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Report on the United Nations Expert Meeting on the International Space Station Benefits for Health

(Vienna, 19-20 February 2014)

I. Introduction

1. The United Nations Expert Meeting on the International Space Station Benefits for Health was held in Vienna on 19 and 20 February 2014. The Meeting was part of the Human Space Technology Initiative, an initiative carried out within the framework of the United Nations Programme on Space Applications (see www.oosa.unvienna.org/oosa/en/SAP/hsti/index.html).

2. The Meeting focused on facilitating dialogue to extend the benefits of the International Space Station (ISS) for health. The Meeting was designed to compile existing or new information related to the six leadership priorities of the World Health Organization (WHO), as defined by the sixty-sixth World Health Assembly in its twelfth general programme of work for the six-year period 2014-2019, and to facilitate a dialogue between ISS partner agencies and WHO aimed at identifying potential areas of collaboration where the needs and requirements of the health sector intersected with the benefits derived from space applications and technologies.

3. The Meeting was organized by the Office for Outer Space Affairs of the Secretariat. WHO and the partner agencies of the ISS programme, namely, the Canadian Space Agency (CSA), the European Space Agency (ESA), the Japan Aerospace Exploration Agency (JAXA), the National Aeronautics and Space Administration (NASA) of the United States of America and the Russian Federal Space Agency (Roscosmos) participated in the Meeting.

4. The present report has been prepared pursuant to General Assembly resolution 68/75. It describes the background, objectives and programme of the Meeting. It also provides a summary of the current leadership priorities of WHO and the health-related activities of the participating ISS partner agencies, describes the identified shared problems related to providing health care for astronauts on ISS

and health services for populations on Earth and describes potential ISS programme results to help solve these problems.

A. Background and objectives

5. From the beginning, outer space has caught the imagination of humanity. With technological development, traveling into space finally became a reality. On 12 April 1961, Yuri Gagarin became the first human being to venture into space, opening up a new era of human activity that was no longer limited to the surface or atmosphere of the Earth. Within a decade, Neil Armstrong walked on the surface of the Moon. In the 1980s, the Union of Soviet Socialist Republics launched the Mir space station, which it operated for more than a decade.

6. Through the combined efforts of its five partner agencies, ISS was developed, constructed and launched to promote peaceful cooperation in space. It has been continuously inhabited since November 2000.

7. The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), held in Vienna from 19 to 30 July 1999, recognized that large human space exploration missions exceeded the capacity of a single country and that international cooperation should be encouraged in that area. ISS was cited as an example of that new paradigm which had been made possible by the end of the Cold War. UNISPACE III recommended the development of future space science programmes, in particular, through international cooperation and the encouragement of access to ISS by countries that had never participated in that endeavour. It also advocated the worldwide dissemination of information about research activities aboard ISS.[1]

8. In 2010, the Human Space Technology Initiative was launched to promote international cooperation in activities related to human spaceflight and space exploration, raise awareness of the benefits of human space technology and support capacity-building in microgravity research and education.

9. As part of the Initiative, the Office for Outer Space Affairs, in cooperation with the five ISS partner agencies, organized a one-day outreach seminar on ISS in Vienna in February 2011. At that seminar, the status of educational and research activities and the process for participating in research aboard ISS were presented. The seminar established that the Initiative could be a meaningful mechanism for creating awareness about the potential of ISS research and educational activities.

10. The United Nations/Malaysia Expert Meeting on Human Space Technology was held in Putrajaya, Malaysia, from 14 to 18 November 2011. With participating experts from around the world, the Meeting was aimed at sharing information about the latest activities on board ISS; multiple space programmes at the national, regional and international levels; microgravity research; and educational activities. The Meeting was also aimed at defining potential activities of the Initiative, in particular, capacity-building in the areas of microgravity research and education in

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[1] *Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 19-30 July 1999* (United Nations publication, Sales No. E.00.I.3), chap. II, paras. 388-390 and 401-402.

developing countries. The Meeting agreed on 10 recommendations for future activities of the Initiative (see A/AC.105/1017).

11. The United Nations Expert Meeting on the International Space Station Benefits for Humanity was held in Vienna on 11 and 12 June 2012. The Meeting was organized to further discuss the identification of potential synergies between existing ISS activities and the needs of United Nations organizations. It focused particularly on the results of ISS research and technology applications. The Meeting agreed on concepts and observations in the areas of Earth observation and disaster response, health and education. The participants concluded that further assessment of those concepts by the interested parties would be needed prior to further exploration of potential activities (see A/AC.105/1024).

12. The United Nations Expert Meeting on the International Space Station Benefits for Health, held in Vienna on 19 and 20 February 2014, was organized to exchange information on the health-related activities undertaken by space agencies on or for ISS. It covered research, development and testing of technology, operational activities and medical procedures. It was also aimed at linking those activities to the leadership priorities of WHO and possible solutions to major obstacles identified by WHO.

B. Attendance

13. Representatives of WHO and ISS partner agencies, which included CSA, ESA, JAXA, NASA and Roscosmos,[2] and the Office for Outer Space Affairs participated in the Meeting.

14. The reporting session of the Meeting was open to observers from all delegations attending the fifty-first session of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space.

C. Programme

15. The programme of the Meeting was developed by the Office for Outer Space Affairs in collaboration with WHO and ISS partner agencies. It comprised four sessions: one morning and one afternoon session on each of the two meeting days.

16. In the first session, the Office for Outer Space Affairs introduced the Human Space Technology Initiative. In his welcome address, the United Nations Expert on Space Applications emphasized two examples of potential contributions of space to global health: space food technology and clothing technology. The representative of WHO then explained the leadership priorities of and obstacles facing WHO, followed by presentations by ISS partner agencies of their health-related activities and achievements.

[2] The contributions of Roscosmos were presented by the Chair during the Meeting, based on information provided by the agency prior to the Meeting.

17. In the second session, potential contributions from ISS partner agencies to support the achievement of the leadership priorities of WHO were intensely discussed. The next day, a plan was agreed on how to consolidate that discussion.

18. The third session was dedicated to the creation of a table listing potential contributions to each of the WHO leadership priorities from the ISS partner agencies, distinguishing existing technologies from those still at the planning stage or under development. Furthermore, recommendations for follow-up activities were discussed.

19. In the fourth and final session, WHO, along with ISS partner agencies and the Office for Outer Space Affairs, presented the results of the Meeting to members of the delegations attending the fifty-first session of the Scientific and Technical Subcommittee.

II. Global health priorities and activities of the space agencies

20. In the first session, mutual information and understanding among the participants of the Meeting were reinforced and increased by presentations from WHO on the demand side of global health, followed by presentations by ISS partner agencies on their health-related activities.

A. Current leadership priorities of and obstacles facing the World Health Organization

21. The WHO representative introduced WHO as a directing and coordinating authority for health within the United Nations system that was responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends. He also outlined the current leadership priorities of WHO and explained the major obstacles facing the organization.

22. He noted that, in May 2013, the sixty-sixth World Health Assembly had approved the twelfth general programme of work for the period 2014-2019, which set out a vision for WHO. It also described the following six leadership priorities that defined the areas in which WHO influenced the world of global health:

(a) Leadership priority 1: Advancing universal health coverage by enabling countries to sustain or expand access to essential health services and financial protection and to promote universal health coverage as a unifying concept in global health;

(b) Leadership priority 2: Health-related Millennium Development Goals, addressing the unfinished and future challenges related to accelerating the achievement of the current health-related Goals, up to and beyond 2015. That included eradication of extreme poverty and hunger, reduction of child mortality, improving maternal health and combating HIV/AIDS, malaria and other diseases;

(c) Leadership priority 3: Addressing the challenge of non-communicable diseases, such as cardiovascular diseases, cancers, respiratory diseases, diabetes and other non-communicable diseases, all subject to the WHO global action plan for the prevention and control of non-communicable diseases 2013-2020;

(d) Leadership priority 4: Implementing the provisions of the International Health Regulations (2005);

(e) Leadership priority 5: Increasing access to essential, high-quality, safe, effective and affordable medical products, such as medicines, vaccines, diagnostics and other health technologies. Leadership priority 5 included the monitoring and use of information, access to and rational use of medicines, innovation and local production of medicines. It also supported the other leadership priorities, in particular, leadership priorities 1 and 3;

(f) Leadership priority 6: Addressing the social, economic and environmental determinants of health, such as the physical environment and the individual characteristics and behaviours of individuals.

23. It was explained that major obstacles with regard to global health included the following:

(a) Poor service delivery, since services were often in short supply and located far from where people lived, especially in rural areas. In addition, such services were frequently of poor quality and sometimes unsafe;

(b) Inadequate or mismanaged information, such as disaggregated data and data from the private sector, which was necessary to make evidence-based decisions at the local and national levels. Such information was often lacking or of poor quality or, where it was available, underexploited or not used at all;

(c) Inadequate, misallocated and mismanaged human resources, such as the critical lack of a sufficient number of properly trained and motivated personnel, which constituted a major barrier to the availability of appropriate services in many countries. In addition, high staff attrition occurred as a result of poor payment and working conditions. Also, there was often a lack of training and continuing education programmes for staff to maintain and update their skills and to cope with emerging health challenges;

(d) Poor infrastructure, including information infrastructure, as lack of investment in new facilities or the renovation of existing ones, lack of access to telecommunications networks and data processing facilities, and the non-purchase or failure to maintain equipment, had implications for the quality of service provision and patient safety.

B. Health-related activities of ISS partners

24. The partner agencies of ISS presented an overview of their health-related activities, emphasizing potential contributions to support global health priorities. The general categories of contributions were: (a) research conducted on or for ISS (e.g. space life sciences, astronaut health and health research); (b) technology development and testing on or for ISS (e.g. directly applicable or spin-off/spin-in/spin-through technologies); and (c) operational activities and procedures on or for ISS (e.g. logistics, software development and crew medical care).

25. Activities relating to space medicine and life sciences that were supported by CSA focused on the identification, understanding, mitigation or elimination of health risks associated with human spaceflight. The Agency presented its "shared problem open innovation model" for collaboration and its "space health and ageing research" (SHARE) initiative, which was aimed at leveraging relevant space research to support research related to human aging. Regarding clinical care, the Agency described its advanced, fully integrated crew medical system, which was under development; Microflow, a miniature, robust-flow cytometer for bioanalysis; and Astroskin, a garment for the monitoring of physiological data.

26. From the broad range of ESA programme activities relevant to terrestrial health issues, information on the following was presented: research on aging and sedentary lifestyles; in-vitro experiments with human cell cultures for gaining new insights into human health issues associated with aging, including cardiovascular disease, osteoporosis, muscle loss and immune dysfunction; bed rest studies; telemedicine applications (the ESA integrated application programme for telecommunications); and the Micro-Ecological Life Support System Alternative, which was focused on recovering food, water and oxygen from waste products, and on small-animal tracking.

27. There were five areas of research undertaken by JAXA: physiological countermeasures against the effects of spaceflight on the human body; physiological support, such as stress monitoring; in-orbit medical technology, including telemedicine and telescience; cosmic radiation and protection against it; and the environment for toxic gases and bacteria. Examples were presented, including a 24-hour electrocardiogram study for monitoring sleep conditions and circadian rhythms, an on-board diagnostic kit, physical activity monitoring, hair analysis and a high-definition camera.

28. Several examples of NASA activities that were closely related to terrestrial health issues were presented. First, research on the risks of spaceflight revealed that bone loss during long missions could be minimized by a combination of exercise and good nutrition, including sufficient quantities of vitamin D and omega-3 fatty acids. Second, simple-to-use small medical technologies such as the dry electrode electrocardiogram system and the ISS ultrasound used to diagnose medical conditions on ISS, a telemedicine system, and research on environmental factors and behavioural health were presented.

29. The representative of Roscosmos presented the Russian State Research Centre Institute for Biomedical Problems, with its various activities that were related to the Meeting goals, including basic processes in humans during spaceflights and derived new knowledge on human health; new technologies and methods for the diagnosis and treatment of, and recovery from, cardiorespiratory disorders; and rehabilitation methods and equipment applicable in neurology, cardiology and traumatology. In addition, several solutions for express diagnostics and screening of public health were also presented.

III. Shared interests and potential contributions

30. Two sessions, with both plenary discussions and work in smaller groups, were organized to identify shared interests between WHO and the ISS partner agencies, guided by the leadership priorities of WHO.

A. Leadership priority 1: Advancing universal health coverage

31. The following shared interests related to leadership priority 1 were identified:

(a) Medical care in the physical absence of health-care professionals;

(b) Health care in remote and/or isolated locations.

32. The following currently applicable solutions from ISS partner agencies that might contribute to leadership priority 1 were indicated by each agency:

(a) CSA: none;

(b) ESA: Telemedicine technologies and applications developed in the framework of the ESA integrated applications programme, including remote assistance to medical teams in remote environments, such as echography, assisted surgery, monitoring of vital signs, remote health monitoring and disease and epidemic tracking;

(c) JAXA: An on-board diagnostic kit, an integrated medical system with various types of novel medical equipment used on ISS to promote health monitoring by astronauts since 2011;

(d) NASA: Remotely guided ultrasound, a multipurpose imaging device equipped with four different probes requiring minimal crew training to achieve measurements with remote sonographer guidance, which could be used for research, diagnostics and treatment; and a portable clinical blood analyser, a compact automated instrument that tested very small blood samples within minutes for certain predetermined constituents;

(e) Roscosmos: Large-scale teleconsultation and the use of teleconsultation software; a multifunctional telemedicine complex; emergency telemedicine and disaster medicine; a mobile e-health complex, mobile telemedicine units and kits; and mobile oxygen generators and concentrators providing oxygen of high purity.

33. The following future applicable solutions from ISS partner agencies with the potential to contribute to leadership priority 1 were indicated by each agency:

(a) CSA: The advanced crew medical system, under development for space and terrestrial use, as a remote-care medical solution for isolated, confined and extreme environments, including devices for bioanalysis, diagnostics, training and simulation, together enabling advanced remote health monitoring;

(b) ESA: Autonomous crew operation workflows and techniques from ISS and Concordia station (an isolated research station in Antarctica);

(c) JAXA: Autonomous diagnostic capability, including commercially available monitoring devices combined with decision support tools;

(d) NASA: A dry-electrode electrocardiogram system for ambulatory cardiovascular monitoring that required no skin preparation or consumables (2015); the Exploration Medical System Demonstration project and a telemedicine suite (ground demonstration in 2014);

(e) Roscosmos: Telemedicine technologies for diagnostics and treatment in remote places or under extreme conditions, developed on the basis of existing technologies, and devices for individual health monitoring for home and out-of-hospital use.

B. Leadership priority 2: Health-related Millennium Development Goals

34. The following shared interests related to leadership priority 2 were identified:

(a) Enabling or enhancing in situ diagnostics through new diagnostic equipment and sample preparation methods;

(b) Supporting the supply of clean water through technologies for water quality management, water purification and storage of water.

35. The following currently applicable solutions from ISS partner agencies that might contribute to leadership priority 2 were identified by each agency:

(a) CSA: A terrestrial variant of a miniature, robust-flow cytometer used for bioanalysis;

(b) ESA: The Micro-Ecological Life Support System Alternative for recovering food, water and oxygen from waste and grey-water recycling, active at the Concordia station;

(c) JAXA: Shared information on food safety and ecosystems, including food for disaster, biodegradable containers and nutrition management;

(d) NASA: A lab-on-a-chip handheld test system for microbes and chemical substances in water and the environment, a rapid water purification assembly of the space regenerative life support system, and portable ultrasound for prenatal and other care;

(e) Roscosmos: Prenosological physical health evaluation methods and devices, such as the ECOSAN device, designed for prenosological control of health levels on the basis of a cardiorespiratory examination and already used in 10 regions; the Health Navigator all-round health screening; and loading tests for the estimation of functional reserves.

36. The following future applicable solutions from ISS partner agencies with the potential to contribute to leadership priority 2 were identified by each agency:

(a) CSA: In situ diagnostics and sample preparation for in situ diagnostics, including environmental and water supplies;

(b) ESA: A miniaturized bioreactor with sensor systems, to be tested in the Arthrospira Experiment on ISS in 2015, a black-water recycling system for Concordia station, and the International Cooperation for Animal Research

Using Space project, implemented by the German Aerospace Centre, to address animal-borne disease tracking and prediction;

(c) JAXA: Nutritionally enforced “functional” food, especially food containing antioxidants and proteins;

(d) NASA: Development of microbial vaccine for salmonella and pneumonia to prevent foodborne illness (2018) and shelf-stable full-nutrition food bars (2018);

(e) Roscosmos: Development with other institutions of special telemedicine programmes and projects at the governmental level, development of new telemedicine technologies and devices for use in space medicine and in public health care, and a new concept of health based on data collected during the selection, training and monitoring of cosmonauts, which could guide the definition of principles for preventive medicine and enable subject-specific health screening applications.

C. Leadership priority 3: Addressing the challenge of non-communicable diseases

37. The following shared interests related to leadership priority 3 were identified:

(a) Research on aging, including research on muscle loss, bone loss, neurovestibular changes and vision impacts;

(b) New or enhanced therapies for non-communicable diseases, with an emphasis on typically multimorbid and frail ageing populations.

38. The following currently applicable solutions from ISS partner agencies that might contribute to leadership priority 3 were identified by each agency:

(a) CSA: None;

(b) ESA: Human health-related studies in the European Life and Physical Science programme, including human physiology, biology and animal experiments; and knowledge from bed rest studies;

(c) JAXA: Joint research on aging and space physiology issues for enhancing support of the well-being of populations with an increasing proportion of elderly people;

(d) NASA: Non-pharmaceutical interventions for osteoporosis, comprising high-impact resistive exercise and a diet containing vitamin D and omega-3 fatty acids;

(e) Roscosmos: A treatment for cardio-respiratory diseases with heated oxygen-helium mixtures; technologies for neurorehabilitation for stroke and Parkinson’s disease patients like the Corrigent suit, the Regent suit, Korvit (a device that supports loads used for the rehabilitation of patients) and an immersion facility (a water pool equipped with a lifting mechanism and temperature control); high-technology training machines for the testing, training and rehabilitation of people of different physical capacities; and a foot-supporting zone-stimulation device adapted for the elderly.

39. The following future applicable solutions from ISS partner agencies with the potential to contribute to leadership priority 3 were identified by each agency:

(a) CSA: The SHARE initiative for joining international research and development communities on space and aging (psychosocial, musculoskeletal, neuroscience and cardiovascular) and mitigation strategies, including measures relating to the neurocognitive state (Performance Readiness Evaluation Tool);

(b) ESA: European Life and Physical Science Research Platforms, offering a programme framework for project incubation, coordination and experimental platform opportunities;

(c) JAXA: A series of pamphlets for outreach on exercise, sleep, nutrition and other issues;

(d) NASA: Freeze-dried or pouch “super foods” (2018) and a non-invasive intracranial pressure monitor for eye diagnostics (2018);

(e) Roscosmos: The conception of physical health centres, new methods of gravitational therapy on the basis of short-radius centrifuges, and probiotics (microorganisms reviving the normal microflora of the human organism).

D. Leadership priority 4: Implementing the provisions of the International Health Regulations (2005)

40. No shared interests or potential contributions were identified with regard to leadership priority 4.

E. Leadership priority 5: Increasing access to essential, high-quality, safe, effective and affordable medical products

41. The following shared interests related to leadership priority 5 were identified:

(a) In situ diagnostics and products;

(b) Telemedicine;

(c) Longer shelf life of pharmaceuticals.

42. The following currently applicable solutions from ISS partner agencies that might contribute to leadership priority 5 were identified by each agency:

(a) CSA: The NeuroArm, a surgical robot that could operate inside a magnetic resonance imaging (MRI) machine, enabling surgical intervention on previously inoperable brain tumours;

(b) ESA: None;

(c) JAXA: Sharing of information on the devices used for stress monitoring, 24-hour electrocardiogram for biological or circadian rhythms and heart-rate variability in frequency domain, and actigraphy to monitor physical activity such as sleep quality;

(d) NASA: Long-term efficacy tests of a basic medical kit of about 80 major medicines to achieve longer stability of pharmaceuticals;

(e) Roscosmos: CARDIOSON contactless recording of physiological signals during sleep, and ECOSAN-TM, with the transmission of physiological signals to a doctor.

43. The following future applicable solutions from ISS partner agencies with the potential to contribute to leadership priority 5 were identified by each agency:

(a) CSA: Advanced Crew Medical Systems remote health monitoring; biosensor devices and textiles such as Astroskin; bioanalysis and biodiagnostics; research on biomarkers and data-mining; and a robot for paediatric surgery;

(b) ESA: None;

(c) JAXA: None;

(d) NASA: Infrared machine to measure pharmaceutical potency (2018);

(e) Roscosmos: New devices on the basis of current space prototypes for effective diagnostics of cardiovascular system dysfunctions such as three-dimensional ballisticardiography and dispersive mapping.

F. Leadership priority 6: Addressing the social, economic and environmental determinants of health

44. The following shared interests related to leadership priority 6 were identified:

(a) Environmental factors;

(b) Stress and behavioural interaction.

45. The following currently applicable solutions from ISS partner agencies that might contribute to leadership priority 6 were identified by each agency:

(a) CSA: The Extravehicular Activity Radiation Monitoring dosimeter variant measuring radiation exposure for safer diagnosis and treatment procedures (already used in cancer clinics for targeting radiation therapy);

(b) ESA: Knowledge from human physiology experiments and isolation studies and derived insights for terrestrial environments;

(c) JAXA: Information-sharing between the space agency and WHO on environmental monitoring and ecosystems, a super-sensitive high-definition television camera for Earth observation and joint research on multicultural issues;

(d) NASA: Experiences in family communication from isolated environments to relieve stress and provide a better context for health;

(e) Roscosmos: Estimation of the micro-ecological status of humans, using chromatography mass spectrometry.

46. The following future applicable solutions from ISS partner agencies with the potential to contribute to leadership priority 6 were indicated by each agency:

(a) CSA: Research on psychosocial issues associated with changes in value systems, family relations and work-life issues linked to space-related isolation;

(b) ESA: Developing countermeasures and physiological support methodologies for isolated individuals or groups;

(c) JAXA: None;

(d) NASA: Improving psychosocial health through environmental factors, including immersive virtual environments, social connections, private space and training (2020);

(e) Roscosmos: Modified methods for assessing human micro-ecological status (including express tests) and expert assessment of toxicological and microbiological contamination of the environment.

IV. Next steps and recommendations for follow-up activities

47. As an immediate next step following the Meeting, it was agreed that ISS partner agencies and WHO would review and consolidate the spreadsheet of shared interests and problems and potential space technology solutions that had been created.

48. As the next step, WHO would prioritize those shared problems and the potential space technology solutions and identify internal WHO technical staff who would be responsible for problems found to be of a high priority.

49. A two-day planning meeting was recommended on space for health, organized by WHO and the Office for Outer Space Affairs and bringing together the public health community with the space community in order to develop a plan of action for specific implementation solutions based on space technologies developed for human spaceflight-related activities, preferably to be held at WHO Headquarters in Geneva. The ISS partner agencies recommended that such a meeting should be preceded by teleconferences or videoconferences between technical experts to discuss possible implementation, to ensure that a face-to-face meeting would be as effective as possible.

50. Finally, WHO recommended that potential collaborations of space agencies and national institutes of health should be explored, similar to a possible collaboration of ISS partner agencies with WHO and the Office for Outer Space Affairs in the field of aging research.

V. Conclusions

51. The United Nations Expert Meeting on the International Space Station Benefits for Health was held with representatives of WHO and ISS partner agencies to exchange information on the health-related ISS activities of those agencies, with the goal of extending the benefits of research, technology development and testing, operational activities and medical procedures on and for ISS to support global health priorities.

52. The Meeting identified various problems that were shared among WHO and ISS, and linked the WHO leadership priorities to potentially promising solutions from space agencies in a detailed spreadsheet. The Meeting recommended follow-up activities for WHO and the Office for Outer Space Affairs to further explore the

ISS-related activities that could be applied towards concrete initiatives on an operational level among interested WHO parties, and to organize a follow-up meeting among technical experts to discuss a way forward for that collaborative activity.

53. After more than 50 years since the first human had ventured into space, a new era of international cooperation, including the ISS programme, had brought numerous scientific and technical advancements. By establishing a link between the leadership priorities of WHO and the knowledge and achievements of ISS partners on health research, technologies and procedures, the Human Space Technology Initiative further strove to harness the benefits of human space technology for all people on Earth.