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Committee on the Peaceful Uses of Outer Space

Report on the United Nations/International Astronautical Federation Workshop on Expanding the User Community of Space Technology Applications in Developing Countries

(Melbourne, Australia, 24-27 September 1998)

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I. Introduction

A. Background and objectives

1. The General Assembly, in its resolution 37/90 of 10 December 1982, decided that, in accordance with the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space,[1] the United Nations Programme on Space Applications should assist the developing countries in establishing an autonomous technological base for the development and use of space technology by promoting the growth of indigenous capabilities. The Committee on the Peaceful Uses of Outer Space at its fortieth session, held in June 1997, endorsed the programme of workshops, training courses and seminars proposed for 1998 by the Expert on Space Applications.[2] Subsequently, the General Assembly, in resolution 52/56 of 10 December 1997, endorsed the United Nations Programme on Space Applications for 1998.

2. The present report contains a summary of the presentations and discussions of the United Nations/ International Astronautical Federation Workshop on Expanding the User Community of Space Technology Applications in Developing Countries. The Workshop was organized as part of the 1998 activities of the Office for Outer Space Affairs of the Secretariat under the United Nations Programme on Space Applications. It was the eighth workshop in this series, and was held in Melbourne, Australia, in conjunction with the forty-ninth Congress of the International Astronautical Federation (IAF). The Workshop was locally supported by the Cooperative Research Centre for Satellite Systems.

3. Presentations at the seven previous United Nations/IAF workshops held from 1991 to 1997 in Austria, Canada, China, Israel, Italy, Norway and the United States of America have demonstrated the utility of space technology applications for accelerating the social development and economic growth, as well as protecting the environment, of developing countries. Well-known examples are meteorological satellite applications, satellite telecommunications, Earth observation applications and the use of navigation, positioning and localization systems. However, despite the broad range of potential applications, many of them are still restricted to a relatively small and specialized user community. Especially in developing countries, potential users and decision makers are sometimes simply unaware of the full capabilities and benefits of space technology applications.

4. The Workshop focused on how space technology applications can serve a larger and more varied user community. It also aimed at: assisting developing countries in establishing and strengthening national capabilities in space technologies and applications; providing them with an insight into the benefits of establishing cost-effective industrial and institutional enterprises in selected fields of space science and technology; exploring the possibility of increased scientific and technical cooperation between developed and developing countries, as well as among the developing countries themselves; and considering possibile cooperative ventures involving space industry and developing countries. Those aims were accomplished by identifying existing obstacles, by suggesting possible solutions and by presenting new, innovative applications of space technology. The Workshop was also intended to provide participants with a forum for interaction with representatives of the space industry, thereby helping the participants to gain a greater understanding of the needs and requirements that should be met if ventures were to be successful. The observations of participants and the conclusions reached by the Workshop will also provide inputs and ideas to the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), which will be held at Vienna from 19 to 30 July 1999.

5. The present report, covering the background and the objectives of the Workshop, as well as the presentations and discussions, the observations made and the conclusions reached by the participants, has been prepared for consideration by the Committee on the Peaceful Uses of Outer Space at its forty-second session and by its Scientific and Technical Subcommittee at its thirty-sixth session. The participants will report to the appropriate authorities in their own countries. The proceedings of the Workshop, including a detailed address list of all participants, will be made available through the Office in due time.

B. Programme of the Workshop

6. During the course of the Workshop, successful examples of the use of space technology applications were presented. The programme of the Workshop was developed to demonstrate how developing countries could benefit from the use of space technology for economic and social development and how the user community, and therefore also the community of benefactors, could be expanded. The Workshop was structured around six sessions, in which 28

invited papers were presented. There was a vigorous exchange of information, comments, questions, recommendations and suggestions. In addition, a number of brief presentations by participants from developing countries provided an insight into the status of space technology applications in their respective countries. Afternoon sessions concluded with panel discussions, followed by an open exchange of views.

7. National and transnational space projects and programmes were discussed, and possibilities were suggested for increased scientific and technical cooperation between developed and developing countries, as well as among the developing countries themselves.

C. Participants

8. The United Nations, on behalf of the co-sponsors, invited developing countries to nominate candidates for participation in the Workshop. Selected participants were required to have university degrees in remote sensing, communications, engineering, physics, biological or medical sciences or other fields related to the themes of the Workshop. In addition, participants were selected on the basis of their working experience in programmes, projects or enterprises in which space technology is or could be used. The participation of specialists at a decision-making level from both national and international entities was specifically encouraged.

9. Funds allocated by the Government of Australia, the United Nations, the Centre national d'études spatiales (CNES) (French National Centre for Space Studies) and IAF for the organization of the Workshop were used to cover international air travel and per diem expenses of more than 30 participants from developing countries. Co-sponsors also covered the cost of registration fees for participants from developing countries to participate in the forty-ninth IAF Congress, which was opened immediately following the United Nations/IAF Workshop, enabling them to engage in discussions with their colleagues in one of the more important international space events.

10. The Workshop was attended by more than 100 participants, including funded participants from Argentina, Azerbaijan, Bangladesh, Brazil, Cambodia, China, India, Indonesia, Iran (Islamic Republic of), Kenya, the Lao People's Democratic Republic, Malaysia, Mongolia, Morocco, Nigeria, Pakistan, Philippines, Republic of Korea, Sri Lanka, Sudan, Tunisia, Uzbekistan, Zambia and Zimbabwe.

11. Invited presentations were delivered by representatives of the Office for Outer Space Affairs, the Arthur C. Clarke Institute of Modern Technologies (Sri Lanka), the Bangladesh Space Research and Remote Sensing Organization, the Brazilian Space Agency, the Chinese Academy of Space Technology, the Centre Royal de Télédétection Spatiale of Morocco (Royal Centre for Remote Sensing), the European Space Agency, the Indian Space Research Organization, the International Space University, the National Aeronautics and Space Administration of the United States, the National Space Development Agency of Japan, the National Aerospace Laboratory of the Netherlands, the Pakistan Space and Upper Atmosphere Research Commission and the University of New South Wales (Australia).

12. Presentations were also delivered by representatives from private industry, including the following: Alcatel (France), AUSSPACE (Australia), BRAZSAT (Brazil), Iridium (United States), Northrop Grumman Corporation (United States), Geomatic Technologies/SpaceImaging (Australia/United States), SPACEHAB (United States), Surrey Satellite Technology Ltd. (United Kingdom of Great Britain and Northern Ireland), Telstra (Australia), The Aerospace Corporation (United States), and WorldSpace India (India).

II. Observations and conclusions

13. Some of the organizers of the United Nations/IAF Workshop series who had participated since the first one noted the increase of awareness of developing countries of, and their involvement in, space activities. While the presentations given by participants from emerging space-user countries and developing countries in general gave an impressive picture of the space activities in those countries, they still faced certain hurdles in implementing such activities on a continuous basis because of a number of problems. These included the issues of education and training of people and the optimal utilization of experts, the need for regional and global cooperation and the importance of convincing policy and decision makers.

14. Participants from developing countries often counted on the United Nations to implement and spearhead programmes. However, the United Nations had limited resources and the Office was limited in the activities it

should pursue in following the directives provided by the Committee. It was therefore up to Workshop participants and experts in developing countries in general to approach the policy and decision makers in their countries and to persuade them to take a more active role within the Committee. UNISPACE III would be an ideal forum for presenting the needs of emerging spacefaring States and developing countries and charting the way forward for regional and global cooperation in the near future. Awareness-raising should start at a national level and should not depend on external initiatives.

15. The need for regional space agencies to make possible the regional sharing of solutions was stressed by several participants. Especially in the field of small satellite projects, for example, the development of a constellation of remote sensing satellites to provide disaster warning and management services should be promoted rather than developing independent costly systems in each country. Several organizations and committees already existed to coordinate activities in remote sensing and space applications, and developing countries should use the occasion of UNISPACE III to establish links with such entities and to voice their opinions. Participants were called upon to approach their national delegations to UNISPACE III so that proper contact could be established with policy and decision makers in their countries who would in turn make and support proposals to the United Nations.

16. It was furthermore stressed that a national commitment and a long-term plan were necessary for continued development of space activities and use of space applications. Space policies should be formed in harmony with other existing national policies, striving for balance with the commercial sector in order to be successful. Existing programmes and frameworks for international cooperation must be utilized and promoted. Regional organizations should be established to promote space applications through international cooperation. The education of the young generation of future space managers and professionals was a precondition for the continuity and successful development of space activities in emerging spacefaring States and developing countries.

17. With respect to microgravity research programmes, it was recommended that future Workshops and conferences organized by the United Nations should continue to inform emerging spacefaring States and developing countries about opportunities to participate in such projects.

III. Presentations and discussions

18. The Director of the Office for Outer Space Affairs welcomed the participants to the eighth United Nations/IAF Workshop. In his opening statement he referred to the growing economic importance of space technology applications in the world and to the large gap that still existed in this field between developed countries and the developing countries. The main objective of the Workshop series was to identify the obstacles that prevented developing countries from obtaining benefits from those technologies. Solutions should be developed to address and to surmount obstacles by means of increased national commitment and by strengthening international cooperation. In that context, the participants were also briefed about the latest developments with regard to UNISPACE III. The international space community saw UNISPACE III as a major potential milestone towards preparing and coordinating space activities in the early twenty-first century.

19. The Executive Director of the Cooperative Research Centre for Satellite Systems, in his welcoming presentation, reviewed the status and role of space technology applications in the world. In the past, space technology had been developed and used by the wealthy, industrialized countries, in many cases driven by military objectives. The cost of space technology, the strong political differences and the lack of technology prevented smaller, less wealthy countries from benefiting from space technology. However, that situation had changed in recent years with political aspects becoming less important and with the growing commercial importance of space applications. He predicted the gradual expansion of the space-technology user community based upon the availability of more affordable, more accurate, more diverse and accessible solutions. All countries—developed and developing—could now greatly benefit from using space technology applications, expanding the user community of space technology applications.

20. In his keynote address, the chairman of the Indian Space Research Organization (ISRO) discussed the benefits of space technology to society. Today, the global space industry had become one of the largest industries in the world, with an annual revenue of about $80 billion and more than 800,000 people employed worldwide. While in developed countries space benefits had been touching almost all social segments, industries and academic institutions, developing countries were still facing constraints in terms of resources, policies and awareness at different levels, which had to be removed through appropriate adjustments in

policies, human resources development, institutional frameworks and international support, coupled with balanced commercial mechanisms. There were tremendous opportunities for expanding space applications. Nearly two thirds of the total global population of 6 billion people lived in developing countries. Those 4 billion people possessed less than 3 per cent of all telephones and 10 per cent of all television sets in use today. There was a growing demand for mobile communications in developing countries, demonstrated by the fact that the percentage of subscribers to mobile services was often comparable to the numbers in developed countries. Other applications included the use of geographic information systems (GIS) and remote sensing data for agricultural applications. The growing population demanded that agricultural productivity would have to be raised from the current level of 1 to 2 tons per hectare to 4 to 5 tons per hectare. Remote sensing data could also help in securing access to safe drinking water and play an important role in disaster management applications. With a literacy rate of greater than 98 per cent and a per capita annual income of greater than $8,000 in developed countries, compared to a 50 to70 per cent literacy rate and an annual per capita income of about $600 in developing countries, space communications was also of growing importance for spreading education rapidly to illiterate populations in rural areas.

A. Establishing and enhancing the use of space applications in developing countries

21. The recommendations and achieved objectives of previous United Nations/IAF workshops in the series were reviewed and a brief overview of current activities of some participants in the series was presented. It was reiterated that the purpose of the workshops was to provide developing countries with a forum to discuss concepts for the development and use of space science and technology tailored to their needs. While some of the recommendations of earlier workshops had already been addressed and partially resolved, others had continued to require attention, including the need to convince government officials and decision makers about the benefits of space technology applications. It was pointed out that other recurring concerns regarding funding, data, equipment and software acquisition, education and training, as well as end-user and private sector investment, had been and would continue to be addressed in future workshops. Such concerns would surface frequently in future discussions, since a growing number of developing countries were starting to implement space technology applications and facing similar problems in the initial implementation phases.

22. Experience had taught that the successful introduction of space technology applications in developing countries required the support of policy and decision makers. It was therefore necessary to raise and increase the awareness of policy and decision makers with respect to the benefits of space technology applications. The Director- General of the Brazilian Space Agency underscored the benefits that could be gained from space technology applications, particularly through improving the daily lives of people. The presentation covered the experience and current activities of Brazil in space technology and highlighted the multidisciplinary requirements of and the multitechnology approach to space activities. Cost-sharing of some space activities between Government and industry were also discussed. The importance of fiscal incentives and funding support for education and training as well as research and development was stressed. Brazil was currently investing in a programme that would result in giving the country an independent capability for space access. It included the development of a launch vehicle, the construction of a launch site and the design and construction of satellites and payloads for a broad range of applications. International cooperation with partner institutions in Argentina, China, France and the United States had been a good strategy for Brazil to reduce the cost and risk of its programmes. The Brazilian Space Agency was continuing to identify potential partners and countries with a view to finding and developing common solutions.

23. Once the political support was ensured, countries should engage in drafting space policy plans to effectively coordinate and enhance the use of space technology applications. The director of the Arthur C. Clarke Institute of Modern Technologies stated that a national space policy was a prerequisite for coordinated use of space applications in the development of a country. The space policy of a country depended on its technological and financial capabilities as well as its maturity in mastering space technology applications. The presentation emphasized the need for considering the ramifications of various space technology applications as well as the essential elements that should be embodied in the space science and technology policy of a developing country such as Sri Lanka. That included accepting space science and technology as an integral part of the broad area of science and technology, which had the following aims: to achieve economic development and human well-being; to give priority to areas

of space applications in which direct results could be achieved and benefits accrued to the common people; to utilize the knowledge and technology gained by other advanced countries rather than trying to reinvent the wheel; to provide education and training in space science and technology to develop some self-reliance in the field, and to ensure that space policy would not be easily thrown off course from political expediency by changing Governments.

B. Training users of space applications

24. One precondition for the effective implementation of space policy plans was the availability of experienced and trained staff. Training opportunities for space experts as well as the education of users of space technology applications had been a major concern raised during previous United Nations/IAF workshops.

25. The inauguration of the regional Centre for Space Science and Technology Education in Asia and the Pacific in 1995, the first of several such centres planned to be established under the United Nations Programme on Space Applications, was an important milestone in addressing the training and education needs of that region. The Scientific Secretary of ISRO introduced the work of the Centre, established in India with the goal of increasing knowledge and understanding in space science and technology among participants in its education programmes, thereby contributing to the enhancement of national and regional capabilities. In the future, the Centre should become a centre of excellence by expanding its outreach and offering activities other than education, such as research and consulting services.

26. The International Space University (ISU) was offering programmes in interdisciplinary space education. An ISU representative described the changes in the global political environment and the resulting changes in the space sector. Space education must strive to meet the new needs and challenges of a changing world. The international character of space activities created the necessity for multidisciplinary professionals with a multinational outlook to bridge the gaps between the different groups involved in space programmes.

27. Education had become a necessity for a better future of humankind. Developing countries faced the problem of providing education to a growing population in rural areas. Distance education using satellite technology offered the possibility of high-quality education to anyone on the globe. The General Manager of WorldSpace, India, described the WorldSpace digital sound broadcasting system, consisting of three geostationary satellites, for distance education and applications to address current needs for distance education in rural areas. Although receiver terminals were still relatively costly, it was expected that prices would eventually come down. The system had been fully designed with the conditions in developing countries in mind, for example, by equipping receivers with solar-powered batteries. The WorldSpace system will mainly provide educational programming targeted towards adult education. It would also be used for providing supporting teaching material to teaching personnel.

28. The marketing and business development manager of Northrop Grumman Corporation provided an overview of the major activities of the company in space technology applications that could be of interest to developing countries, focusing on a future synthetic aperture radar (SAR) system with 5-metre resolution developed for small satellite platforms. A radar system could provide all-weather data of special interest to equatorial regions that were frequently hidden under cloud cover. The company was also providing training in image processing at its Spectral Imagery Training Center on a commercial basis. It was promoting real-time GIS that would allow the linking of real- and near-real-time data sources directly into GIS to enable better decision-making for environmental and agricultural applications, for the sustainable use of natural resources, and for transportation, hydrology, tracking and tagging and defence matters. In the future, the aim was to combine such GIS with real-time or near-real-time data acquired from Earth Observation satellites. Such an application would be an important step towards the operational use of high-resolution remote sensing data beyond what was already currently possible with data acquired from meteorological satellites or advanced very high-resolution radiometer data at low resolution (in the 1-kilometre range), and would allow the use of such data in new application fields, contributing to expanding the user community for space technology applications. However, because of technological constraints in the space and ground segment and in computing power, it would still take some time until such real-time GIS using remote sensing data acquired by satellites would be commercially available.

29. The Earth Science programme of NASA included many activities of relevance to the region of Asia and the Pacific and offered several opportunities for international participation. One such opportunity consisted in the recent and planned airborne SAR deployments carried out in parallel to flown and future C-band spaceborne imaging

radar (SIR-C) and X-SAR mapping campaigns conducted from the Space Shuttle. Data were collected for agencies and universities in Australia, Brunei Darussalam, Cambodia, Malaysia, New Zealand, Papua New Guinea, the Philippines and Thailand. Applications included the study of cultural resources, land-use studies, natural hazards, geology and mining and urban studies. Earth imaging radar materials could be obtained from the World Wide Web at http://southport.jpl.nasa.gov/.

30. Global Learning and Observations to Benefit the Environment (GLOBE) was an international science and education programme bringing together students, teachers and scientists to enhance the environmental awareness of people throughout the world, to contribute to the scientific understanding of Earth and to support improved student achievement in science and mathematics. The initiative was launched on 22 April 1995, on the occasion of Earth Day. Internationally, GLOBE was being implemented through bilateral agreements between the Government of the United States and Governments of partner States. More than 120 States had expressed interest in GLOBE, and over 70 had signed GLOBE agreements. GLOBE measurements had been selected by the international science community and were used in ongoing research. The measurements included data for atmospheric and climate studies, hydrology studies, soils studies, land cover and biology studies. Further information could be obtained from GLOBE at http://www.globe.gov/.

31. During the first panel discussion on the theme “Expanding the user community of space technology applications: opportunities and constraints”, panelists noted the changing geopolitical situation in the world and its impact on the development of space technology. The changing economic and political environment, bringing with it the growth of commercial space activities, the deregulation of the telecommunications and trade sectors, the integration of the global market and the information society, had led to an increasing demand for space technology applications. However, in some countries, those changes had not brought about the expected easier access to space benefits. They had rather resulted in constraints that prevented potential users from benefiting from those opportunities. One reason was that national policies sometimes did not keep pace with the swift technology changes and required updating. Participants concluded that Governments should provide incentives and encourage competition in the private sector, but should still continue with funding and carrying out space-related activities needed for the well-being of society (for example, in the fields of education and the environment), but which could not yet be conducted on a commercial basis.

32. Participants suggested that the Office for Outer Space Affairs should establish a programme specifically designed for educating policy makers and legislators on space applications and their derived benefits. The language barrier between decision makers or potential users and space experts, for example, through the overuse of technical or legal terms, was identified as a major hurdle. The hope was expressed that a programme taking that issue into account would help to accelerate the formulation of space policy plans and increase the commitment of a country to the implementation and operational use of space technology applications. It was noted that the Office had already been charged with organizing UNISPACE III, which would be held at the ministerial level. In preparation for the Conference, a package of 12 background papers had been prepared, each containing a summary of the state of and the benefits from space technology applications in a non-technical language. Participants agreed that awareness-raising should start at the national level.

33. A major issue for developing countries was the operationalizing of remote sensing applications. A comparison was made between the remote sensing field and satellite communications. The remote sensing market had not been growing as quickly as the satellite communications market. Remote sensing projects had mostly been limited to pre-operational applications. The problem was that remote sensing applications must sell information, not data, as was the case with telecommunications. However, it had proven to be difficult to extract the kind of information that was relevant and useful to the decision makers using that information. In other cases, the information was extracted, but it is was difficult to convince decision makers of its actual use.

C. Small satellite and microsatellite systems for promoting space capabilities and applications

34. The Secretary-General of the Chinese Academy of Space Technologies presented the development history of the Chinese small satellite programme. China was following the worldwide trend of developing small satellites that had shorter project times from conceptualization to operation and lower costs of development as well as launching. Several projects were in the engineering development stage or in the conceptual study phase. The Practice-5 (SJ-5) satellite would conduct scientific and technical experiments and demonstrate the platform technology. The first application satellite using the small satellite platform operationally would be Oceansat-1 (HY-1). It would be used mainly for the observation of sea fish distribution, marine-life breeding resources and the distribution of mud and sand in river mouths and ports. A project in the conceptual study phase was the Asia-Pacific Small Multi-Mission Satellite (SMMS), developed in cooperation with other Asian countries. SMMS would be based on the SJ-5 satellite bus platform and mainly carry remote sensing instruments. Ka-band communication and space environment experiments, as well as a constellation of satellites for environment and disaster monitoring, were also under study. The latter would be based on a constellation of six low-Earth-orbit satellites, four operating in the optical regime and two SAR satellites providing an all-weather capability. China had realized the need for radar-based observation systems because of the flood disasters experienced by the country in 1998. Such a small satellite constellation would achieve short-time resolution and reasonable spatial resolution while keeping an acceptable cost limit.

35. The Deputy Director-General of the Department of Foreign Affairs of the China National Space Administration highlighted the role of space technology in planning, monitoring and managing resources. He gave a detailed description of the operation and objectives of the SMMS project, which was initiated during the Asia-Pacific Multilateral Cooperation in Space Technology and Applications Conference series. In that connection, a memorandum of understanding on cooperation in the SMMS project was signed on 22 April 1998 in Bangkok by China, Iran (Islamic Republic of), Mongolia, Pakistan, the Republic of Korea and Thailand. The Government of China was also welcoming further bilateral and multilateral cooperation with other States, with special emphasis on small satellite development, to share the benefits of such technology for sustainable development.

36. The Chief Executive Officer of Surrey Satellite Technology Ltd. (SSTL) described the small satellite projects developed by SSTL and the Surrey Space Centre in cooperation with other countries and the technology transfer achieved through them. SSTL was well known for its small satellite programmes, which offered developing countries the opportunity to build up a domestic capability for developing national satellite programmes within a relative short period of time and within a realistic cost range. He also discussed future programmes, including the development of a constellation of small satellites for disaster warning, monitoring and mitigation applications, as well as the possibility of lunar and interplanetary missions. The Surrey Space Club, a forum of emerging spacefaring States with experience in small satellite projects, was established with the aim of increasing international cooperation and eventually embarking on international joint small satellite projects.

37. A representative of Alcatel Space, described the light-weight Proteus satellite bus and its technical details. The bus could be adapted to a wide range of space missions. Fields of application included telecommunications, navigation, Earth Observation and science. With a payload capacity of 300 kilograms and a power capacity of 300 watts, the Proteus platform was designed to meet the requirements of space missions too large for small satellites (in the 100-kilogram range) and too small for large, full-scale satellites (in the above-1,000-kilogram range). Possibilities for cooperation and participation ranged from delivery of the standard service module to delivery of a complete satellite and in-flight reception of the complete system. The Proteus platform could also be used as a generic base for the development of dedicated satellite buses in the 300- to 1,000-kilogram range. The platform would be used for the JASON-1 satellite, an oceanography mission involving the cooperation of Alcatel, CNES and the NASA Jet Propulsion Laboratory, replacing the Topex-Poseidon satellite, and in the scientific COROT satellite, a mission for studying the inner structure of stars and for the detection of planets beyond the solar system.

D. Space technology for disaster management

38. Natural and human-made disasters created many problems in developing countries, which often lacked the infrastructure to react efficiently to such disasters. Each year, the result was an unacceptably high economic and human loss. Space technology, in the form of Earth Observation or telecommunication satellites, could alleviate many of those problems and help stabilize the situation in the aftermath of disasters more quickly. Certain space applications could also be used to introduce effective preventive measures and to implement a disaster early-warning capability to reduce the expected economic and human loss when disasters struck. The importance of addressing that topic became even more evident to the Workshop participants when it was announced that a space expert from Bangladesh, who was to give an invited presentation on space-assisted disaster management, was unable to attend the Workshop because of catastrophic floods then taking place in his country.

39. The application of telecommunications systems for disaster management was illustrated by a representative of Telstra, an Australian provider that had recently introduced a new telecommunications service. The new service was based on the International Mobile Satellite Organization (Inmarsat) mini-M system using a laptop mobile terminal. The system compared favourably with other global mobile personal communication systems in terms of its data rate and operational costs, and would be especially useful in situations where the terrestrial telecommunications infrastructure was unavailable or inoperative. Terminals based on earlier versions of that system had been successfully used in crisis situations all over the world.

40. In the second panel discussion on the theme "International and regional cooperation: small satellites and disaster warning projects", panelists stressed that critical factors for disaster monitoring and mitigation applications were not only spatial and spectral resolution, but also temporal resolution. For some types of disasters, for instance, floods, SAR systems had advantages over optical systems, such as all-weather imaging. However, SAR systems were still costly in terms of both acquiring and processing the image data when compared with optical systems. It was suggested that a gradual development from the use of optical data to data obtained by near-infrared sensors, and then to SAR data, might be a viable approach for emergency response offices with little or no remote sensing experience.

41. Disaster monitoring applications were a good means of convincing Governments of the benefits of space technology. For example, the Government of Indonesia had increased its support for remote sensing applications after the huge damages and economic losses caused by forest fires in 1997. A major effort was required to slowly acquaint the management responsible for mitigation actions with the new technology. The implementation of space technology in disaster management applications was often met with resistance, since management was not always ready to accept the new technology. Well-structured education and training programmes were therefore a precondition for introducing space technology.

42. For the development of a national satellite programme, an inventory of national technology and manpower resources should first be taken and long-term plans be made before starting such an activity. A long-term commitment was necessary for a national satellite technology programme to maintain momentum. Participants also discussed the idea of sharing the development, cost and benefits of a constellation of small satellites. A cost- benefit analysis would help to establish the cost of such a project and to better inform decision makers. Participants concluded that regional multilateral or bilateral cooperation in small satellite projects should be promoted and would provide a synergy resulting in greater benefits than the independent pursuit of development programmes in each country.

E. Satellite communications and applications: mobile systems and Very Small Aperture Terminals

43. In late 1998, the first operational telecommunication satellite constellations had been fully deployed. The IRIDIUM and Orbcomm satellite systems had entered into service. Several other projects were in the design or testing stage. The advantage of satellite constellations was their worldwide or near worldwide coverage regardless of the nature of the local telecommunications infrastructure. The IRIDIUM system could provide voice communication between any two points on the planet. Regulatory aspects were still the biggest hurdles for providing services in all countries.

44. While the current personal mobile satellite communication systems were designed to provide data rates sufficient for messaging services and voice data, future systems were designed to support broadband applications.

The Skybridge system was a proposed constellation of approximately 80 satellites and would provide global access to interactive, multimedia communications starting in late 2001 to address the growing demand for high-speed data communications and broadband applications. The system would be integrated with existing terrestrial broadband networks and use satellite links only when they were essential to bring down the overall cost.

45. Very Small Aperture Terminal (VSAT) networks were providing a variety of services suitable for business communications in India. VSAT technology was an ideal solution to provide telecommunication services to users in developing countries, especially in rural areas with insufficiently developed telecommunications infrastructures or at remote sites of geographically dispersed organizations. In the later case, a central, larger hub station connected via the space segment to the various remote sites, which were equipped with small, simple and relatively cheap satellite antennas. Applications ranged from stock market and news broadcasting, distance education and training, pricing databases, audio broadcasting and relay advertising in one-way VSAT networks to interactive computer transactions, database enquiries, videoconferencing, bank and automated-teller-machine transactions, reservation systems, voice communications and e-mail in two-way VSAT networks. The Indian VSAT networks were based on the domestic Indian National Satellite series of satellites. Currently, there were four operational satellites providing telecommunications, broadcasting and meteorological services. In the not-too-distant future, Ka-band satellites would be able to provide connectivity with a data rate of up to 2 megabytes per second between ground stations equipped with antennae dishes having a diameter as small as 75 centimetres. VSATs had a major role to play in the concept of a global village.

F. Earth Observation applications

46. Remote sensing from space could provide essential information for policy-making, land use and land cover, environmental and agricultural applications and planning of resource utilization. When combined in GIS with data from other sources, for example, with socio-economic and population data, it could become an essential tool for the implementation of national and local development strategies. For such a system to be successfully applied in implementing programmes of major importance for the country, the following was necessary: to have the support of high-level policy and decision makers; to train a critical number of well-qualified specialists to supervise the system; to establish effective mechanisms to transfer the information extracted from the data to the application specialists and to train the latter in using the data to assist in practical decision-making; and finally, to ensure access to the information by the user community on a regular and timely basis.

47. The Royal Centre for Remote Sensing of Morocco was using GIS for the location and sustainable exploitation of resources. The use of GIS was dictated by the increasing constraints on the exploitation of resources and by the complexity of natural phenomena. The need for the identification of long-term trends in the evolution of natural resources and phenomena could best be tagged by GIS combining data from different sources that could capture interaction on different scales (global, regional and local). GIS for sustainable development made possible the integration of all components involved in resources management by using a systems approach aimed at the optimal use of resources. The availability and continuity of data, problems in data exchange standards, copyright issues and the lack of expertise were among the hurdles in implementing such GIS. They had to be overcome by improving education, training, technology transfer and access to data. Several professional organizations were promoting the use of GIS and working towards solving the known problems. However, users in developing countries were sometimes unaware of those organizations, or in many cases could not afford to subscribe to the relevant publications.

48. The National Space Development Agency of Japan (NASDA) was conducting a number of activities in the region of Asia and the Pacific. The activities consisted in education and training programmes, pilot projects, satellite data reception agreements, data utilization agreements, cooperative experiments and data network programmes. Within the Asia-Pacific Pilot Project, NASDA had been working with Indonesia and Thailand in the operational use of satellite data for rice field classification and acreage assessment and for pest disease detection and identification. For that purpose, ground receiving stations and processing facilities for the JERS-1 satellite and the Advanced Earth Observation Satellite had been established in those countries. In addition, the Global Research Network System (GRNS) was designed to establish a human network and to develop standardized data sets for desertification, forest cover, hydrological management and the coastal

environment. Participants in GRNS were Australia, China, Indonesia and Thailand.

49. Spatial information technologies of remote sensing, the Global Positioning System and GIS would facilitate the manipulation of environmental data to provide better or more appropriate information for decision-making and resource management than had previously been available. Experience showed that the success of any technology transfer programme depended on the provision of trained personnel. To sustain remote sensing applications, two forms of assistance were necessary, namely, financial and technical assistance. The financial commitment to the successful implementation of remote sensing had been limited in the past, lacking an overall strategy at the Government, industry or institution level. Few Governments had committed sufficient funds to allow remote sensing and GIS technologies to become fully operational, let alone sufficient money for the necessary training and personnel. It was therefore necessary that the developers of remote sensing technology and agencies committed to technology transfer should support and fund the establishment and maintenance of training programmes in remote sensing, until a sufficient number of potential users had adopted the technology and thereby created a demand for trained and capable personnel.

50. Local decision makers often chose not to use Earth Observation data because of the perceived high cost and the fact that in many cases information was not available in the local context. To find a solution to such problems, the National Aerospace Laboratory of the Netherlands had developed RAPIDS, a personal-computer-based local ground station for the reception of optical and radar data. Through the ground station, satellite data could be received directly and locally by the user organization in a relatively cheap and straightforward manner. It had been developed to operate automatically and to be managed without excessive technical support and with the ability to collect data for the principal area around the user (plus or minus 45 degrees elevation). The ground station was flexible enough to receive data from a range of satellites (European Remote Sensing Satellite (ERS-1 and ERS-2), Japanese Earth Resources Satellite (JERS) and Système pour l'observation de la Terre (SPOT 1-4) (French Earth observation satellite)), allowing for a multimission and multisensor approach. For ease of transportation, it had been designed to keep within the minimum physical size. The system would be further tested during the monsoon season (March-October) in Bangladesh in 1999 to deliver timely information on floods. It was anticipated that the more timely, cost-effective access to less expensive high-resolution data would lead to an explosive growth in the transfer and utilization of applications using remote sensing data. The focus needed to be on operational activities and the use of appropriate technology to sustain operational remote sensing. RAPIDS was an example of such an appropriate technology. It made it possible to obtain vast amounts of data in a regular and cost-effective manner. Further information on RAPIDS can be obtained from http://www.neonet.nl/rapids/.

51. Space Imaging would start to commercially distribute 1-metre panchromatic and 4-metre multispectral images in mid-1999. The data would be acquired by a new generation of remote sensing satellites, Ikonos-1 and Ikonos-2. The image resolution provided by those satellites would be the highest available in the civilian remote sensing data market. The short maximum revisiting time of three days would make possible new applications in infrastructure development, transportation, urban planning and development, environmental management and engineering, disaster assessment, management of natural resources and national and global security.

52. In the panel discussion on the theme "Matching developing country needs and commercial space applications", needs of the developing countries with regard to satellite communications and satellite remote sensing applications and the relevant commercialization aspects in both areas were discussed. While satellite communications were used on a personal level, remote sensing applications were mainly used by institutions or organizations and were not directly linked to personal needs. The broad base of users was one reason why satellite communications had developed into a strong market, while the remote sensing data market was still in a somewhat developmental stage, although slowly growing. To address that problem, the focus for remote sensing applications should be placed on the generation of value added information that was relevant to users on a personal level. Five factors were needed for the remote sensing data market to succeed, namely, affordability, accessibility, availability and timeliness of data, as well as user awareness.

53. Changes in the commercial remote sensing sector, such as the increasing number of data providers arising from the deregulation of image products after the end of the cold war would also benefit users. The need for a balance between the interests of users who preferred to receive data free of charge and those of the commercial sector that had to work on a profit basis was also discussed. It remained a challenge to match the needs of developing countries and commercial data providers. However, there was the potential for both

sides to benefit and to create a win-win situation, if data providers succeeded in demonstrating the cost-benefit advantage of using remote sensing data.

G. The way forward

54. With the launch of the first components of the International Space Station (ISS), there would soon be long-term research opportunities for researchers to operate their experiments under microgravity and space environment conditions on ISS. Various initiatives were already under way to commercialize ISS. One of the first private companies providing services for the resupply of ISS, as well as for providing equipment for a large variety of space experiments, was SpaceHab Inc. The company was selling space on its logistical carriers and pressurized payload modules, and also acting as a consultant for researchers to fly their experiments on ISS. Several institutions in developing countries, for example, universities in South America, were already participating in various experiments. The high cost of delivering payloads into space and in operating experiments on ISS were still major hurdles to overcome for both developed and developing countries in performing such experiments on a routine basis. However, reusable launch vehicles currently under development might one day help to considerably reduce the cost of space access. It was therefore important to inform institutions in developing countries about opportunities to engage in microgravity research, which, for example, could help to develop drugs for major illnesses that caused considerable economic and human losses in those countries.

55. A representative of BRAZSAT, a commercial space company in Brazil, discussed the issue of matching developing country needs and commercial space applications. BRAZSAT was a major player within the Brazilian space programme. Brazil did not intend to reinvent the wheel, and its space programmes were therefore designed to engage in active global cooperation. The success of the Brazilian space programme and efforts towards commercialization illustrated once more the importance of convincing policy and decision makers of the benefits of space technology applications.

Notes

[1] See *Report of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 9-21 August 1982* (A/CONF.101/10 and Corr.1 and 2), part one, sect. III.F, para. 430.

[2] *Official Records of the General Assembly, Fifty-second Session, Supplement No. 20* (A/52/20), para. 39.