United Nations A/AC.105/1050

General Assembly

Distr.: General
27 November 2013

Original: English

Committee on the Peaceful Uses of Outer Space

Report on the United Nations/China Workshop on Human Space Technology

(Beijing, 16-20 September 2013)

I. Introduction

1. The United Nations/China Workshop on Human Space Technology was held in Beijing from 16 to 20 September 2013. The Workshop was part of the Human Space Technology Initiative (HSTI), 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 Workshop was co-organized by the Office for Outer Space Affairs of the Secretariat and by the International Academy of Astronautics (IAA), and was hosted by the China Manned Space Agency (CMSA) on behalf of the Government of China.

3. The present report describes the background, objectives and programme of the Workshop, summarizes the presentations made during the technical meetings, provides a summary of the discussions at the working group meetings and documents the observations and recommendations made by participants. The report is prepared pursuant to General Assembly resolution 67/113.

A. Background and objectives

4. The establishment of the Committee on the Peaceful Uses of Outer Space and its Scientific and Technical and Legal Subcommittees corresponded with the time of the launch of Sputnik I in 1957 and the first human space flight by Yuri Gagarin in 1961. In its resolution establishing the Committee, the General Assembly requested that body to review the scope of international cooperation in the peaceful uses of outer space, to devise programmes in that field to be undertaken under United Nations auspices, to encourage continued research and the dissemination of

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information on outer space matters and to study legal problems arising from the exploration of outer space.

5. The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), which was held in Vienna in 1999, recognized that large human space exploration missions exceeded the capacity of a single country and that cooperation in that area should be privileged. The Conference therefore recommended that future space science programmes be developed through international cooperation.

6. Over the past decade, with the growth of economic and technological development, an increasing number of emerging countries have shown an interest and undertaken activities in human space exploration. China sent its first citizen into space in 2003 with its own spaceship. While the International Space Station (ISS) has been operational since 2000, the private sector has also been developing commercial systems to transfer cargo and crew to ISS and beyond.

7. In 2010, the Office for Outer Space Affairs launched HSTI within the framework of the United Nations Programme on Space Applications. HSTI is aimed at promoting international cooperation in human space flight and activities related to space exploration, creating awareness among countries of the benefits of utilizing human space technology and its applications, and building capacity in microgravity education and research.

8. The United Nations/Malaysia Expert Meeting on Human Space Technology, the first United Nations meeting of its kind, was held in Putrajaya, Malaysia, from 14 to 18 November 2011 (see A/AC.105/1017). The meeting focused on facilitating discussions on the benefits of human space technology, capacity-building and microgravity research in general and on defining activities of HSTI to meet its objectives. Cooperation with IAA was initiated in 2012 in view of the common objective of fostering global cooperation in human space flight.

9. The Workshop was an extension of the United Nations/Malaysia Expert Meeting. The objectives of the Workshop were:

(a) To exchange information on the latest developments and future plans relating to human space flight and space exploration;

(b) To create further awareness of the benefits of space technology and its applications;

(c) To promote capacity for microgravity science education and research; and

(d) To identify potential opportunities for emerging countries to participate in space exploration-related activities.

B. Attendance and financial support

10. The participants in the Workshop were selected on the basis of their academic qualifications and professional work experience in a field related to the overall theme of the Workshop, including involvement in the planning and development of national, regional or international space programmes, in microgravity science, in

capacity-building and education on space science and technology, and in human space exploration-related activities.

11. The Workshop was attended by 150 professionals from governmental institutions, universities and other academic entities, and non-governmental organizations in the following 31 countries: Algeria, Austria, Bangladesh, China, Colombia, Costa Rica, the Czech Republic, France, Georgia, Germany, Ghana, India, Ireland, Italy, Japan, Jordan, Kazakhstan, Kenya, Malaysia, Mexico, Nepal, the Netherlands, Nigeria, Pakistan, Romania, the Russian Federation, Singapore, Somalia, Thailand, the Netherlands, Turkey and the United States of America.

12. Funds allocated by the United Nations and CMSA were used to defray the cost of air travel, a daily subsistence allowance and accommodation for 25 participants. CMSA also provided funds for facilities, meals and refreshments, as well as organizing a tour of space facilities, a cultural event for all the participants and an outreach activity for the general public.

C. Programme

13. The programme of the Workshop was developed by the Office for Outer Space Affairs in cooperation with the programme committee. The programme committee comprised representatives of CMSA, IAA and the Office for Outer Space Affairs. The honorary committee and the local organizing committee also contributed to the successful organization of the Workshop.

14. The programme comprised an opening meeting, nine plenary technical meetings, five poster sessions, four working group meetings, one joint working group meeting, one wrap-up meeting, a facility tour, an outreach activity, followed by a closing meeting. The working group meetings were the principal occasions for discussion to provide observations and recommendations which were reviewed in the joint working group meeting and consolidated in the wrap-up meeting by all the participants.

15. The chairs, co-chairs and rapporteurs assigned to each plenary technical meeting and working group meeting provided their comments and notes as input for the preparation of the present report. The detailed programme, background information and full texts of the presentations made at the Workshop have been made available on the website of the Office for Outer Space Affairs (www.oosa.unvienna.org/oosa/en/SAP/hsti/index.html).

II. Summary of the Workshop programme

A. Opening meeting

16. At the opening meeting, the Deputy Chief Commander of the China Manned Space Programme, the Secretary General of IAA and the Director of the Office for Outer Space Affairs delivered welcoming remarks, in which it was pointed out that the great achievements in human space exploration in the past half century had led to technological innovation and the beginning of emerging industries. While human space exploration was embracing brighter prospects, it was also facing economic,

technological and management challenges. The only way for human space exploration to continue in the future was to strengthen international cooperation and to accomplish and exchange more revolutionary innovation in concepts, technology and applications.

17. The Director General of CMSA made a keynote speech in which he said that China was ready to contribute to the world by collaborating with other countries on constructing and utilizing its planned manned space station in the following four areas: technical cooperation on its construction; space experiments and applications; an international astronaut programme; and promotion of human space technology. In his keynote speech, the Secretary General of IAA explained the history and role of IAA over the previous 50 years and stressed that the second Heads of Space Agencies Summit, organized by IAA and taking place in Washington D.C. on 9 and 10 January 2014, would foster international collaboration on future space activities.

18. The keynote speeches were followed by a commemoration of the 10th anniversary of China's first human space-flight that was co-organized by the Office for Outer Space Affairs and CMSA, and arranged and directed by the United Nations Expert on Space Applications to celebrate the achievements of China in human space exploration. Astronauts, representatives of the co-organizers and participants delivered congratulatory remarks.

B. Technical meetings

19. The nine plenary technical meetings were divided into four themes: national, regional and international space programmes; microgravity science; capacity-building and education; and human space exploration and international cooperation. A total of 42 presentations were made by participants during the plenary technical meetings.

20. The plenary meetings started with introductions to the United Nations Programme on Space Applications, including its mandates, activities and initiatives, and to HSTI, including its objectives, its three pillars and their supporting activities.

C. Poster sessions

21. The poster sessions were organized for participants to present their work on the themes of the Workshop. The posters covered a wide range of developments in national space programmes, space education and capacity-building, and human space exploration.

22. CMSA displayed mock-ups of the Tiangong space laboratory and the new heavy-lift rockets in development, as well as posters on the history and achievements of its human space programme.

23. The Office for Outer Space Affairs displayed the hardware of a one-axis clinostat, a microgravity simulation instrument which is being distributed worldwide under the zero-gravity instrument project of HSTI.

D. Technical tour and outreach activity

24. A technical tour of the human space facilities at Beijing Space City took place on the afternoon of 18 September. Participants visited the assembly, integration and test centre for manned spacecraft, the exhibition hall of manned spacecraft and satellites, the simulators for training astronauts, the neutral buoyancy pool, the extra-vehicular activity training laboratory and the Beijing Aerospace Control Centre.

25. The International Astronauts/Cosmonauts/Taikongnauts Public Forum was held at Tsinghua University on the evening of 17 September on the theme “Mission and dream: why we go into space”, with the aim of sparking enthusiasm in young people for exploring space. Six invited astronauts, cosmonauts and taikongnauts from China, Japan, Malaysia, Romania and the United States shared their space experiences with over 500 college students and the Workshop participants.

E. Working group meetings

26. Working groups on microgravity science, capacity-building and education, and human space exploration met in parallel during the Workshop. The purpose of the working group meetings was to identify niches, capabilities and current activities in countries which could be of relevance for the themes of the working groups, to identify issues and problems in implementing specific objectives, and to discuss how to solve any issues and problems and how to foster new activities. Observations and recommendations from the working group meetings were then presented to all participants during the joint working group meeting to document a draft set of recommendations for the wrap-up meeting.

III. Summary of technical meetings

A. National, regional and international space programmes

27. The two technical meetings on this theme were designed to provide opportunities for participants to exchange information on the latest developments and future plans of national, regional and international space programmes. International cooperation was stressed as an important factor in the implementation of a national space programme. Space science and technology were frequently mentioned as the means of enhancing the socioeconomic situation in a country.

28. CMSA focused on the space station project of China, including the structure and systems of the station, technical breakthroughs, the current plan and future activities, and the vision of collaboration with other countries on utilizing the space station.

29. The representative of the European Space Agency (ESA) briefly summarized the investigations in various disciplines conducted on board ISS and presented its future programmes and mission scenarios, including user-driven exploration of low-Earth orbit infrastructure and robotic exploration of the Moon and Mars.

30. The representative of the Italian Space Agency emphasized its activities and achievements in human space technology, including its human space flights during the past decade and its achievements in building space infrastructure, such as the habitat modules of ISS, and in conducting more than 50 scientific experiments on board ISS.

31. The representative of the Japan Aerospace Exploration Agency highlighted the recent launch of its H-11 transfer vehicle (HTV)-4 cargo spaceship “Kounotori” to ISS; the planned HTV-R cargo spaceship with manned capability; and the enhanced capability for utilizing the “Kibo” experimental module of ISS for small satellite deployment.

32. The representative of the Czech Space Office presented its national space programme, including its unique simulation infrastructure called Hydronaut. The Asia-Pacific Space Cooperation Organization described the progress achieved so far in advancing space technology, and its applications for improving the socioeconomic situation of the people in the region.

33. The representative of Sergio Arboleda University in Colombia presented various space projects of several emerging countries in Latin America, as well as their space policies. The representative of the National Space Research and Development Agency of Nigeria presented a new organization, the Centre for Atmospheric Research, which was conducting various activities, including research on microgravity and human space technology. The representative of TurkSat AS described the space technology road map of Turkey, together with plans for manned space flights.

B. Microgravity science

34. The two technical meetings on this theme provided opportunities for scientists to present their activities and plans in the area of microgravity education and research using space and ground facilities. They mainly focused on microgravity life science, space medicine, materials science and fluid physics.

35. A microgravity science programme was cited as a means of capacity-building since it could involve scientists, academicians, the general public and students in exploring the frontiers of education in science and technology. The representative of the National Space Agency of Malaysia highlighted a new horizon for that country’s scientific platform, especially in its microgravity programme, such as with regard to space agriculture.

36. A representative of the Chinese Academy of Science presented the results of experiments in the material sciences, life sciences and fluid physics on board the Shenzhou spaceships and the Tiangong-1 space laboratory as well as the plan of experiments in the Tiangong-2 space laboratory and indicated that the experiment racks on board the Chinese space station were under development. A representative of the China Astronaut Research and Training Center (ACC) reported on the activities of the Chinese space medicine system, which covered space medical monitoring and support, countermeasures to the effects of weightlessness, and psychological and nutritional support.

37. Ground-based facilities such as drop towers, parabolic flights and clinostats, were considered essential for microgravity education and research. The presentation by a participant from the VU Medical Centre Amsterdam in the Netherlands on the use of a ground-based centrifugal facility that generates hypergravity explained the potential for understanding and predicting the adaptation of the human body exposed to long-term altered gravity conditions.

38. Human space flight had opened a new field of life science through the experiencing and monitoring of the effects of weightlessness. Understanding the mechanism of bone loss, or osteoporosis, induced by both microgravity and functional disuse could also make a contribution to ageing societies. The presentation by a participant from Stony Brook University in the United States explained the use of quantitative ultrasound technology to deliver image-based bone quality assessments, particularly under extreme conditions such as on space missions of long duration.

C. Capacity-building and education

39. The two technical meetings on this theme focused on the progress and challenges of capacity-building in space science and technology. Progress in raising awareness and building capacity in space science and technology and its applications had been achieved in various countries and regions. Governmental policies and decisions were highlighted as being pivotal in promoting education and research, in particular, in space science and technology.

40. In China, ACC had been conducting various popularization activities of its human space programme by providing science lectures at schools as well as publishing magazines and journals. The China Association for Science and Technology focused on inspiring children's interest and curiosity in science and technology by conducting space camps, contests and lessons.

41. The importance of governmental organizations in strengthening national awareness, developing national plans for space technology development, supporting and coordinating national space activities, and promoting international cooperation was further recognized. The representative of the Pakistan Space and Upper Atmosphere Research Commission presented its plan to raise awareness of the importance of space science education and research by constructing a drop tower facility and strengthening international cooperation. The representative of the Geo-Informatics and Space Technology Development Agency of Thailand presented its Space Krenovation Park initiative, in which an academic and industrial partnership could be strengthened to enhance research and development for space technology-based products and services.

42. Various educational strategies and their applications were also presented as an efficient means of promoting capacity in space science and technology in various countries and regions. The African Regional Centre for Space Science and Technology Education in English, in Nigeria, has been providing post-graduate courses in space science and technology. The Ghana Space Science and Technology Institute presented its public awareness programmes, which included high school outreach activities, weekly lectures to the general public and radio astronomy observations.

43. Limited government funds for space science research were identified as a challenge in advancing capacity-building in some countries. The desire was therefore expressed for collaboration on training, projects and advice and consultation on space science, as well as on space flight projects, for countries with scarce resources. In the area of space products and services, the private sector should be encouraged to engage in capacity-building projects and human space exploration-related activities.

D. Human space exploration and international cooperation

44. The three technical meetings on this theme provided opportunities for participants to exchange information on the latest developments in and future plans for human space exploration and its related activities, and to share views on how to promote international cooperation on such endeavours. Legal framework issues related to human space exploration were also presented.

45. International cooperation is essential to the success of human and robotic space exploration, in particular, in the execution of large-scale projects. The representative of the International Space Exploration Coordination Group (ISECG), in which 14 space agencies participate, published an updated version of the Global Exploration Roadmap in July 2013 summarizing the exploration policies and plans of ISECG participants, including pathways towards the human exploration of Mars. The representative of ISECG also documented the common benefits of space exploration, grouped by innovation, culture and inspiration, and new means of addressing global challenges.

46. The work of IAA had included the publication of a report in 2010 entitled "Future human space flight: the need for international cooperation." Several projects had been initiated by IAA to foster global cooperation in that arena and they would be presented at the forthcoming Head of Space Agencies Summit, scheduled to be held in January 2014. The ongoing IAA studies on the global human Mars mission framework, critical health issues for exploratory missions, and standardized career radiation dose limits for astronauts were presented as part of its intensive work.

47. The development of compatibility and standardization in human space technology was also presented as a necessary means of collaboration in every phase of human space flight, from transport and supply to joint space experiments. A representative of the China Academy of Space Technology presented its technical analysis in that respect, which had been taken into account in the design of the Chinese space station for various modes of future collaboration. A representative of the China Academy of Launch Vehicle Technology described the development of its Long March launch vehicle and its manned space mission capability.

48. As precursor missions for human space exploration, many space agencies are conducting robotic exploration missions beyond low-Earth orbit. The representative of the Japan Aerospace Exploration Agency presented its planned robotic lunar mission (Selenical and Engineering Explorer-2) to demonstrate technologies for safe and effective human exploration, as well as its robotic asteroid sample return mission (Hayabusa-2) to explore the mystery of life and the formation of the Earth.

49. With the global nature of its space exploration, Costa Rica was recognized as an excellent model of emerging countries engaging in human space exploration by conducting world-class research on a magnetoplasma propulsion system which could be used for station-keeping of ISS and future planetary missions.

IV. Summary of working group meetings

A. Working group on microgravity science

50. The discussion in the working group on microgravity science at the United Nations/Malaysia Expert Meeting on Human Space Technology in 2011 had provided the following observations. On-orbit space facilities could provide an ideal microgravity environment for research, experiments, technological development and verification for long duration space flight. Microgravity research institutions and programmes using ground-based facilities such as clinostats, drop towers and parabolic flights could significantly contribute to capacity-building in microgravity science and the facilitation of space flight experiments; and international cooperation in microgravity research was considered essential for non-space-faring countries in particular.

51. The participants in the working group on microgravity science further discussed how to advance microgravity science. The working group again recognized the importance of the use of on-orbit facilities such as ISS and the planned Chinese space station for microgravity research. In order for researchers from non-space-faring countries to participate, it was emphasized that international coordination efforts to conduct space flight research would be important, and that the space flight research should incorporate a sound ground-based programme. An international approach for in-flight artificial gravity on long-duration space flight missions, to mitigate their adverse effects on human physiology and psychology, was also discussed.

52. It was encouraging that new ground-based research facilities had been developed. The Czech Space Office had constructed the Hydronaut. ESA had developed the Large Diameter Centrifuge, which could generate up to 20 g of acceleration. The European Magnetic Field Laboratory currently operated high magnetic field facilities. Those facilities might provide opportunities for international studies.

53. However, there was still a lack of infrastructure, mentorship, funding and collaborative opportunities for microgravity research in many non-space-faring countries. There was definitely a need for more collaboration in microgravity research worldwide. There was also a clear need for a comprehensive, transparent and open database of microgravity studies in the life and physical sciences carried out in the past, in order to learn from and draw upon them for future research.

B. Working group on capacity-building and education

54. During the United Nations/Malaysia Expert Meeting on Human Space Technology, the participants in the working group on education, outreach and capacity-building had addressed the need to develop capacity through training and

education and enhanced cooperation in sharing various opportunities for using space and ground research facilities. The participants had also recognized the need for countries to develop policy, strategy and governance in that area. The desire had been expressed for wider access to space education for developing countries and for cross-border education projects aimed at allowing students in various countries to gain competence and acquire international experience.

55. The Office for Outer Space Affairs presented the status of its ongoing zero-gravity instrument project, which had been initiated in response to the recommendations of the Expert Meeting in 2011. The project had so far provided 19 clinostats to selected institutions and high schools in Asia, Africa and South America. Along with the clinostats, the *Teacher's Guide to Plant Growth Experiments in Microgravity*, developed by the Office for Outer Space Affairs with the support of the HSTI Science Advisory Group, was also available to support proposed activities in school laboratories.

56. Filling the gap in educational opportunities between rural and urban areas as well as among countries was identified as a challenge in space science and exploration. Cooperation in sharing existing educational materials such as those developed on board space laboratories, incorporating such materials in school curriculums and increasing train-the-trainers programmes were recognized as means of fostering education around the world on human space activities. Databases on human space activities, including technical, scientific and legal information, could greatly assist in building capacity in space science and exploration. Better coordination among relevant institutions within and among countries was also necessary to maximize the benefits of existing resources.

57. The United Nations-affiliated Regional Centres for Space Science and Technology Education were cited as excellent examples of providing intensive post-graduate courses for the various regions. It was observed that it was necessary to enhance educational mechanisms by offering space subjects, including human space activities, through global efforts, including those conducted by the Regional Centres as well as by various institutions around the world.

58. In parallel with institutional efforts to provide learning opportunities, the organization of seminars, workshops and training courses supported by national experts and/or by the United Nations in relevant areas was also identified as an effective way to enhance human capital. Public forums, including web-based interactive ones, attended by astronauts could also assist in increasing public and political awareness of human space exploration.

C. Working group on human space exploration

59. The working group on human space exploration met for the first time at the Workshop. The working group began its work with a presentation by the representative of ISECG of the Group's Global Exploration Roadmap and the opportunities for coordinating preparatory activities towards the human exploration of Mars.

60. All the participants in the working group were asked to provide information about activities related to human space exploration in their countries. Many of them

acknowledged that there was a lack of understanding of the importance of human space exploration in governmental, academic and educational circles. That was mainly because human space exploration activities were still very limited and opportunities for non-space-faring countries to participate had been scarce.

61. All the participants, however, recognized the importance of human space exploration as a common goal for humanity as well as for the benefit of society. International cooperation in human space technology could enhance scientific and technological development by using existing skills and developing new ones.

62. Some of the critical technical aspects of human space exploration were recognized to be environmental control, life support and human health care. A representative of Beihang University in China introduced its research programme, called “Lunar PALACE”, in which closed-cycle agriculture systems for habitats on the Moon and Mars could be used to generate food and oxygen and recycle waste in a closed looped environment without contaminating the outside environment.

63. The working group also discussed how to bring non-space-faring and emerging countries onto the international stage of human space exploration. One way was to initiate various research activities in space life science, physics and even advanced space technology, as demonstrated in Costa Rica.

V. Observations and recommendations

64. The last day of the Workshop was devoted to finalizing the observations and recommendations of the participants. The findings of each working group were first presented by the Chair for the participants to share in the joint working group meeting. After that, in the wrap-up meeting, a draft of the consolidated recommendations was presented for the participants to review.

65. The Workshop acknowledged that human space exploration could be regarded as a common goal of humanity and that all countries, particularly emerging countries, should be encouraged to become involved in understanding and defining the common goals and benefits of human space exploration.

66. A lack of awareness of the importance and benefits of human space exploration was found to exist, as well as a lack of capacity for conducting related activities. Education and outreach activities on this theme were cited as being very important for gaining support for worldwide involvement in human space exploration.

67. It was also emphasized that synergies exist between human space exploration technologies, developed for habitation in outer space and on other planets, and the United Nations Millennium Development Goals, and that they should be used in applications on Earth to benefit the world.

68. A proposal was made to foster the involvement of emerging countries in the preparation of human space exploration, such as by demonstrating on space stations and at ground-based research facilities enabling technologies such as those identified in the IAA Cosmic Studies.

69. It was noted that international forums for coordination existed at the political level, such as the International Space Exploration Forum, and at the space agency

level, such as ISECG. By extending those forums to non-participating countries, space agencies and appropriate groups would promote worldwide involvement in human space exploration activities.

70. Various ground-based microgravity simulation instruments were used extensively in the biological sciences. A better understanding of the physical principles and operational parameters involved might lead to a more standardized use of those instruments, in order to improve their application. Space flight research should incorporate a sound ground-based programme, including mathematical modelling.

71. Long-duration flights on human-tended space stations or interplanetary missions could have adverse effects on human physiology and psychology. The application of artificial gravity might mitigate such effects. Broad international collaboration to that end would be essential.

72. The Alpha Magnetic Spectrometer currently attached to the International Space Station is recognized as an example of true international cooperation in manned space flight and technology and provides a blueprint for building future international scientific collaboration for planned space flight research.

73. While several databases exist, there is a clear need for a comprehensive, transparent and open database of microgravity studies undertaken in the life and physical sciences in the past in order to learn from and draw upon them for future research.

74. Based on those observations, the following recommendations were formulated.

75. HSTI should play a role in informing Member States about the latest developments in human space exploration and in facilitating coordination among Member States to pursue common goals in a long-term perspective, identify opportunities for international cooperation and put forward proposals.

76. HSTI should promote education and outreach activities by providing educational materials as well as expert and astronaut forums to assist professionals and to inspire students, academia and the general public about human space exploration.

77. Governments, institutions, industry and individuals are encouraged to participate in the global human space exploration endeavour. That would inspire young people by exposing them to new discoveries in science and technology and would enhance international cooperation in the pursuit of common goals of humanity.

78. Governments and institutions are encouraged to create databases which include scientific, technical and legal information to promote the dissemination and exchange of information on human space exploration and its related activities.

79. Governments and institutions are encouraged to establish educational mechanisms, develop appropriate curriculums and provide training for teachers in order to promote education in space science and technology.

VI. Conclusions

80. The United Nations/China Workshop on Human Space Technology was organized as an extension of the 2011 United Nations/Malaysia Expert Meeting on Human Space Technology, with the aim of enabling participants to exchange information and views on human space exploration, and human space technology and its applications, and to put forward constructive and innovative proposals on promoting international cooperation in microgravity science, capacity-building and education, and human space exploration.

81. Experts from 22 countries participated in the Expert Meeting held in Malaysia in 2011; experts from 31 countries participated in the Workshop. A total of 38 countries participated in the activities conducted under HSTI. This proves that human space exploration and its related activities have become truly global undertakings.

82. Recognizing that human space exploration can be regarded as a common goal of humanity that can unite the world, HSTI is striving to bring the benefits of human space activities to all and to bring countries together for that endeavour and thus create new opportunities for international cooperation.