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Space and global health

Responses to the set of questions regarding policies, experiences and practices in the use of space science and technology for global health

Note by the Secretariat

Addendum

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II. Replies received from Member States

Hungary

[Original: English]
[19 November 2020]

Question 1

There is no formal cooperative agreement in Hungary yet between the health sector and other sectors directly involved in space activities. However, Hungary is currently working on the National Space Strategy of Hungary, which may facilitate the interoperability between space and non-space sectors.

Question 2

It is not advisable to create any new institutions as a platform for coordination. However, it is recommended that the World Health Organization (WHO) be consulted in order to include relevant space actors in the coordination of global health issues.

Question 3

Hungary is not aware of any barriers in Hungary to the effective use of space-based technologies in support of global health. At the multilateral level, it is recommended that stakeholders such as the Office for Outer Space Affairs, WHO and the Food and Agriculture Organization of the United Nations (FAO) foster regular consultations.

Question 4

The Earth Observation Information System (FIR) is the central government infrastructure in Hungary whose task is to integrate the data of the European Earth Observation Programme (Copernicus) into government processes and to provide them to governmental bodies, organizations, private companies and citizens. The FIR system is also part of the data distribution network of the European Space Agency (ESA).

The full archive and latest recordings of the European Sentinel satellite family are available in the FIR system. With its significant computing and storage capacity, the system directly supports a number of sectoral monitoring processes (water, disaster management, agriculture and forestry), which later may also be supplemented by the health sector.

Questions 5, 10 and 11

No answer.

Question 6

In Hungary, national coordination is initiated among universities, which would lead to – among many other desired results – an institutional framework for students of medicine and students of space science and technology to raise awareness of each other’s fields, and the general design of a space-focused interdisciplinary post-graduate education.

Question 7

In Hungary, the Department of Aviation and Space Medicine of the University of Szeged offers education in space science and space medicine.

Hundreds of medical students get acquainted with this special field every year as part of their training, expanding their general medical knowledge. The possibilities

of telemedicine and the use of robotics in certain forms of surgery are part of the curricula at the Department of Aviation and Space Medicine.

Question 8

The Global Navigation Satellite System application "Galileo-based trusted applications for health and sustainability" (GOEASY) is a great example of how space-derived data can contribute to the monitoring of health and sustainability. GOEASY leverages European Satellite Navigation System (Galileo) features such as increased trust and improved availability, together with interoperability with existing Internet-of-things infrastructures, to enable more secure location-based services. GOEASY will be evaluated by means of two concrete use cases, namely, the applications ApesMobility and AsthmaWatch, both evaluated by engaging real users in a medium-scale pilot in Torino, Italy, and Stockholm.

Question 9

Information is not to be shared in such an open format.

India

[Original: English]
[17 November 2020]

Question 1

The Indian Space Research Organization (ISRO) of the Department of Space of the Government of India has signed the following memorandums of understanding:

(a) A memorandum of understanding with National Medicinal Plants Board of the Ministry of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy for the mapping of rare and endangered species (2017);

(b) A memorandum of understanding with the Central Bureau of Health Intelligence of the Ministry of Health and Family Welfare for creation of the National Health Resource Repository, based on geospatial data (2017);

(c) A memorandum of understanding with the National Institute of Malaria Research of the Indian Council of Medical Research of the Ministry of Health and Family Welfare for geo-health analytics for vector-borne diseases (malaria, dengue and chikungunya) using geoinformatics (2018);

(d) A memorandum of understanding with the Government of the State of Bihar on disaster management support through space data (2019). Under this, a geoportal was created for the Health Department of the State of Bihar for identification of coronavirus disease (COVID-19) containment zones, buffer zones and boundaries for effective planning and monitoring.

Question 2

A dedicated, common platform will be useful for the sharing of datasets, methodologies, best practices and success stories in which space technology has been effectively used in the health sector.

Question 3

In order to meet the growing demand for remote sensing data and the growing need to involve the participation of Indian industry to bridge the gap between the demand and supply, a comprehensive remote sensing policy for India is being worked out. This draft policy aims at dealing with any data access and use issues regarding the effective use of space-based technologies.

Question 4

ISRO satellite and geospatial information is made available on the Bhuvan geoportal, which has various tools for visualization, analysis and participatory approaches to analytics and solutions. Furthermore, many satellite and geospatial datasets are made available freely as open data in order to improve access for users.

Question 5

The project named National Health Resource Repository is aimed at collecting health resources datasets existing in India covering both government and private resources. The Repository is the first effort in the country in the field of health census, wherein the data are being collected using a tab-based app, having more than 7,000 attributes. More than 2 million health-care establishments spread across 2.5 million enumeration blocks will be mapped in 707 districts of India. This initiative will create a web-based and geomapping-enabled single platform for all the health resources, including, inter alia, hospitals, diagnostic labs, doctors and pharmacies, and will comprise data on health infrastructure, human resources and the availability of medical facilities in each health establishment in the country.

Question 6

A large number of professionals and officials from ministries are provided with training on utilizing space technology in the field of health. Short-term courses for the same are organized regularly. Similarly, pilot studies are being carried out jointly with relevant ministries as a capacity-building activity at the national level.

Question 7

Linkages between educational institutions can be facilitated using effective satellite communication technology to reach out to professionals located in remote parts of the country, along the lines of telemedicine.

Question 8

There are several case studies on utilizing space technology for decision-making related to health. In addition, recent examples of COVID-19 studies have demonstrated, inter alia, customized geoportals to track the pandemic and update the general public on the current situation of COVID-19 spread, high-resolution data to map the hotspots designated for containment with buffer zones in order to manage the pandemic, support in geotagging all patients under home quarantine and enabling them through an easy-to-use dashboard to access essential services and medical facilities, and a tool for providing free food to the needy, with easy navigation functionality to deliver food to the needy in various locations.

Question 9

Under the Disaster Management Support Programme of ISRO, the National Remote Sensing Centre of ISRO has developed the National Database for Emergency Management, which hosts and continuously updates the information on health facilities such as hospitals, primary health centres, private clinics and medical shops, including details on location, address, etc., down to the village level. The database contains other infrastructure layers such as a transport network layer.

Question 10

To our knowledge, no published documents on space for global health care are currently available.

Question 11 (a)

In India, the telemedicine system is operational for rural and remote areas of India and has been useful for connecting the populace in those areas with specialty

hospitals. In the recent past, a facility for teleconsultation between pilgrimage places within the Indian territories has also been realized.

The gap area, or challenge, is the maintenance of such a system in village areas and coordination among all stakeholders.

Question 11 (b)

Space technology for geographic information system mapping of diseases, particularly in relation to their geographical distribution, has been used successfully for, inter alia, the mapping of the ecological risk of malaria at the village level, niche modelling for kala-azar, early warning tools for malaria and an early warning system for the outbreak of Japanese encephalitis.

Question 11 (c)

No specific inputs.

Question 11 (d)

India actively participates in global and regional disaster management efforts, including the International Charter Space and Major Disasters and the Sentinel Asia Project under the Asia-Pacific Regional Space Agency Forum. India, through ISRO, has been sharing the Indian remote sensing satellite data of medium to high resolution as and when Member States request them.

III. Replies received from international organizations

Committee on Space Research

[Original: English]
[11 November 2020]

Question 1

The Committee on Space Research (COSPAR) believes that this needs to be addressed at the national level by various Member States. In Germany, the German Aerospace Center (DLR) has launched an initiative called “Space to Health” under which various space stakeholders and applied industries are brought together in a network to address health-related topics in the context of the space setting. In the United States of America, the National Aeronautics and Space Administration (NASA) has many such initiatives within the domain of the International Space Station (ISS) and covers health topics such as delivery of cancer treatment, vaccine development and advanced water purification technology, to name a few.

In addition, in the United States, a Notice of Memorandum of Understanding between the National Institutes of Health and NASA Concerning Laboratory Animal Welfare (NOT-OD-20-095) was issued in April 2020, covering NASA-funded animal research both in space and in ground-based settings. The Public Health Service Policy on Humane Care and Use of Laboratory Animals requires institutions to establish and maintain proper measures to ensure the appropriate care and use of all animals involved in research, research training and biological testing activities. Institutions receiving Public Health Service funding through grants, contracts or cooperative agreements for research involving vertebrate animals are required to comply with the Policy.

The United Nations Programme on Space Applications provides capacity-building in the areas of tele-health and tele-epidemiology (landscape epidemiology), assists Member States in the use of satellite remote sensing, global positioning, geographic information systems and satellite communications to integrate ecological, environmental and habitation data into models for disease surveillance and control

activities. The Programme regularly organizes or contributes to workshops, conferences and training programmes on leveraging space for global health.

Question 2

Recommendation 1. Informal online meeting of the Working Group on Space and Global Health on the coronavirus disease (COVID-19).

Recommendation 2. Establishment of a repository of space research and global health documents.

Recommendation 3. COSPAR should engage the World Health Organization and the United Nations to create a task force to discuss and coordinate on global health issues.

Question 3

NASA has published a list of ISS research that has benefited human health on its website: www.nasa.gov/mission_pages/station/research/benefits/human_health.html.

Unfortunately, not much is known at the moment about the removal of barriers, both physical and political, to the effective transfer of space-based technologies in support of global health.

Question 4

Several mechanisms are currently available for data sharing, including open-access journals such as Geo-spatial Information Science, (www.tandfonline.com/toc/tgsi20/current) and the online resources Global Health Observatory data repository (https://apps.who.int/gho/data/view.main) and Geo-Spatial Data Resources (www.cdc.gov/dhdsp/maps/gisx/resources/geo-spatial-data.html). However, we are not aware of any existing policy governing such data-sharing endeavours.

Question 5

The COVID-19 crisis demonstrates that good examples are, inter alia, international coordination in the development of COVID-19 tracing apps and the exchange of testing methods.

Question 6

Currently, the overwhelming majority of space science is focused only on research. In the medical sector, global pharmaceutical players are slow to embrace space applications owing to the rigorous safety requirements and the long duration of the progress from conceptual development to the experimental stage in space.

At the subnational level, in Germany, the Centre for Space Medicine and Extreme Environments Berlin (www.charite-in-space.de) of Charité – Universitätsmedizin Berlin are currently embarked on the Myotones project sponsored by the Federal Ministry of Economy Affairs and Energy of Germany. The project is aimed at investigating changes in muscle properties in astronauts during spaceflight and in healthy participants in bed rest, without and with exercise as a countermeasure, using non-invasive Myoton technology involving a digital palpation device (MyotonPRO). The findings have the potential to merge into future health management efforts and collaboration, and memorandums of understanding between actors in the national health/occupational health sector such as clinics, hospitals and emergency workers.

In addition, in China, in cooperation with the China Manned Space Agency, the Institute of Environmental Systems Biology at the Dalian Maritime University is developing a microfluidic system for in-orbit monitoring of space radiation using biomarkers in peripheral blood lymphocytes. The system can be used for astronaut on-orbit radiation damage assessment and early warning, and can provide basic data for medical prevention and protection.

Question 7

In the United States, NASA has several outreach programmes for grade levels K–4, programmes in science, technology, engineering and mathematics for grade levels 5–8 and educator programmes for grade levels K–12, as well as college- and university-level science programmes to promote and engage young minds in capacity-building efforts (see www.nasa.gov/stem/highereducation/index.html).

Question 8

In our response to question 4, we noted the various data-sharing mechanisms to enrich and promote space-derived data in global health. A possible future mechanism to better integrate space science into industry is to encourage more applied research in the area of global health.

Question 9

Satellite technology in the areas of weather forecasting, global warming and emergency disaster management are some of the prime examples.

Satellite and Global Positioning System applications in telemedicine and rescue efforts, and emergency medical support in remote and hard-to-reach areas.

Question 10

The Expert Group on Space and Global Health, established by the Committee on the Peaceful Uses of Outer Space at its fifty-seventh session, in 2014, held its first meetings in 2015. The Expert Group served as a platform for collaboration between the World Health Organization, several national space agencies, including the Canadian Space Agency, the European Space Agency, the Japan Aerospace Exploration Agency, NASA, the State Space Corporation "Roscosmos", and the Office for Outer Space Affairs. At present, there is already a rich body of literature and documents available on the subject (see http://dx.doi.org/10.2471/BLT.15.030815).

More recently, just before the global COVID-19 pandemic erupted, the head of the United States delegation to the fifty-seventh session of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space, held in Vienna in 2020, laid out how the multidimensional contributions of space research and technologies significantly improve public health (see https://vienna.usmission.gov/2020-copuos-stsc-u-s-on-nuclear-power-sources-in-outer-space-3/).

At the European Space Agency in Germany, 3D printing technologies for printing human tissue are being developed that could help to keep astronauts healthy all the way to Mars. Under the project, the first bioprinted skin to be produced using human blood plasma as a nutrient-rich platform is being developed by scientists from the University Hospital of Dresden Technical University, together with its industry partners OHB System AG and life sciences specialist Blue Horizon. In addition, bone samples involved the printing of human stem cells with a similar bio-ink composition, with the addition of a calcium phosphate bone cement as a structure-supporting material, which is subsequently absorbed during the growth phase (see www.esa.int/Enabling_Support/Space_Engineering_Technology/Upside-down_3D-printed_skin_and_bone_for_humans_to_Mars).

Economic and Social Commission for Asia and the Pacific

[Original: English]
[20 November 2020]

Question 1

The secretariat of the Economic and Social Commission for Asia and the Pacific (ESCAP) is in the process of establishing a trust fund agreement with the Korea International Cooperation Agency to implement, in partnership with the National Institute of Environmental Research of the Republic of Korea, a project on building the pan-Asia partnership for geospatial air pollution information. The project will focus on installing spectrometers in Asian countries to calibrate and validate the Geostationary Environment Monitoring Spectrometer data from the GEO-KOMPSAT-2 satellite, launched by the Republic of Korea in February 2020. The project will also focus on building the capacity of Governments to utilize those data for their air pollution monitoring programmes while promoting cooperation and dialogue on air pollution management strategies and policies.

In addition, the secretariat is developing a new project in the data and health sector. The project aims to strengthen the capacity of member States of the Association of Southeast Asian Nations (ASEAN) to use satellite-derived data and integrated geospatial information to analyse and monitor air pollution and its negative impact on people in the ASEAN region. The project is being developed jointly with Seoul National University, National Research Institute of Environmental Research and the World Health Organization.

Through its long-standing Regional Space Applications Programme for Sustainable Development (RESAP), ESCAP has made concerted efforts to promote the application of space technology and geographic information systems for supporting disaster risk reduction and inclusive and sustainable development. RESAP serves as a mechanism for regionally coordinated actions. For example, in times of disaster and emergency, and to avoid the loss of life and minimize economic losses, ESCAP responds promptly to requests for support by disaster-affected Member States. Furthermore, ESCAP gives high priority to capacity-building programmes and knowledge-sharing geared towards implementing the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030). Additionally, the “Space+” initiative goes beyond the traditional space applications approaches to support implementation of the Asia-Pacific Plan of Action and will seek to: (a) leverage frontier technologies such as artificial intelligence, the Internet of things, cloud computing and big data; (b) engage end users in multiple areas, such as youth or the private sector; (c) more effectively manage information through the creation of a regional or national cloud-based metadata platform; and (d) strengthen implementation through enhanced partnerships with global and regional stakeholders.

Question 2

The secretariat is establishing an Asia-Pacific Geospatial Information Platform. The initiative, which spans a 10-year period through to 2030, aims to enhance the sharing of satellite data and geospatial information among member States. The platform plans to provide services in the following six areas: (a) disasters (drought and flood); (b) natural resource management (land and water); (c) connectivity (city); (d) social development (health and pandemics); (e) energy (renewable energy); and (f) climate change (environment and air quality). Work will be carried out in partnership with the United Nations Global Service Centre in Brindisi, Italy, and a proposed Asia-Pacific geospatial data hub of the Group on Earth Observations.

Question 3

The Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030), with much foresight, included epidemics in its proposed

actions. It specifically requested ESCAP and its member States to strengthen regional cooperation in order to: (a) leverage data-sharing and promote big data analytics for the containment of present and future spreads of diseases and epidemics; (b) develop capacity for mapping health-risk hotspots using geospatial information and big data; and (c) pay special attention to the countries that are most vulnerable to emergency health situations.

ESCAP, as the secretariat for RESAP and the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific, is promoting the sharing of best practices among countries in the region through a series of webinars and online meetings. Furthermore, ESCAP, as the RESAP secretariat, is working in pilot areas with national partners to integrate geospatial and socioeconomic information and identify correlations between the coronavirus disease (COVID-19) and "place, space and community" characteristics.

Question 4

The above-mentioned Asia-Pacific Geospatial Information Platform aims to promote the sharing of open and interoperable data. It encourages member States to take participatory approaches to developing and improving access to geospatial information, not only on global health but also on other sectors in the Asia-Pacific region. A more open sharing of comparable cross-country and cross-sector satellite data and geospatial information, notably between spacefaring data-supply countries and regional data users in the Asia-Pacific region, will deepen the understanding of complex sustainable development problems and facilitate the finding of solutions for the successful implementation of the Sustainable Development Goals.

The secretariat is working on an initiative entitled "One Data–One Map–One Platform", focused on building, in partnership with Governments, an innovative cloud system that utilizes frontier technologies, and integrates big Earth data to support monitoring and decision-making for the Sustainable Development Goals.

The ESCAP "One Data–One Map–One Platform" initiative encourages member States to build a system ("One Platform") that utilizes the frontier technologies and integrates with big Earth data ("One Map") to support local monitoring and decision-making in regard to the Sustainable Development Goals. Given the unstructured characteristics of big Earth data, common data formats for cross-sectoral geospatial data-sharing are needed so that big Earth data can facilitate and support the Sustainable Development Goal indicators. In this way, member States and stakeholders will be able to explore the possibilities for effective country-level Sustainable Development Goal assessment and monitoring. ESCAP is currently piloting the approach in selected cities in Thailand and Indonesia.

Geospatial data should be accessible, available, actionable and affordable, in order to benefit people and inform practices, processes and policies. In its approach to reviewing and sharing good practices for its publication *Geospatial Practices for Sustainable Development in Asia and the Pacific 2020: A Compendium*, ESCAP included the following: the practices in the region, the people behind them and benefiting from them, the processes behind the implementation, and the subsequent or enabling policy elements. The skills capacity of people is critical for the effective implementation of policies, calling for well-trained professionals who have utilized these practices, who have been trained to provide future sustainability and who can implement and understand geospatial applications. Indeed, the processes behind the implementation of geospatial applications do not occur overnight, especially as they are based on individual country and community needs, bridge sectoral silos and provide space for co-learning, thereby enabling collaborative, new ways of integrating, using and sharing information.

Question 5

ESCAP is integrating geospatial information for finding correlations between COVID-19 and socioeconomic sectors, as well as identifying hotspot areas in

vulnerable countries. This includes identifying the characteristics of risk hotspots, such as high population density, mobility, poor sanitation, low connectivity and awareness, by conducting geographic information system-based analysis of relevant data, for example, census and household surveys and data on population mobility, sanitation and Internet access. This allows us to map and target the communities most in need and at risk and identify correlations with policy impacts.

Question 6

In response to the COVID-19 outbreak, ESCAP organized two webinars, with the participation of stakeholders from more than 30 countries, to share good practices and cross-cutting approaches in integrating geospatial information into the COVID-19 response and explore how to strengthen regional collaboration in developing capacity to map health risk hotspots and mitigate potential risks using geospatial information and big data. Various member States in South-East Asia requested ESCAP to take further action, including the sharing of good experiences and operational tools through regional and subregional training programmes and the holding of specific capacity-building events to support other countries in using satellite imagery to analyse the impact of COVID-19, the development of a data hub for determining the potential risk of COVID-19 across the country, focusing on methodology development, and a comprehensive COVID-19 situation map focusing on tracking confirmed cases and preventing further infections.

In this regard, ESCAP is collaborating with the Geo-Informatics and Space Technology Development Agency (GISTDA) of Thailand to develop operational procedures and training materials on integrating georeferenced data regarding the pandemic into a comprehensive data hub and to support policymakers in understanding the pandemic situation and to support evidence-based action.

Question 7

ESCAP is collaborating with GISTDA to develop an operational platform and sample dashboard for the integration and analysis of data on the COVID-19 situation to support policymakers in central government agencies and provincial disease control centres. Additionally, ESCAP and GISTDA will organize two online training workshops for government officials from ASEAN countries on geospatial information applications for COVID-19 response and impact analysis.

Question 8

RESAP serves as a framework for collaboration and a mechanism to support countries in better integrating space-derived data into decision-making processes related to the global health sector and nearly all other sectors. The ESCAP “One Data–One Map–One Platform” initiative encourages member States to build a system (“One Platform”) that utilizes frontier technologies and integrates with big Earth data (“One Map”) to support local Sustainable Development Goal monitoring and decision-making, with a focus on locally identified priority needs. Given the unstructured characteristics of big Earth data, common data format technologies for cross-sectoral geospatial data-sharing can be implemented so that big Earth data can facilitate and support the Sustainable Development Goal indicators. ESCAP is currently piloting the approach in selected cities in Thailand and Indonesia, with an updated focus on health and pandemic preparedness and response.

Question 9

The ESCAP “One Data–One Map–One Platform” initiative encourages member States to build a system (“One Platform”) that utilizes frontier technologies and integrates with big Earth data (“One Map”) to support local Sustainable Development Goal monitoring and decision-making, with a focus on locally identified priority needs. The data from this single platform will help to support emergency planning and management and disaster management plans. ESCAP is currently piloting the

approach in selected cities in Thailand and Indonesia, with an updated focus on health and pandemic preparedness and response.

Question 10

The Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030), with much foresight, included epidemics in its proposed actions. It specifically requested ESCAP and its member States to strengthen regional cooperation in order to: (a) leverage data-sharing and promote big data analytics for the containment of present and future spreads of diseases and epidemics; (b) develop capacity for mapping health-risk hotspots using geospatial information and big data; and (c) pay special attention to the countries that are most vulnerable to emergency health situations.

Governments are using geospatial data and space applications to support the monitoring of, response to, and preparation for the COVID-19 pandemic. The public and private sectors have collaborated to develop platforms and publish information products, such as web maps of confirmed infections and deaths, maps of critical infrastructure and supplies, and available routes for medical staff, among others.

A sample of country initiatives from Asia and the Pacific:

(a) Thailand: lockdown measure impacts and COVID-19 iMap (intelligent map) dashboard;

(b) Indonesia: heat maps of vulnerability levels;

(c) India: the ISRO “Bhuvan-COVID-19” geoportal;

(d) Fiji: a dashboard and managing disasters during the COVID-19 pandemic;

(e) Malaysia: the WebGIS dashboard;

(f) China: health Quick Response codes;

(g) Philippines: a campaign that supports innovative apps;

(h) Republic of Korea: the private sector’s role in developing vital platforms.

(See www.unescap.org/publications/geospatial-practices-sustainable-development-asia-and-pacific-2020-compendium, chapter 6, for the details of each example.)

Question 11

See the responses to question 10.

Space Generation Advisory Council

[Original: English]
[11 November 2020]

About the Space Generation Advisory Council and points of contact

The Space Generation Advisory Council (SGAC), in support of the United Nations Programme on Space Applications, is a global non-governmental, non-profit organization and network that aims to ensure representation of university students and young space professionals between the ages of 18 and 35 at the United Nations and in space agencies, industry and academia. SGAC represents 15,000 members from over 150 countries worldwide, and holds permanent observer status at the Committee on the Peaceful Uses of Outer Space. For more information about SGAC, please visit our website: spacegeneration.org or contact info@spacegeneration.org.

The Space Medicine and Life Sciences project group is a core group of SGAC members and experts aiming to provide an international, intercultural and interdisciplinary platform for young professionals with an interest in space biomedical science. SMLS was informally founded in June 2018, ahead of the

fiftieth anniversary of the United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE+50), to provide a forum for students and young professionals to discuss the contributions of space to global health and medicine. The project group was formally launched thereafter, and members have been invited to contribute, and have contributed, to the activities of the Working Group on Space and Global Health of the Scientific and Technical Subcommittee. For more information about the Project Group, visit spacegeneration.org/projects/smls or contact smsl@spacegeneration.org.

Question 1

The Space Medicine and Life Sciences project group has collaborated with a range of international partners from academia and industry to provide subject-matter expert mentorship to the next generation in solving global health issues by utilizing space-based solutions.

In 2019, the project group partnered with the pharmaceutical company Merck to host a space medicine panel and working group discussion during the fourth European Space Generation Workshop, held at Imperial College London (spacegeneration.org/esgw2019).

In late 2019, the project group partnered with the Secure World Foundation and the SGAC Space Technologies for Earth Applications project group to coordinate and deliver the Space4Earth hackathon in conjunction with the 70th International Astronautical Congress, in Washington, D.C., in October 2019 (spacegeneration.org/event/sgac-space4earth-hackathon). The hackathon provided a forum for SGAC members to innovate and solve United Nations Sustainable Development Goals-related challenges in interprofessional and multidisciplinary groups.

Over the course of 2019 and 2020, the project group has also partnered with UK Space Life and Biomedical Sciences Association (UK Space LABS; www.ukspacelabs.co.uk/) to deliver online educational workshops on space life sciences and global health. The project group is also delivering the six-month online Space for Health Systematic Review Workshop in collaboration with UK Space LABS and the University of Northumbria Aerospace Medicine Systematic Review Group (aerospacemed.rehab/systematic-review-group), with observers and expert supervisors from the European Space Agency Education Office, and the Ames Research Center and the Exploration Medical Capability Element of the National Aeronautics and Space Administration of the United States of America. The SGAC Space Medicine and Life Sciences project group also conducted an online workshop at the SpaceGen Summit. The Summit included such sponsors and partners as NASA, Blue Origin, Virgin Galactic and Lockheed Martin (see spacegeneration.org/sgs2020/sponsors-and-partners).

Going forward, we are in the process of forming partnerships with the Next Generation of Aerospace Medicine group of the Royal Aeronautical Society of the United Kingdom of Great Britain and Northern Ireland (nextgenasm.wordpress.com/) and InnovaSpace (www.innovaspace.org/) to deliver science, technology, engineering and mathematics (STEM) outreach initiatives to encourage students from around the world to engage in STEM education.

Question 2

The Space Medicine and Life Sciences project group would like to recommend the following: (a) that this survey be used to map the key stakeholders in space and health, and that sustainable long-term investment in space for global health be encouraged through an e-workshop; and that the e-workshop conclusions be used to (b) derive a road map with key thematic priorities; and (c) create a collaborative online toolkit to draw the attention of global health actors to space-based solutions. These three recommendations are outlined in more detail below.

(a) Stakeholder mapping and e-workshop

To achieve this, the project group recommends a cross-sectoral stakeholder exercise to map the relevant actors on the basis of the results of this survey. These stakeholders could then be invited to a hybrid or online workshop as a side activity of the Scientific and Technical Subcommittee, under the coordination of the Working Group on Space and Global Health, with the participation of key players from international agencies, industry, academia and United Nations entities. The aim of this workshop will be to identify key priorities in global health that can be addressed by space applications.

(b) Road map for space for global health priorities

The workshop could be used to derive a space for global health five-year road map to outline key priorities for the space sector and to achieve the Sustainable Development Goals, driving the global health agenda forward effectively. Each year of the road map could have a thematic focus in order to raise awareness of key global health priorities among the space community.

(c) Collaborative online toolkit and workshops

The project group also recommends a dedicated platform that would help facilitate communication between United Nations entities, international organizations and relevant actors on space and global health issues. This platform could include a collaborative online toolkit, encouraging engaged stakeholders in the space and health sectors to openly share data and best practices for the benefit of public health. An example of a collaborative dashboard is the rapid action coronavirus Earth observation dashboard (race.esa.int/), which is a valuable asset for public health agencies collating Earth observation data across operators and agencies to help with the coronavirus disease (COVID-19) pandemic. Moreover, those engaging with the platform will benefit from educational workshops for the stakeholders and the next generation of researchers facilitated by the project group.

All in all, these cooperative ventures would enable the sharing of science and data, as well as spin-offs for space and Earth for the benefit of the next generation.

Question 3

SGAC aims to employ the creativity and vigour of youth in advancing humanity through the peaceful uses of outer space. This objective aligns with the resolution entitled “The Space Millennium: Vienna Declaration on Space and Human Development”, which aims to create, within the framework of the Committee on the Peaceful Uses of Outer Space, a consultative mechanism to facilitate the continued participation of young people from all over the world, especially women and citizens of developing countries, in cooperative space-related activities.

A key objective of the organization is to steward the views and opinions of students and young professionals by representing their views at international, regional and national forums. This includes being a permanent observer to the Committee on the Peaceful Uses of Outer Space and actively participating in the Working Group on Space and Global Health of the Scientific and Technical Subcommittee. Our work is also directed by the overarching themes set out in the 2030 Agenda for Sustainable Development.

The views and representations expressed at these forums are informed by multiple mechanisms that directly engage with students and young professionals throughout the world. These policy-driven mechanisms remove barriers to the use of space-based technologies and applications in global health, primarily by creating opportunities for information-sharing and education, connecting needs with resources, and disseminating relevant knowledge and methodologies throughout the world, particularly in developing countries. Our mechanisms to help early

investigators include open-access events, scholarships and opportunities for professional development. These are outlined in greater detail below.

Events

- Events of SGAC and the Space Medicine and Life Sciences project group create a forum for information- and knowledge-sharing that crosses the international, interdisciplinary and intergenerational divide by attracting attendees throughout the world from a broad range of professional backgrounds and by providing access to key leaders and thinkers in the space sector.
- The working group discussions held at these forums contribute to the generation of policy white papers aimed at international, regional and national governing organizations that support capacity-building and information-sharing activities to engage students and young professionals in the area of space technologies for global health.

Scholarships

- Reduce or eliminate financial barriers to participation for students and young professionals of any background or nationality to attend SGAC events or its partners' events.
- Create opportunities for engagement through global competitions on relevant topics.

Professional development

- Disseminate knowledge and the state of the art through webinars.
- Build capacity, including skills and abilities, through professional development workshops.
- Publicize career-building opportunities through our jobs board.
- Provide mentorships to members.

Questions 4 and 5

Not applicable.

Question 6

SGAC, through its Space Medicine and Life Sciences project group has created a virtual platform, hosted on the business communication tool Slack, focused on international and interdisciplinary cooperation for young professionals and students interested in the application of space science and technology in the field of global health. SGAC and the project group also engage early investigators through social media platforms such as Twitter. We have a combined following of approximately 14,000 members.

The platform, founded in January 2019, had grown to 321 members as at the end of October 2020. This virtual technology hub aims to build critical mass through a community of practice and capacity-building activities to encourage students and young professionals from anywhere in the world to be involved in the field of space and global health. It is innovative in breaking down barriers to participation for individuals who may not have access to the resources or technical expertise in their local area or country.

Apart from the intangible value created from the significant capacity-building and networking undertaken through it, the platform has also been responsible for spinning off a number of key projects and programmes. This is exemplified by the project group members' participation in the NASA Space Apps Challenge on the use of space for solutions to tackle the COVID-19 pandemic (covid19.spaceappschallenge.org/). Similarly, project group members supported a

team (shortlisted among the finalists) for the Mars Society's Mars City State Design Competition. The role of the project group team was to envision the medical infrastructure for a future Mars settlement based on current and emerging technologies utilized to care for patients in remote Earth environments (see www.marssociety.org/news/2020/09/28/finalists-chosen-in-mars-city-state-design-competition).

Question 7

As outlined in previous responses, SGAC and the Space Medicine and Life Sciences project group both engage with educational institutions to provide an environment for young health professionals to acquire skills required to apply space solutions in improving patient care on Earth. As part of this objective, the project group has recently launched the Space for Health Systematic Review Workshop (spacegeneration.org/projects/smls/ongoing-projects). This six-month-long project, outlined in more detail below, will equip early investigators with the skills to critically appraise and review space technology, science and applications.

Space for Health Systematic Review Workshop

Project focus

The Systematic Review Workshop aims to enable students and young professionals to identify gaps in human research priorities and potential solutions with spin-offs to global health. This is in collaboration with the Aerospace Medicine Systematic Review Group and the UK Space Life and Biomedical Sciences Association, affiliated with the UK Space Agency. This educational initiative will also ensure that the next generation of researchers are aware of the challenges we need to solve in the space and global health sector.

Experts from space and health

A call for projects was launched earlier this year. Experts applied from a range of organizations, including the ESA Education Office, the NASA Ames Research Center, Blue Abyss, UK Space LABS and universities such as King's College London. Nine projects were shortlisted after a peer-review led by 14 experts representing the space and health sectors.

Multidisciplinary teams

Fifty-four multidisciplinary early investigators, including health-care professionals, bioethicists and geneticists, from a pool of more than 150 applicants were selected for the workshop after a free and open-access webinar.

The Workshop as an educational platform

The webinars are available on the SGAC YouTube channel, alongside other videos from our 2019/20 "Health in Space" webinar series. In addition, all workshop resources have been collated on Google Classroom, accessible from their own shared Google Drive space by means of a joint interface, for a shared learning experience available to all 74 participants, experts and coordinators from the Space Medicine and Life Sciences project group and UK Space LABS. All participants and experts are volunteers.

Question 8

The Space Medicine and Life Sciences project group and UK Space LABS coordinated an essay competition focused on space applications for COVID-19, and the shortlisted winners were encouraged to submit a summary of their space-derived solution as a YouTube video. The finalists were invited to present at a session on space technology and solutions for COVID-19 at the SpaceGen Summit (see spacegeneration.org/sgs2020/spacegen-summit-schedule). The feasibility and

challenges were discussed in breakout sessions and then presented at the SpaceGen Summit by a team representative. In particular, the early investigators attending the session discussed the feasibility of using mobile technology and gamification to engage the younger generation in adhering to preventative public health measures and monitoring symptoms of COVID-19. This team and the essay winners will be encouraged to take their projects further by the project group through online project management tools such as Slack and Trello.

Question 9

The Space Medicine and Life Sciences project group has developed a COVID-19 Trello board template for curating key resources for medical students and doctors in hospitals. The template is editable and can be tailored to local departments all over the world. On the basis of feedback, we know that the template has been used by multiple doctors on the front lines all over the world, for education, checklists and key resources (see trello.com/invite/b/acmPNw1V/5cacb70b83280a66eb246ba97e699e9d/trello-template-please-copy-the-template-and-make-it-your-own-covid-19-dashboard-for-doctors).

Question 10

As outlined above, the Space Medicine and Life Sciences project group has built a community of early investigators, such as health-care professionals, life scientists, public health doctors and Earth observation experts, under the age of 35, and experts from all sectors. The plan is to continue to build an international group of early investigators interested in space for global health and to circulate our monthly newsletter containing a range of opportunities that encompass events, projects and educational initiatives.

Question 11

Please see our responses above. As a group we encourage free and open-access projects in all these areas in order to enable early investigators to learn more about the space for global health field. As we move forward, we will promote the participation of the next generation in events and initiatives, with a view to proposing viable solutions for these challenges, as well as providing education.