can be manufactured by utilizing relatively simple technology and low-cost parts. Therefore, we thought this was a good educational and human resource development opportunity, not only domestically in Japan, but internationally to the entire world. Through our cooperation with UNOOSA in KiboCUBE, we are using this distinctive capability to provide opportunities for developing economies and economies in transition that do not have access to space.

We see various benefits in the space environment, especially through the activities at the ISS. Many types of scientific research and technological experiments have been conducted in Kibo in microgravity and there have been many breakthroughs. Human research and life science experiments have brought many benefits to life here on Earth such as providing insight into certain muscle or bone conditions. High-quality protein crystals grown in space help to identify potential treatments for diseases. Using the Electrostatic Levitation Furnace (ELF), high-temperature liquid, with a melting temperature higher than 2,000 degrees Celsius, can be handled without contamination. It enables accurate measurements of thermophysical properties which contribute not only to science but also to computer-based casting simulation in order to develop efficient turbines, aircraft, and jet engines.

Q: How does KiboCUBE contribute to capacity-building in developing countries and the achievement of the Sustainable Development Goals?

CubeSats lowers the threshold for countries to enter space activities and allows teams to acquire invaluable technical skills and experience through the whole development and operation process. Although it looks like just a tiny box, it is a complex system and there are many things you can learn from this experience ranging from space engineering, systems engineering, program management etc.

We believe KiboCUBE has strong links to SDG 4: Quality Education, as we are opening an inclusive and equitable quality education opportunity to developing economies and economies in transition who would not have access to space infrastructure and information. Furthermore, by fostering education, we have been supporting SDG 8: Decent Work and Economic Growth by training the workforce in the country. We have seen many students being involved in the KiboCUBE teams. For example, for some of the larger teams, there were more than 100 students being educated. We are pleased to hear stories of them pursuing careers in space-related fields afterwards. In the case of the 2nd round awardee from Guatemala, after the success of their first satellite Quetzal-1, the new enrollment at the Universidad del Valle de Guatemala's Mechanical Engineering Department grew 176%! We are also pleased to see all

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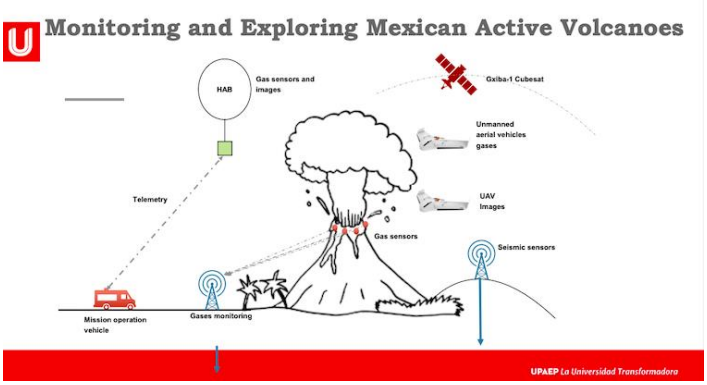
UVG's female students conducting workshops for female students ©Ivan Castro

the educational and outreach activities done by the teams for the younger generation, and some focused on females. These activities are giving hope to future generations for STEM education – specially to have a career in space.

Another concrete example of KiboCUBE's contribution to developing countries is the 1st round awardee from Kenya. KiboCUBE was a significant trigger for the creation of the Kenyan Space Agency. It supported the technical knowledge development of the engineers at the University of Nairobi, but also the country in encouraging the government to establish the necessary institutions and systems to realize space activities in the country.



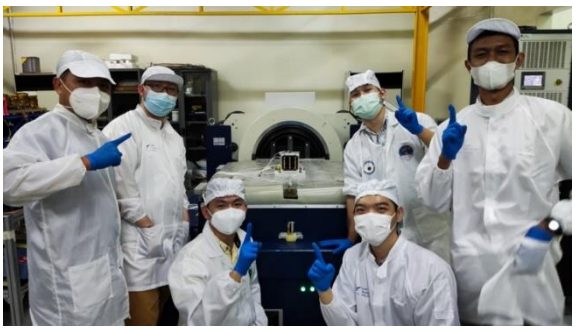
(Above) UPAEP's plan to monitor active volcanoes ©UPAEP
(Below) Images from the last eruption of Popocatépetl ©UPAEP

Furthermore, the utilization of satellite data and satellite communication contributes to developing a resilient society, such as supporting disaster management and understanding the impacts of climate change. The awardee team from the 5th round, the Central American Integration System (SICA) is developing a CubeSat to test a communication platform that could be used for early warning during extreme weather events. The 6th round awardee from Mexico, Universidad Popular Autónoma del Estado de Puebla (UPAEP) is developing a satellite to observe active volcanoes in the region and analyze ash dispersion. They hope to build an early-warning system using the data acquired from the CubeSat.

Through KiboCUBE, teams not only develop the satellite itself but also key infrastructure such as ground stations or testing facilities. These tangible assets can be used for missions in the future. The 3rd round awardee from Mauritius is trying to use its ground capabilities to support missions of other countries as a service. We see this as a connection to SDG 9: Industry, Innovation, and Infrastructure.

Q: What is the current status of the KiboCUBE cooperation?

As of now, we have selected eight teams from four different regions. We have successfully deployed five CubeSats from Kenya in 2018, Guatemala in 2020, Mauritius in 2021, Moldova in 2022, and Indonesia in 2023. Out of the five, four CubeSats were the first space objects launched into space for the respective countries. Currently, three teams are developing their CubeSats: 5th round awardee SICA has finished their Preliminary Design Review and is in the phase of developing their satellite and focusing on the safety review, as well as one of the 6th round awardees from Mexico, UPAEP. The other team from the 6th round, Private Higher School of Engineering and Applied Technology (ESPITA) of Tunisia is now rebuilding their team and we hope to see progress in the development soon.



Surya University team from Indonesia that successfully built SS-1, the first student CubeSat of Indonesia, deployed into space in January 2023 ©Surya University

In parallel, JAXA in collaboration with the University Space Engineering Consortium (UNISEC) has been working with UNOOSA to bring KiboCUBE Academy. KiboCUBE Academy is educational content to provide theoretical knowledge for the whole life cycle of satellite development. We have delivered live sessions, both online and onsite, and we prepared 24 on-demand pre-recorded lectures where people can easily access the presentation and recordings. In addition to the lectures, we have also conducted technical consultation sessions to provide current KiboCUBE teams with concrete advice on the issues they are facing and future applicants with

advice on how to build a better CubeSat mission. At JAXA, we really believe that CubeSats can bring “Hope” to countries and we are trying our best to realize this with the utilization of Kibo.

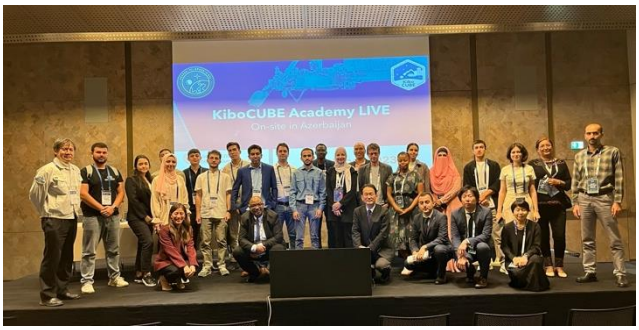
Q: How has Access to Space for All and the cooperation with UNOOSA helped your organization?

Our cooperation with KiboCUBE has been very successful in providing access to space to many countries. This has not only been a positive aspect to the countries we supported but also to JAXA as it has helped the government and the general population in Japan understand the values of the activities conducted at the ISS and Kibo. The Japanese government praises KiboCUBE as a diplomatic tool for international cooperation and also a programme that contributes to the SDGs activities of Japan. Adding to that, KiboCUBE has been a learning experience for JAXA as well, on how to support developing countries efficiently. Through working with the various teams, our team at JAXA is also gaining valuable experience in international cooperation, teamwork, and communication.

In August 2023, KiboCUBE won the Innovation Award in STEM Education at the ISS Research and Development Conference held in Seattle, USA. It was awarded for pioneering an opportunity to support STEM education in developing countries by utilizing the capabilities of the ISS. This was an extraordinary moment for us since our continuous efforts with UNOOSA have been recognized internationally.

ISS R&D Innovation Award in STEM education awarded to the KiboCUBE programme ©JAXA

Q: What are your future plans for KiboCUBE and cooperation with UNOOSA?



(Above) Participants of the KiboCUBE Academy onsite workshop in Azerbaijan
(Below) JAXA engineer explaining how the CubeSat is released from the deployer

The KiboCUBE programme has been extended for more rounds until the end of the current lifetime of the ISS which is agreed as 2030. We will be able to open opportunities in the coming years and support more countries to realize their access to space.

Needless to say, we will continue our cooperation under KiboCUBE Academy, to provide support for knowledge building for small satellites. We are overwhelmed with the positive response we hear from UN Member States about how useful the online lectures are. In addition, we enjoyed having live sessions and engaging with participants directly in Tunisia and Azerbaijan. The energy and motivation that comes from the people we meet is always amazing. We hope that we can do more hands-on workshops in the future.

My advice to potential KiboCUBE applicants is to read the JEM Payload Accommodation Handbook (JPAH) very carefully. We sometimes receive proposals that do not meet the technical standards of this document. There are many different ways to build a CubeSat, but you must know that for KiboCUBE, we will be applying the Japanese standards and your team will go through the safety assessment of JAXA. Please make sure to build a CubeSat that meets these requirements.

Besides KiboCUBE, UNOOSA and JAXA also have begun working together on the Kibo Robot Programming Competition (Kibo-RPC) since 2023. This is an exciting educational programme where JAXA in collaboration with NASA, offers an opportunity to obtain software programming and robotics-related skills. The participating teams will use a web-based simulator using Android Studio and develop a software code to move free-flying robots on the ISS. It was an opportunity that was only available for the Asia-Pacific region through the Asia Pacific Regional Space Agency Forum (APRSAF) framework, but UNOOSA joined the scheme to expand the number of countries that could join this activity. With this, more than 15 countries from Africa and Latin America also were able to take part in this activity. With diverse activities like KiboCUBE and Kibo-RPC, JAXA hopes to help more countries acquire the skills and expertise to join us in space exploration missions in the future.

Second, we talked with Viorel, who is the Rector at the Technical University of Moldova (TUM).

Q: Why did you decide to undertake this space project? What benefits do you see in space?

Professor Bostan has worked in attitude determination and structural analysis of satellites at TUM for over 12 years. ©TUM

There are several motivations that led us to undertake projects in space. First, space activities attract the younger generation to pursue education and careers in STEM education. Through the space projects at our university, especially at the Centre of Space Technologies, which is a consortium of TUM where we work with academic institutions and high-tech SMEs to work on developing satellite subsystems and ground stations, we wanted to make sure that we provided the opportunity for students to get interested in STEM and deepen their knowledge and acquire skills. Our space project team consists of all students, Bachelors, Masters, and PhD, meeting the demands at the different levels to step up in academia. Second, there was a motivation for us to highlight our national science and technological capabilities. Moldova was part of the Soviet Union and the Technical University of Moldova was part of the Soviet Union's space activities during that era. We have the inherited knowledge that was built up and we wanted to transfer it to the young generation in Moldova. Through our first CubeSat, TUMnanoSAT, we wanted to show the people in our country that we are able to take part in space activities.

Q: How did your project contribute to capacity-building and to achieving the SDGs in your country?

TUMnanoSAT has contributed to capacity-building and the SDGs in many aspects, but the main aspect has been how it has really accelerated education. When we started to work on the Center of Space Technologies, a great focus was put on updating the curriculum to make sure the content taught at the university includes the knowledge that students will need to be able to join satellite projects. And this is a continuous endeavour. We wanted to ensure that the students not only studied the theoretical aspects but had an opportunity to apply what they learned in practical terms. This is where the TUMnanoSAT experience was of great help, as it gave us the opportunity to apply the knowledge and move our hands to develop the hardware and software, but also identify gaps and make our existing curriculum and facilities better. Our university does not have a dedicated aerospace engineering department, but we have different types of engineering such as electrical, mechanical, communications, and computer science. Satellite development is a multidisciplinary activity and faculty and students from all these disciplines came together to organize this curriculum and other courses, inspired by TUMnanoSAT. Furthermore, by working on this project, we identified equipment that would be useful for the development and update our laboratory by obtaining this equipment during the process. Thanks to this, we have some well-equipped facilities that can support capacity-building for future generations in Moldova. We believe this has links to SDG 4 Quality Education.

In Moldova, we have a relatively large discrepancy between the urban and rural areas in quality education. Therefore, we also had a goal to attract more female students and students from under-represented rural areas. We invested in our communications effort to high schools, especially in the rural areas to promote the activities of TUM at the Centre of Space Technologies. Various NGOs showed interest to us since we had female students and staff at the Centre pursuing their academic and professional careers that could be great role models to the female students in Moldova. This is connected to SDG 10: Reduced Inequalities.

Workshops with female students ©TUM

Promotion event targeted towards young generation in Moldova ©TUM

Q: What was the objective of your project?

Flight model of TUMnanoSAT ©TUM

The main objective of taking part in KiboCUBE was education and capacity-building for students in Moldova. Besides that, we had many technical goals that we wanted to achieve as well. A significant goal we set with TUMnanoSAT was to test our ground infrastructure's communications systems that we already have at the Centre of Space Technologies at the university. We wanted to make sure that we would be able to have reliable communication with satellites using this infrastructure. Furthermore, at the university, we have a strong interest in nanotechnology and were developing some nano-sensors for space conditions. Therefore, we wanted to test these sensors in a space environment, so what better than to put it on our CubeSat and launch into space! Owing to this TUMnanoSAT experience, I can proudly say that we are more mature technically and ready to explore the possibility of developing larger CubeSats.

Q: How has Access to Space for All and KiboCUBE helped your organization? Do you recommend it for other people?

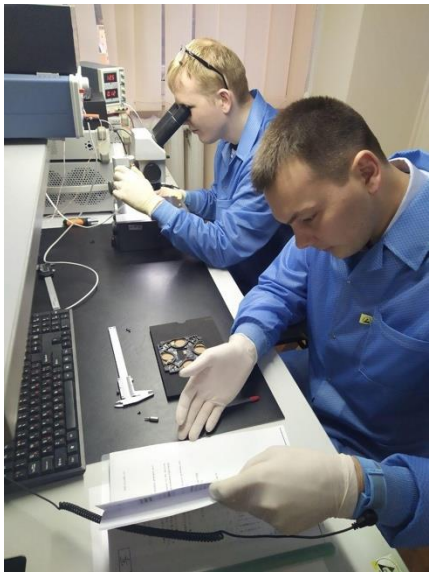
The success of TUMnanoSAT has led to more investment in the university and the Moldovan economy. Having this knowledge and experience of developing a CubeSat has made us more attractive for investments. As rector, I have the opportunity to meet with many potential investors, who are specifically interested in financing electronics and communication related educational and R&D. With more funding to support our projects and infrastructure, for sure we will be able to educate more students and boost the Moldovan economy.

Having this knowledge and experience of developing a CubeSat has made us more attractive for investments.

We applied to KiboCUBE several times before becoming selected as the 4th round awardee, so I would advise teams not to despair and keep trying.

I would absolutely recommend KiboCUBE to anyone who is interested – personally, I would love to do it again! It is definitely a difficult and complex task, but it is realizable and manageable. It will bring a plethora of expertise and knowledge. We applied to KiboCUBE several times before becoming selected as the 4th round awardee, so I would like to advise potential applicant teams not to despair and keep trying. Even by applying, you will be able to realistically understand your capabilities, gain insights from the experience, and it is an opportunity to grow. If your dream is strong and your motivation is high enough, you will be selected. That is what I kept telling my team and look where we are now!

Moreover, the support we received from JAXA was extraordinary. In the beginning, we did not fully understand the complexity of a CubeSat and every step was a learning experience for us. During our development phase, the COVID-19 pandemic hit, so it became more difficult logistically, as we did not have access to the facilities we needed. Adding to these technical aspects, we experienced other obstacles such as the bureaucratic process. For example, it was not a simple process to ship the satellite to Japan. We had to contact many different agencies within the government to sign different agreements. Despite these difficulties, thanks to the existing communication channels, we were able to continue to work with JAXA through emails and teleconferences and steadily progress with the development of our CubeSat. JAXA guided us through the whole process of the safety assessment step by step. They shared knowledge and advised us throughout the project which is one of the most precious exchanges that you will get out of KiboCUBE.



Manufacturing and testing TUMnanoSAT ©TUM

Q: What are your future plans?

Currently we are working on a proposal to get financing from the Ministry of Education and Research for research positions. We are in a partnership with Transilvania University of Brașov and the Institute for Space Technology in Romania for the next satellite project – a joint 2U CubeSat. We have identified future missions and are in the design process, hoping in 1-2 years it will be ready for launch. The research positions will contribute heavily to the advancement of this new satellite.

At TUM, we have the Centre of Space Technologies where we have sufficient infrastructure, but we would like to expand that and be able to do more things in-house and bring in more students to space activities. The university has many different research and project topics that can be pursued, and we are promoting that widely. We also have various educational activities at the Centre, where many student groups of different ages can come and visit.

We are confident that the technical knowledge, skills, and experience gained through KiboCUBE will not be lost as we will make sure it is kept alive in the university and be transferred to generations. The team members of TUMnanoSAT are still students at the university or they are employed at the Centre, which makes this transfer of information feasible and sustainable. Please stay tuned and follow our continuing journey!

(Top) Assembly and testing of TUMnanoSAT in the clean room ©TUM, (Middle) Ground station antenna cluster at the Centre of Satellite Technologies at TUM ©TUM, (Bottom) Deployment of TUMnanoSAT from ISS ©JAXA/NASA