United Nations
A/AC.105/706

General Assembly

Distr.: General
4 November 1998

Original: English

Committee on the Peaceful Uses of Outer Space

Report on the second United Nations International Conference on Spin-off Benefits of Space Technology: Challenges and Opportunities

(Tampa, Florida, United States of America, 30 March-3 April 1998)

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V.98-57169 (E)

I. Introduction

A. Background and objectives

1. The General Assembly, in its resolution 43/56 of 6 December 1988, requested the Committee on the Peaceful Uses of Outer Space to consider at its thirty-second session a new agenda item entitled "Spin-off benefits of space technology: review of current status". Pursuant to its work, the Committee, starting in 1992, recommended that the United Nations Programme on Space Applications should consider devoting at least one of its training courses, seminars or expert meetings each year to the promotion of spin-off benefits from space. Organized as part of the 1998 activities of the Programme, the second United Nations International Conference on Spin-off Benefits of Space Technology: Challenges and Opportunities was a response to that mandate.

2. The General Assembly, in its resolution 52/56 of 10 December 1997, endorsed the activities of the Programme on Space Applications for 1998, including the organization of the above-mentioned Conference.

3. The main objectives of the Conference were: (a) to expose industrialists and private establishments in the developing countries to the many ways in which their companies and countries could directly and indirectly benefit from the various technologies that have and are being developed for space exploration and utilization; (b) to accumulate experiences by developed and developing countries in the application of space technology spin-offs; (c) to identify a common approach to cooperation among interested industrial partners in both industrialized and developing countries; and (d) to discuss joint follow-up activities for strengthening the technological capabilities of developing countries in order to realize the spin-off benefits of space technology.

4. The present report covering the background, objectives, organization and recommendations of the Conference has been prepared for the Committee on the Peaceful Uses of Outer Space. Participants will report to the appropriate authorities in their own countries.

B. Participants

5. The United Nations targeted for participation in the Conference individuals in decision-making positions in governmental agencies and private industries who were engaged in programmes and projects in which spin-offs of space technology were being or could be utilized. The co-sponsors also requested that each participating entity or private establishment wishing to attend the Conference should send both its chief executive officer and senior technical manager.

6. Funds allocated by the United Nations, the Federal Laboratory Consortium of the United States of America, the International Society for Photogrammetry and Remote Sensing and private entities in the United States, including Lockheed Martin Corporation and Spectrum Astro Inc., were used to cover international air travel and per diem expenses for the period of the Conference for the senior technical managers from selected organizations and companies from developing countries.

7. The following Member States, United Nations Secretariat units, governmental and non-governmental organizations, international organizations, and private entities were represented at the Conference: Brazil, Bulgaria, Canada, Chile, China, Egypt, Ethiopia, Hungary, India, Japan, Kenya, Nigeria, Romania, Tunisia, Thailand, United States and Zambia; Office for Outer Space Affairs of the Secretariat; Canada Centre for Remote Sensing, Federal Laboratory Consortium (FLC), United States Department of Commerce, United States Department of Energy and United States National Aeronautics and Space Administration (NASA); International Society for Photogrammetry and Remote Sensing; Farabow, Finnegan, Garett & Dunner L.L.P., Henderson, HOBECO Ltda., Lockheed Martin Corporation, Mitsubishi Electric Corporation, Nippon Electric Company, OPTOMECH Engineers PVT, Ltd., ORBIMAGE, Resource 21, Space Imaging-Earth Observation Satellite Company (EOSAT), Space Vest, Spectrum Astro Inc. and Système pour l'observation de la Terre (SPOT)-Image. Speakers and chairmen of the Conference came from Brazil, Chile, Canada, India, Japan, United States and the Office for Outer Space Affairs.

II. Observations and recommendations

8. Throughout the Conference, participants had the opportunity to take part in discussions on spin-off benefits. Within the framework of the specific themes of the Conference, discussions were held on the following issues: participation of potential business partners in developing a joint business plan, including the needs and desires of partners; emerging opportunities available to all participants, including projects that are appealing to developed countries and that could provide significant benefits to developing countries; and steps to be taken by developing countries to further their development, with emphasis on

challenges and opportunities in spin-off programmes. The following observations and recommendations were made:

(a) The successful transfer of space-related technologies and spin-offs from research and development institutions to industry required the availability of appropriate methods and infrastructures, as well as clearly defined government policies and support. Those requirements included the following: establishment of organizational structures dedicated to technology transfer and commercialization in national space agencies or other government bodies in charge of technological development; stimulation of marketing mechanisms focusing on widespread promotion of technologies and spin-offs; development of financial incentives encouraging innovators, entrepreneurs and investors; creation of relevant educational and training networks;

(b) Of paramount importance was the elaboration of a sound business plan in a manner capable of attracting interested investors by focusing on the value of products and services to be offered to the public. In creating a friendly investment atmosphere, investment opportunities were vital for the development and success of technology transfer projects. In order to attract the latter, the following factors were emphasized: political will and commitment by national leaders regarding the introduction of new technologies and development of appropriate infrastructure; political, social and economic stability to enhance the possibilities of foreign investment in emerging markets; and tax incentives to encourage both foreign and local investors. The latter were instrumental in order to stimulate the adaptation of technologies required from abroad to meet local needs. It was suggested that Governments could provide subsidies and financing on a liberal and competitive basis to promote opportunities in research and development, as well as funding and facilities to encourage and facilitate technology transfer. Finally, effective and close coordination between Government and industry was absolutely necessary to further development programmes in the area of space technology spin-offs and, generally, to achieve basic sustainable development programmes;

(c) Networking facilitated technical development opportunities in the establishment of contacts with Government, industry, academia, financial organizations and others. With regard to obtaining the support of developed countries, contacts should be established with the focal point at the local level. Direct contacts between industry leaders would also facilitate partnerships and collaborative ventures;

(d) International cooperation was considered to be a powerful mechanism in promoting the development and application of high-technology spin-offs in a developing country. That mechanism needed to take into account the policies of developing countries regarding space technology and the priorities and policies of the international organizations assisting developing countries in strengthening their technological capacities;

(e) Another significant aspect in meeting the challenges of international cooperation was the establishment and maintenance of contacts with potential facilitating organizations from around the world, including national and regional space institutions such as those represented at the Conference. When an opportunity for a cooperative venture arose, it should be encouraged and taken. Also of importance was the substantive involvement of the private sector as much as possible in those projects in order to ensure their sustainability. Moreover, business leaders needed to talk to government representatives to state their interests as well as using other methods to express their views, including contact with chambers of commerce. Information generated from the Conference should be passed on by the participants to relevant and supportive government agencies in order to facilitate follow-up;

(f) Regarding the challenge of the development of human resources, technology transfer from spacefaring countries to developing countries could be promoted by providing more training opportunities for scientists and engineers of developing countries. Furthermore, those opportunities would be instrumental in understanding the direction of development in civil space technology, which would facilitate the decision-making process in developing countries, particularly in prioritizing the space-related research and development activities to be pursued. The solid foundation for future entrepreneurs and innovators in basic education was of particular importance, especially in relation to applied research and technology transfer and its adaptation. That challenge would permit local entrepreneurs and industries to prepare themselves to begin development activities by acquiring licences to technology and by training in the effective utilization of know-how and the effective management of a high-technology-based business;

(g) Technology transfer was a two-way process. It was important that when contacts were made between a potential provider and user, both parties should benefit from the transaction. Large companies might not necessarily be the best contact for research and experimental institutions when seeking potential partners in specific transactions. It might therefore be more appropriate to approach small to medium-sized firms. However, a potential problem in that approach was that such firms did not necessarily have available the resources needed to establish business contacts with industry counterparts, for example, in connection with industry trade shows;

(h) Companies from developing countries involved in the field of space technology required certain preconditions in order to proceed with space research as a tool for the development of advanced technology. The preconditions included: an existing level of experience and education in order to absorb new knowledge; the organization of existing groups and institutions in a way that enabled the smooth flow of relevant information; close collaboration between research groups in order to produce the best results; international cooperation; and, in particular, cooperation with more experienced partners in order to successfully transfer technology and subsidies from Government or other sources;

(i) Regarding the role of the United Nations, the Organization could play a vital role as a facilitator. The Office for Outer Space Affairs should continue to assist developing countries and pursue the issues of technology development at the local level through international conferences such as that covered by the present report, which provided a good forum, and by promoting interaction between developed and developing countries in technology applications. The organization of a third international conference on spin-off benefits of space exploration and implementation of follow-up activities was suggested. At the third conference or perhaps through the World Wide Web site discussed in subparagraph (j) below, representatives of developing countries could identify the needs or specific problems of each of their countries, thereby giving an opportunity to the developed countries to better understand how space-derived technologies could be better applied towards solving those problems. Other potential roles for the United Nations included the identification of companies that had received spin-off technology from the space laboratories of spacefaring States, an assessment of the capabilities of those companies and a study of the extent to which they were interested in participating in the transfer of their know-how to other companies in developing countries;

(j) The Office, in collaboration with interested industries, should develop a Web site, available through the Internet, that could be accessed by all developing countries for information on all aspects of space technology transfer. The Web site could contain information for industries on opportunities for partnerships, and provide a link-up to a database of usable technologies that any country could access and use. The Web site should not only cover technology transfer successes, but also refer to the failures experienced by developed countries when implementing the new technologies.

9. Taking into account the importance of adequate access to space technologies and applications relevant to sustainable development programmes in developing countries, including the mutual commercial benefits available to both providers of technology and its recipients and users, international cooperation in the area of space technology transfer and spin-offs should attract the particular attention of the Member States. In that connection, the legal frameworks and international agreements developed by United Nations bodies and agencies had been essential to fostering international cooperation in programmes for the transfer of space technology.

10. On the eve of the twenty-first century, space cooperation with developing countries had become a key issue. Space industries from developed countries wishing to do business in developing countries needed to harmonize their policy and business strategies within the framework of national space policy, usually defined by a national space agency and by the political decision-making bodies of the developing country that had decided to use space technology for the development of the national economy.

11. All participants expressed the opinion that the general organization of the Conference and the planning of the presentations were of high quality. Participants were of the view that developing countries had become better able to obtain precise knowledge about the importance of investing in space applications programmes in order to take advantage of their benefits in improving the conditions of life in their respective countries. They also expressed their appreciation to the United Nations for having organized the Conference and to the Governments

and industries represented for making an invaluable contribution to its success.

lge between space technology benefits and research in the medical field

III. Presentations and discussions during the Conference

A. Background

12. The global political, economic and technological changes of the past decade had altered the operating environment of the space industry. Space technology had become an economic asset and a valuable source of know-how, technology transfer and spin-off programmes, rather than a means of political supremacy. Space activities incorporated important areas of high technology, including computer software and hardware development, sophisticated electronics, telecommunications, satellite manufacturing, life sciences and launch technology. Space activities also involved significant issues of international trade and policy, such as global markets, gaining access to remote areas, government-subsidized competition and international standardization and regulation. Cooperation was the key to maximizing spin-off benefits and providing mutual advantage through the promotion of joint activities between developed and developing countries.

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space technology applications, the quality of life had been enhanced particularly in the areas of distance education, training and development, solar energy, fisheries operation, telecommunications, health and telemedicine, precision agriculture and crop yield assessment, global monitoring of natural resources and the environment.

B. Spin-off benefits of space technology to developing countries

1. Telemedicine and human health

14. The provision of health services to non-urban and isolated areas had always been a challenge for developing countries. The health and safety of many countries could be significantly improved with proper planning of natural resources, water supply and sanitation. In addition to the impact of space activities on business and daily life, there were numerous socio-economic benefits that derived directly from scientific and space exploration missions. As a result of improved technology, telemedicine was becoming increasingly cost-effective. Given the growing financial constraints of today in most sectors, including the health-care industry, alternative methods of delivering health care were being sought.

15. A
number of applications derived from space technology had influenced areas such as biomedical instrumentation, cardiology, surgery and medical imagery. In 1989, NASA established a space bridge to Armenia five months after the earthquake in the region. The system was a double satellite hop using the American Telephone & Telegraph (AT&T), International Telecommunications Satellite Organization (INTELSAT) and NASA Satcom satellites. It consisted of a two-way audio channel and one-way black and white video link. Once established, the system was used easily to alleviate the effects of other disasters in the region.

16. NASA had also been applying remote sensing technology, specifically satellite and airborne Earth sensing, to study various environmental and public-health-related problems around the world. The data acquired was applied to the regulation and monitoring of Earth resources and the environment. Improved environmental conditions led to an improved quality of life for the population. Such an approach made it possible to study habitats that harboured vectors capable of transmitting diseases from one species to another. Since certain diseases were associated with particular landscapes and environmental conditions, the study of those associations could provide research tools capable of identifying the time and place of future global outbreaks of human diseases.

17. An example of applying remote sensing technology to improve public health was provided by Indonesia, where there were high levels of malaria and tuberculosis in various regions of the country. The Government of Indonesia, through its National Development Planning Board, funded the Agency for Assessment and Application of Technology to study the problem and make recommendations on the reporting of disease statistics. In order to report the data from two regions where the diseases were prevalent, it was decided to automate the process in a very user-friendly manner by developing a personal-computer-based geographic information system (GIS) that used the exact reporting format of the clinics. The process made it easier to fill out the forms digitally. In order to assess the spatial distribution of people with the disease in association with the potential disease vector habitats, the following types of spatial information were entered into the system: political boundaries, clinic locations, patient living locations, soil types, topography, land use and cover. Land Remote Sensing Satellite data were used to create detailed land-cover maps. The data sets were currently being statistically assessed.

18. With better information at the national level, governmental agencies could also better plan and prioritize the use of limited resources to help solve serious health problems at the local level. The overall goal of the project in Indonesia was to develop a user-friendly methodology that could be implemented in local clinics to better study, report and solve health problems in local clinics across the country. An important aspect of the project was to emphasize the importance of using GIS on a daily basis providing government officials with an effective and operational system for monitoring diseases.

able to access a wide range of products that had many useful applications.

19. To facilitate the dialogue between physicians and the space industry, in early 1996 the European Space Agency (ESA) created an association called Promotion of Medical Use of Space, which disseminates information about space technology and ongoing projects with the space industry in order to promote the transfer of space technology to medical applications. ESA had invited physicians, medical research organizations, hospitals and the biomedical industry to become active members of the association, and thereby to interact with the space industry.

2. Agriculture

20. With the emergence of an agricultural information revolution, information derived from satellite remote sensing and aerial photography had made it possible for farmers and agribusiness companies to estimate food and fibre production and to develop survey sampling frames and prediction models. The data could be used in agricultural surveys to accurately predict crop yields, to estimate and map crop damage, to monitor conservation practices and to implement precision farming practices.

21. Farmers were beginning to rely on remote sensing for timely crop monitoring and information on production in large disparate areas. Such information was used to identify crop health problems, monitor food supplies and assess famine risk. Remote sensing offered numerous benefits in the field of agriculture, in particular the following application opportunities: (a) early identification of crop health problems, which would allow growers to employ timely remediation techniques; (b) targeted remediation of crop problems resulting in lower costs and reduced environmental impacts; (c) simultaneous monitoring and management of large disparate areas with little additional cost or effort; (d) early crop yield predictions and periodic revisions throughout the growing season with improved accuracy; and (e) the analysis of overall crop, field and farm performance to evaluate sensitivity to management changes and achieve production optimization.

22. In addition, the analysis of satellite and ground data in conjunction could produce acreage data with substantially more statistical precision at local levels. Earth observation and weather satellite data could also be analysed together to aid in monitoring crop conditions. Furthermore, the monitoring of vegetation conditions on a national scale could be carried out through the use of data generated from polar-orbiting weather satellites.

3. Data imaging applications

23.

NASA technologies were being used to help map, plan and improve country development programmes. High-resolution topographical maps could also be used in commercial applications ranging from road-building and urban planning to community development and identification of flood plains.

24. To assist in the advance planning of relief efforts, vegetation monitoring information was used to assess regional food and water supplies and to mitigate the risks of drought, pest infestation and environmental contamination. Geospatial technology was used to assess food-supply vulnerability in drought-stricken areas. For instance, African countries continually faced food shortages that resulted in widespread famine and starvation, devastating the population. The normalized difference vegetation index was used to measure key variations in agricultural productivity. The results of those measurements compared to long-term averages and correlated with rainfall, market prices and logistical factors determined the spatial distribution of the food-security risk.

25. In terms of global security, high-resolution imaging and data applications could be used to monitor regional conflicts. More importantly, in the field of peacekeeping, the images and data could be made available to countries and individuals around the world in a timely, accurate and cost-effective manner.

26. Regarding fisheries management, remote sensing images had revealed important patterns in both the sea-surface temperature and pigment concentration. The distribution and relative abundance of fisheries resources were related to surface oceanographic conditions. The process of using remote sensing data allowed oceanographic information to be provided to vessels, and vessel operation data sent back to shore enhanced both the industry and resources management. The data acquisition allowed fishermen to obtain information about surface temperature distribution and to reduce operation risks and costs by

searching only in areas with a high probability of success. The same data allowed managers to track current fish-population conditions, to carry out faster resource analysis and to provide fleets with operational recommendations. The information acquired was useful in optimizing the sustainable exploitation of natural resources and in managing the existing fishing infrastructure in the most cost-effective manner possible. The Food and Agricultural Organization of the United Nations also assisted numerous developing countries, such as China, Costa Rica, Thailand and Viet Nam, in the sustainable development of fisheries operations. That process benefited villages by enhancing their food supply and income and through the overall improvement of their quality of life.

C. Research and development

27. Space technology provided know-how, as well as knowledge of who and what was involved and why, from a valuable bank that was used by companies worldwide to bring new products, processes and services to the world market at more competitive prices. The indirect effects of space technology applications, previously considered by-products of research and development, were increasingly seen as a meaningful element of industrial policy. To remain competitive in their fields, the non-space industrial sectors were more demanding of the new technology, processes and materials.

28. sfer of space technology were Governments, space agencies, multisectoral consortia, aerospace companies, small and medium-scale enterprises, research laboratories, academic centres and networks consisting of different organizations ranging from large companies to research laboratories and non-space industries. Technology transfer and spin-off programmes developed by national and international space agencies demonstrated a new market-oriented approach based on demand and well-identified market segments. Space technology provided a reservoir of potential solutions for the industry.

1. Government role

29. The successful transfer of technology and spin-offs required an appropriate method and infrastructure, as well as a clearly defined government policy on each technology to be transferred. FLC promoted and strengthened technology transfer throughout the United States. In that capacity, FLC represented the technology outreach programmes of 16 federal departments and agencies operating over 600 national research and development laboratories. The mission of FLC was to cooperate with federal laboratories and the private sector in the following areas: (a) developing and administering technology transfer activities; (b) advising and assisting federal laboratories and industry in transferring technology; (c) providing a clearing house for requests at federal laboratories for technical assistance from States, local governments and industry; and (d) facilitating communication, coordination and resolution of federal technology transfer activities throughout the federal research and development community.

30. Mechanisms used for accessing the resources and expertise of FLC included the following network: (a) sharing of information; (b) exchanging personnel; (c) carrying out cooperative research and development agreements directly with private companies and other entities; (d) working cooperatively with NASA; and (e) forming consortia and using technology developed under government contracts.

31. In addition to the FLC network, six regional technology transfer centres had been established through a competitive process, designed to benefit a specific industry, using an innovative process model in high-technology development. Four of the six centres were managed by universities. Forty per cent of the activities of the network were related to technology and concepts developed by NASA. The concept was developed and commercialized, and appropriate market research was then done on the market viability of a product. When those steps were completed, a product was deemed appropriate for possible commercial ventures, and would be offered to the private sector for financing and ultimate distribution to the market.

32. For the private sector, the advantages of working with the United States federal laboratory system was that the laboratories had a reservoir of facilities and talented people with the ability to undertake long-term projects that

required more time and resources than what some private industries could provide.

33. Over the past 25 years, there had been a successful increase in and diversification of the technologies of NASA through commercialization. Research in aeronautics, in life, microgravity and space science, in communications and in space flight and access had brought an array of high technologies ready for transfer to the private sector. Interested developing countries might wish to work and cooperate with NASA on mutually beneficial projects. Many countries had already entered into cooperation agreements

with NASA in fundamental science and technology areas. NASA was interested in cooperating with civil space programmes of particular countries where mutually acceptable benefits could be derived. To facilitate that process, the following steps were to be taken into account:

(a) An initial request should be made by an interested country wanting to cooperate with NASA;

(b) An exchange of teams from both sides would be made to discuss and to determine common areas of interest;

(c) Beneficial interests of both countries that did not conflict with their national policies on transfer of technology would be determined when mutual agreement was reached;

(d) NASA would act as a coordinator for the benefit of the interested country with all other agencies and departments of the United States Government.

34. In providing such opportunities to developing countries, the cooperation between NASA and a particular country would: strengthen the technological capabilities of the developing country; provide the opportunity to examine and adapt new technology to meet local needs; and expand market opportunities for space-related industry in the country concerned. Furthermore, a policy of creating reciprocal relationships where knowledge was shared through mutually beneficial cooperation was being offered by NASA through internships to foreign officials, so long as reciprocal opportunities were made also available to NASA officials.

35. In the area of renewable energy, the United States Department of Energy had undertaken extensive research into the production of energy through wind, solar thermal sources and photovoltaic cells, as well as into lasers and high-temperature superconductivity. A successful tool was photovoltaic conversion used to provide power to man-made satellites. NASA pioneered photovoltaic power and supported Department of Energy programmes to expand terrestrial applications. The NASA jet propulsion laboratory was primarily responsible for developing advanced photovoltaic technology. Photovoltaic conversion of energy could provide a viable alternative energy source to sites where no conventional energy source existed, such as remote automated weather stations, sea-based navigation buoys and forest stations in villages of developing countries.

36. Photovoltaic conversion technology had been introduced in many developing countries to promote the use of renewable energy sources as a viable, cost-effective and environmentally friendly way to provide necessary power generation. Solar panels were being used in several African countries and in Brazil to provide electrical power to homes in rural and remote areas, and high-capacity storage batteries were used for solar-power-generated electricity in rural and remote areas.

2. Industry role

37. Lockheed Martin Corporation was teaming with various investors in order to establish firms with traditional vendors to develop a variety of communications services from space. The emerging systems were targeted to a variety of users. Practically every country in the world currently benefited from a range of communications services through participation in international, regional or domestic satellite communications systems. Satellite communications technology was an established critical tool for social and economic development, while advances in technology continued to lower the costs of its utilization. Communications satellites were used for a wide variety of purposes, including rural and wireless communication, news and data dissemination, emergency communication, navigation, disaster warning, television and radio programme distribution, search and rescue operations, telemedicine and remote education.

38. The above-mentioned technology had created huge opportunities that could promote economic development. Moreover, those benefits were potentially accessible to all sections of society and could further the process of sustainable development. Lockheed Martin recently announced its involvement as partner with other companies in the development and launch of the SATPHONE mobile communication satellite system. The system would provide telecommunication services across western Asia, northern Africa, the Mediterranean basin and eastern Europe. It would offer the following opportunities to those regions: the enhancement of existing terrestrial communications network; the provision of superior service and flexibility to millions of customers; and the possibility for participating companies and countries to develop and benefit from multiple communication services.

39. Spectrum Astro, a rapidly growing private company, was dedicated to the development and production of reliable, affordable and timely space products. The company was creating and addressing opportunities, through partnership, for industries in developed countries to expand in the emerging markets of developing countries. It was dedicated to the promotion of technological advances in the miniaturization of electronics, computer-aided design and the standardization of components. It was also providing services and products for all phases of the life cycle of the

space system, including: system engineering and mission development for space systems; development and production of small spacecraft bus vehicles; space electronics and power management systems; high-performance data storage systems; and electrical ground support and ground control equipment. Spectrum Astro recently announced its involvement in supplying the power systems for the Ellipso system, a global communications satellite system.

D. Industry experiences in developing countries

40. The challenges confronting developing countries, particularly in the areas of emerging markets, involved developing a better, faster and cheaper strategy for participation in the market that should include technology transfer and academic and entrepreneurship training. A national project that met national needs could also provide for the design and manufacture of low-cost, high-performance small satellites and related subsystems for sophisticated defence, science and selected commercial opportunities. If implemented correctly, the end result would be a sustaining business base that would be capable of competing in global markets.

41. The opportunities available in the global space industry for developing countries included the following areas: commercial remote sensing; wireless communication; access to space (commercial launches); and precision positioning and timing. Most developing countries were not engaged in the full range of space activities, but were rather focusing on space applications with operational and commercial potential for developing business opportunities in the countries concerned.

42. In developing countries, much work had been done on products that had been derived from work in their space-related institutions and organizations. In the field of solar power, solar panels were used in Botswana, Ghana, Kenya and South Africa to provide electrical power to homes in rural areas. Since a majority of the world population lived in rural and remote areas beyond national power grids, using solar energy provided a less expensive alternative.

43. In Brazil, in the 1980s, many government incentives were given to the private sector to start industries based on high technology. As Brazilian industry gained experience, the Brazilian National Institute for Space Research (INPE) sought opportunities to find suitable companies to manufacture solar panels and provided an environment in which an exchange of ideas between private companies and INPE could take place. That approach by INPE resulted in a private company manufacturing solar panels for INPE as well as working on the Brazil-China Earth Resources Satellite programme. Another company had also built space components and assemblies for the Brazilian space programme. Several small Brazilian companies were cooperating with other developing countries, especially in selling or buying images from Earth observation satellites. INPE continued to collaborate and work with Brazilian industry in the development of its space-based industry.

44. In Bulgaria, research work was undertaken by the Bulgarian Aerospace Agency on Neurolab-B, designed for use on board the Mir space station for the psychological and physiological examination of crews. A version of that system was also being developed for clinical environments on Earth. The Agency had also developed an ultraviolet (UV) indicator for personal use that determined the presence and intensity of UVA and UVB radiation. That device provided individuals with a clear indication of the intensity of the Sun, and therefore assisted in determining the maximum amount of exposure to the Sun under different circumstances.

45. The application of space technology in China had played an important role in solving problems relating to population, resources, the environment, disasters, communication, transportation and education. The economic and social benefits gained from space technology had accounted for 70 per cent of the gross income of China Aerospace Corporation. In addition, the space industry of China provided direct services to the national economy and scientific research.

46. industry of China had implemented a policy of applying space technology to benefit other national industries. From space research-derived applications, over 20 per cent were usually incorporated into other industries. Some examples of spin-offs in China include the following benefits: a low-temperature thermal tube transducer; a new energy resource, a zinc-air cell, based on H_2-O_2; fuel cells used in satellites and large Zn-O_2 storage batteries; a photoelectronic diameter measurement system; and an elaborate industrial process control system.

47. Moreover, a land survey satellite, Ziyuan-1, jointly developed by China and Brazil, was to be launched in 1998. The satellite could play an important role in the survey, exploitation, use and management of resources and in the monitoring of agriculture, forestry, hydraulic power, geology, minerals, oceans and the environment.

48. In Hungary, the National Crop Monitoring Operational Project was successfully concluded, and provided accurate crop yield maps 2 to 12 weeks earlier than the target date.

The forecast yield data of the monitored areas were reported regularly to the Ministry of Agriculture.

49. India provided another example of government/industry cooperation in developing countries. In terms of technology transfer arrangements, the Indian Space Research Organization (ISRO) worked closely with industry in all facets of development of space-derived products and services. There was continuous interaction between companies and ISRO to ensure that proper quality-control procedures, inspection standards and other manufacturing requirements were followed.

50. Their collaboration included spin-off products that had been marketed under various trade names and that included optical and optoelectronic products for remote sensing data interpretation. As a result of their collaboration, private industry could develop on its own a series of products that used optics for industrial and medical imaging applications. The effective participation of a private Indian company, Optomech Engineers PVT. Ltd., in all stages of development of low-cost optical products for visual interpretation of satellite remote sensing data led to the granting of a licence to the company to market a series of optics-based products for industrial and medical imaging applications. As a result, several products had been successfully marketed by the company, and it had been able to expand into areas of medical imaging equipment and machine-tool manufacturing.

51. A review of the highly cooperative venture between Indian industry and ISRO resulted in the following observations and guidelines:

(a) Smaller companies run by technically qualified entrepreneurs were more likely to succeed in absorbing the technology faster;

(b) The licensor should identify a contact person in its organization with whom the licensee could communicate directly on all matters relating to technology transfer;

(c) The number of recipients of know-how for a technology or product should be in proportion to its perceived or estimated market potential;

(d) Technology transfer would enable the licensee to acquire skills that could be used for developing new products using the same technology but for different applications.

52. In Romania, particular attention was given to the development of a microsatellite mission for hazard management and monitoring of space communications, of global positioning and information systems and of Earth observation. In addition, Romania, through its National Institute for Aerospace Research and the Romanian Space Agency, had developed a small unmanned aircraft, a lenticular aerodyne, equipped to perform training in remote sensing communications, attitude control and navigation. The vehicle helped to reduce the period of time necessary to understand and adjust the phase of a mission, with lower costs.

E. Intellectual property

53. Intellectual property concerns and related legal challenges involving technology in different countries required appropriate action in cases where a business held intellectual property. Identifying, protecting, transferring and preserving intellectual property raised issues of fundamental importance. Their various aspects involved such matters as the identification of intellectual property through an audit and protecting it in its different forms, including patents, trade marks and copyright. Protection of trade secrets, inventions and designs, computer software, trade marks and product configuration was needed in order to safeguard the rights inherent in the products. Confidentiality agreements were also necessary when applying for patent and trade-mark protection. Moreover, when commercializing an invention, it must be ensured that the invention did not infringe on the patents owned by others, compliance with export control and foreign licensing regulations was therefore essential. Another area that required attention was technology licensing, which was important for a variety of reasons depending on business goals, market situations, the type of licensee, antitrust considerations and the type of intellectual property right. Licences could be structured as exclusive or non-exclusive and subject to limitations based on geography, field of use and/or time requirements, as well as renegotiation of the licensing provision.

F. Human resource development

54. ogy and its spin-offs, companies in developing countries needed to acquire knowledge through a process of learning by innovation, whereby user/producer relations could play an instrumental role. Since the users of space applications technology in developing countries seemed to be playing a more active role in its promotion, development and use, there was a need for strategies that could provide users with a comprehensive knowledge of the technology. Such an approach would make it possible for users to establish a local production capacity, and would promote cooperation between users and producers.

55. elaborated to enable developing countries to become educated on the benefits of technology transfer and acquainted with the latest developments of space technology and its applications. Training courses were being implemented in space-related institutions to make their employees aware of the process of technology innovation and transfer. They were an essential factor in improving the infrastructure for business decisions and management, a matter of primary concern to both decision makers and policy makers.

56. he resources available for training and education. For example, regional centres for space science and technology education were being established under the auspices of theOffice for Outer Space Affairs in various regions covered by the the regional economic commissions, including Asia and the Pacific, Latin America and the Caribbean, Africa and Western Asia.

57. Science and Technology Education in Asia and the Pacific, located in India, was offering unique opportunities for individuals to learn about space technology, including spin-off benefits, focusing on the themes of remote sensing, satellite meteorology, satellite communications, geopositioning systems and atmospheric science. The Centre for Space Science and Technology—in French Language was inaugurated in Morocco in October 1998, and the Centre for Space Science and Technology Education—in English Language was inaugurated in Nigeria in November 1998. The regional Centre for Space Science and Technology Education in Latin America and the Caribbean, to be hosted by Brazil and Mexico, was also to be inaugurated by the end of 1998. Following an evaluation mission in western Asia, a host country would beselected in the near future to host the centre in that region. Additionally, in central, eastern and south-eastern Europe, a network of space science and technology education institutions was being established.

G. Exhibition

58. In conjunction with the second United Nations International Conference on the Spin-off Benefits of Space Technology: Challenges and Opportunities, an exhibition was organized at the Tampa Convention Centre by the 1998 Annual Conference of the American Society for Photogrammetry and Remote Sensing-Resource Technology Institute. Participants were given a valuable opportunity to interact with industries and private companies taking part in the exhibition for possible short- and long-term collaboration in areas of mutual interest. Through the exhibition, participants improved their understanding of the constant state of change in the mapping sciences, which promote applications of photogrammetry, remote sensing, GIS and supporting technologies.