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THIRD UNITED NATIONS CONFERENCE ON THE EXPLORATION AND PEACEFUL USES OF OUTER SPACE

ECONOMIC AND SOCIETAL BENEFITS

Background paper 11

The full list of the background papers:

1. The Earth and its environment in space
2. Disaster prediction, warning and mitigation
3. Management of Earth resources
4. Satellite navigation and location systems
5. Space communications and applications
6. Basic space science and microgravity research and their benefits
7. Commercial aspects of space exploration, including spin-off benefits
8. Information systems for research and applications
9. Small satellite missions
10. Education and training in space science and technology
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12. Promotion of international cooperation

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PREFACE

The General Assembly, in its resolution 52/56, agreed that the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) should be convened at the United Nations Office at Vienna from 19 to 30 July 1999 as a special session of the Committee on the Peaceful Uses of Outer Space, open to all Member States of the United Nations.

The primary objectives of UNISPACE III will be:

(a) To promote effective means of using space technology to assist in the solution of problems of regional or global significance;

(b) To strengthen the capabilities of Member States, in particular developing countries, to use the applications of space research for economic and cultural development.

Other objectives of UNISPACE III will be as follows:

(a) To provide developing countries with opportunities to define their needs for space applications for development purposes;

(b) To consider ways of expediting the use of space applications by Member States to promote sustainable development;

(c) To address the various issues related to education, training and technical assistance in space science and technology;

(d) To provide a valuable forum for a critical evaluation of space activities and to increase awareness among the general public regarding the benefits of space technology;

(e) To strengthen international cooperation in the development and use of space technology and applications.

As one of the preparatory activities for UNISPACE III, the Office for Outer Space Affairs of the Secretariat has prepared a number of background papers to provide Member States participating in the Conference, as well as in the regional preparatory meetings, with information on the latest status and trends in the use of space-related technologies. The papers have been prepared on the basis of input provided by international organizations, space agencies and experts from all over the world. A set of 12 complementary background papers have been published and should be read collectively.

Member States, international organizations and space industries planning to attend UNISPACE III should consider the contents of the present paper, particularly in deciding on the composition of their delegation and in formulating contributions to the work of the Conference.

The Secretariat gratefully acknowledges the contributions made by specialists and organizations in the preparation of the paper, in particular the European Space Agency, the International Society for Photogrammetry and Remote Sensing, the World Meteorological Organization and the National Aeronautics and Space Administration of the United States of America.

The assistance of Mr. S. E. Doyle as technical editor of background papers 11 and 12 (A/CONF.184/BP/11 and 12) is also gratefully acknowledged.

SUMMARY

Some benefits from space programmes are, by nature, more quantifiable than others. For instance, scientific benefits are basically non-quantifiable. However, they contribute to the improvement of the knowledge of the universe, of the Earth and of fundamental physics. There are three types of benefits resulting from space programmes, namely, direct, indirect and socio-economic benefits. The direct economic effects are those which are directly related to the explicit objectives of projects. Industrial return is, of course, the obvious direct economic effect, but other direct economic effects exist as well. For instance, if the objective is to develop a new product, the sales of that product are considered a direct effect; correspondingly, if the objective is to develop a new process, the economic effects generated by the use of the new process are considered direct economic effects. Indirect effects and those not explicitly specified in and expected from the contracts can be divided into four main groups: technology transfers (including products, processes, services and patents); commercial transfers (including reputation and industrial grouping effects); organization and method transfers; and the effect on manpower (improvement of skills and training). Socio-economic benefits are of a macroeconomic nature and are related to the improvement of nations' economies, as well as the associated social benefits, for example, better weather forecasting and faster and cheaper communications.

The present background paper reviews some of the fields of application and uses of space technology related to the Earth and its space environment from a socio-economic point of view: disaster prediction, warning and mitigation; satellite communications; satellite navigation and localization systems; education and training in space science and technology; and human spaceflight. The paper also reviews the rapid development of space technology and applications for environmental monitoring and sustainable development programmes that could help countries fulfil their obligations as regards implementation of the recommendations of the United Nations Conference on Environment and Development, held at Rio de Janeiro from 3 to 14 June 1992.

The paper also discusses the impact of space activities by assessing the direct and indirect benefits of space programmes on society as a whole.

Knowledge and application of science and technology are a necessity for achieving sustainable development. It is therefore also essential that all countries learn about the benefits of space technology applications. However, because of a range of economic, operational and education problems and the lack of awareness, currently only a few developing countries are making optimum use of space technology, although that technology can provide cost-effective tools to help address many problems faced by the developing world.

I. INTRODUCTION

1. Humanity is facing major challenges in ensuring the adequate provision of basic necessities, such as food, shelter, a clean and healthy environment and proper education, for the growing population of planet Earth.

2. Only through sustainable development, that is, the process of meeting the current needs of humankind without compromising the ability of future generations to do so, can one hope to ensure a peaceful world. The concept of sustainability is closely linked to the carrying capacity of ecosystems, which sets the physical limits to economic development and may be defined as the maximum rate of resource consumption and waste discharge that can be sustained on a permanent basis in a defined planning region without impairing productivity and ecological integrity.

3. Political, social and economic commitments must be made by all States to create a global partnership for sustainable development and to ensure the equitable allocation of available resources.

4. Space technology, one of the outstanding developments of the twentieth century and one that has contributed significantly to sustainable development, offers many benefits to mankind.

5. The present paper highlights some of the major economic and societal benefits derived from space activities, notably Earth observation, satellite communications services, satellite navigation services and space exploration.

II. EARTH OBSERVATION

A. Sustainable development of land and forest resources

6. Over the years, remote-sensing satellites have accumulated vast amounts of information about the Earth's environmental conditions. With the aid of state-of-the-art technology, that information can be processed, interpreted and applied in the planning of the utilization of limited natural resources in a sustainable manner. Detection of change through satellite remote sensing on various temporal and spatial scales offers the most economical means to assess the environmental impact of a particular developmental project, to monitor the composition of species and the biological diversity of an ecosystem and to establish action plans for sustainable development.

B. Commercialization

7. The remote-sensing data market may well be the most significant commercial application of space technology, following applications in the field of telecommunications. Information derived from remote-sensing data are used in such areas as agriculture, civil engineering, environmental management, forestry and natural resource management. With the launch of over 100 new remote-sensing satellites in the next decade, capacity for data collection will increase dramatically. The new systems will provide resolutions on a scale as low as one metre. The availability of cost-effective computing power, user-friendly software, including highly integrated geographic information systems (GIS) and enhanced data-compression capability, as well as the proliferation of applications adapted to specific user needs, may well lead to an explosive growth in applications using remote-sensing data. Experts project that the GIS market should more than triple by the year 2000 from its current annual market share of US$ 1.2 billion.

8. The accelerating rates of deforestation, desertification, soil erosion, salinization and sodification and the occurrence of floods and droughts have reached alarming proportions in some of the Earth's regions. Developments in space-based remote-sensing applications have established the potential of that technology to tackle some of those problems in a timely and cost-effective manner. Digital data-processing techniques and software packages have been developed to use the acquired data for various resource inventory and management purposes. In countries with vast forest areas, such as the Amazonian basin in Brazil, remote sensing and GIS have become regular tools for the monitoring and management of forest resources. Remote sensing offers a cost-effective option for land monitoring.

When combined with map or point data, such integrated spatial information can greatly improve the efficiency and quality of decision-making.

9. For example, forest cover accounts for the storage of carbon through photosynthesis, contributing to climatic stability. Tropical forests can store carbon at the rate of about one ton per year in 0.1-0.3 hectares. To store an equal amount of carbon, a forest area of four times that size would be required in the more temperate regions. Tropical forests are therefore significant assets of humanity that need to be preserved carefully.

10. In other regions, land degradation is increasing as a result of the cycle of poverty, population, deforestation, unsustainable agricultural practices, environmental pollution and natural disasters. With its biotic functions partially destroyed, most of the affected land would need major improvements to restore its productivity. The negative ecological repercussions of large-scale irrigation and the extensive use of fertilizers without due regard to adequate drainage and proper agricultural practices have led to an alarming increase in soil salinity, rendering a considerable amount of fertile land unproductive and severely degraded.

11. Preserving biological diversity is today another important area of human concern. Biological diversity is the essence of a living environment, playing a significant role in the origin and the evolution of species in their natural surroundings. Loss of biodiversity and the practice of monoculture can lead to disastrous consequences and are thus a clear indicator of environmental degradation. Present estimates indicate that at least a quarter of all bio-species are facing the danger of extinction as a result of the changes in their habitat caused by anthropogenic intervention. Unprecedented in its dimension, the loss of biodiversity has immediate as well as long-term effects on human survival, since the majority of the world's population depend on plants and animals for their food, medicine, housing and energy requirements.

12. Changing perceptions about the role of world forests have increased the information requirements needed to determine the current status of land and forest resources. Remote sensing and GIS are recognized as valuable tools for sustainable land management and the conservation of natural resources. Remote-sensing data integrated into a GIS are used to plan for the sustainable use of natural resources and to confront environmental problems while limiting damage caused by natural disasters. GIS support the evaluation of different aspects of the Earth's surface in an integrated, multidisciplinary manner.

13. Data from space-borne observations are an important source of geographically referenced information. High-resolution satellites currently in operation provide the user community with significant data for carrying out forest surveys at the local level. It is only on a global scale, however, that the scientific community has been able to understand and appreciate the extent of large-scale forest depletion. Such depletions have had a serious effect on soil erosion, global climate, water resources and global food production. A combination of remote sensing and GIS has a crucial role in the investigation and monitoring of the Earth, its oceans, atmosphere and lithosphere for the protection of the environment and the management of limited natural resources.

14. Remote-sensing information on land and forest resources can be used by informed decision makers at all levels and in all countries when defining goals, policies and strategies for effective, continuous and sustainable development. Indeed, the information garnered from such sources should assist decision makers in examining an entire interconnected system and realizing that common goals and practices within a region would not only promote the effective use of resources but also increase regional cooperation. An integrated approach to land and forest resource management using available information from space observation can help decision makers to monitor crop conditions, plan mineral exploration, plan and manage urban growth effectively and detect and possibly mitigate the damage associated with natural disasters.

C. Urban planning

15. Remote-sensing data constitute an important tool for urban planning, identifying suitable areas for locating industries and planning infrastructure requirements.

16. Explosive population growth combined with limited land availability is bound to alter demographic dynamics and ultimately will result in large-scale expansion of urban areas and the creation of mega-cities. The urban population in developing countries has increased from 20 per cent a few decades ago to 40 per cent and could reach 70 per cent in the coming decades. The difficulty in providing adequate health care, the continued practice of open drainage, the indiscriminate disposal of waste water and industrial effluents and rampant water pollution have resulted in the creation of mega-slums unsuitable for human living.

17. The management of any growing urban society is essentially an elaborate process involving careful analysis, meticulous and comprehensive planning and timely implementation, tempered by the constraints imposed by the availability of resources, space and time. The development of a strong information base of both the physical and socio-economic parameters, as well as constant monitoring and updating of that information base at all stages of the urban planning process, is a necessary prerequisite. Such an information base should necessarily include data on urban sprawl, growth rates, demographic data and other relevant environmental information, as well as the availability of financial resources for urban projects. Based on that information, a clear description of an urban setting can be deduced and optimal expansion of commercial activities, industrial establishments, service facilities, residential complexes and other facilities can be planned in a coherent and well thought out manner, taking fully into account the existing state of the urban environment and its capability to accommodate new pressure from expansion. Such comprehensive planning should seek to promote a better quality of life for all.

18. Conversion of agricultural lands into urban habitat and industrial complexes is inevitable as urban areas expand. A study of the impact of growth patterns and intensity of land use on the environment is the most basic requirement for any urban/rural or regional plan. However, the task of urban land-use mapping using conventional methods is very time-consuming and expensive and often has to start with preparation of the base map itself. The easy availability of synoptic and repetitive images acquired through satellites has drastically changed that situation by effectively replacing the traditional methods of urban land-usage mapping as a result of their versatility, timeliness and ability to detect change. Remote-sensing data, utilizing both airborne and space-borne sensors, have the added advantage of providing additional information on environmental, geomorphological features, soil moisture and infrastructural growth.

D. Meteorology and water resources

19. Agriculture, construction, transportation and energy industries are dependent on accurate short- and long-term weather forecasting. Accordingly, achieving a higher degree of reliability in the forecasting of global weather has a profound bearing on the world economy. The range of activities for meteorological services over the last decade has progressively been extended from traditional weather forecasting to the support of climate and environmental research and monitoring. Satellite observations for operational meteorology have been in use for over 30 years and a full-scale satellite-based global observing system has been maintained through a worldwide cooperative effort since 1979. In addition, operational meteorology provides support to hydrological and agricultural development projects all over the world.

20. The advent of weather satellites in the 1960s and the Earth resource satellites of the 1970s created opportunities for man to improve his knowledge of environmental resources. One of the best known uses of outer space is the ability to monitor the location and intensity of meteorological phenomena, especially natural disasters such as tropical cyclones, severe thunderstorms and tornadoes, bush fires, floods, sand storms and desert locust infestations. Forecasting activities are highly dependent on the quality of the satellite information received, owing to the limited coverage achievable from ground-based observation networks and limited transmission facilities.

21. Data from polar and geostationary orbiting meteorological satellites have also proved quite useful for continuous monitoring of weather systems for better forecasting. The data generated from such satellites has made it possible to follow weather systems from their inception to their interaction with global and regional flows. Satellite observation studies have been used in tandem with ground-based radar data to study the formation and convective activity of thunderstorms as well as squalls, frontal boundaries, cirrus outflows and jet streams.

22. Global energy availability, climate and weather, the hydrological and carbon cycles and atmospheric and physical processes are all critically influenced by the properties and processes of the oceans. The oceans are also a vast source of living and non-living resources. As the physical and ecological degradation of coastal areas accelerates, a cause of coastal management problems can be traced to the growth of human populations and their economic activities. The rapid development of coastal settlements, expansion of recreational areas and centres of maritime transport and the concentration of industrial development along coastlines have all contributed to accelerated coastal degradation.

23. It is important to note that hydro-geomorphological maps containing groundwater information can also be developed with the aid of remote sensing. That information can be used to help villages without other information sources to find adequate water resources. The amount of water available for irrigation and energy production can also be calculated from area measurements and depth readings taken to form topographic maps. It should be noted that most of the developing countries are in the arid and semi-arid tropics and subtropics where the water capabilities of the land are much lower and precipitation occurs less than 100 days a year. Such maps would therefore be of significant use to those countries.

24. Additionally, there are remote-sensing applications in the field of hydrology. Besides irrigation, one could address problems associated with the development, planning and construction of hydroelectric power plants, engineering works on river beds and the creation of water reservoirs to ensure the provision of drinking water to local populations. Optimal management of water becomes particularly crucial in the dry land tracts of tropical countries where most of the precipitation occurs in a short time-span, as compared with mid-latitude countries where snow and rain precipitation can continue for over eight months in any given year. With the added problem of higher temperature regimes and greater evapo-transpiration rates, the need for optimal harvesting of run-off and recharging of underground aquifers in tropical countries is of paramount importance. Even with the adoption of optimal land and water management practices, because of the oxidation of organic matter, the intensive weathering processes that cause phosphorous depletion and the leaching action of heavy tropical rains, the maximum yield achievable in tropical countries is limited to about two thirds of what can be achieved in temperate zones.

25. Remote sensing can also be utilized for snow-mapping purposes. Snow mapping is extremely important in assessing available surface water. Since snow-covered areas are easily differentiated on satellite imagery, the extent of mountain snow pack is easily measured, thus facilitating its management as a water resource.

26. Experience gained over generations by fishermen around the world shows that information on features such as water colour, turbidity, state of the sea, wave size and direction, wind patterns and other climatic features has a direct influence on fishing strategies. Taking this into consideration, attempts have been made to utilize satellite-based remote sensing for the identification and exploration of potential fishing grounds in order to maximize fish catch. Techniques have been developed to chart observable environmental parameters through data from various space-borne sensors. Remote-sensing satellites, with their capability to cover large areas over oceans on a repetitive basis, have proved to be of substantial economic benefit, in particular for nations with a long coastline. Such technology provides information that is essential for proper harvesting, conservation and mapping of valuable fishery resources.

E. Disaster management

27. Because of its synoptic and repetitive nature, observation of the Earth from space provides one of the most effective tools for gaining an understanding of and predicting the continuous changes to Earth brought about by

natural and man-made causes. Various kinds of satellites, including communications, meteorology, remote-sensing and geophysics satellites are, or may become, useful in disaster prevention, monitoring and mitigation. The most important application of those satellites is the detection and delivery of early warning of impending disasters and dissemination of information on hazardous situations to those in need in order to minimize the possible loss of life and damage to property and to facilitate timely rescue, relief and any other required assistance.

28. Natural disasters such as cyclones, floods, earthquakes, droughts and other extreme events cause suffering, hardship and loss of life, as well as damage to property. With a world population expected to reach 10 billion by the middle of the twenty-first century, the number of people affected by natural disasters will be far larger than at present. Statistics show that, for the period from 1967 to 1991, extreme meteorological and hydrological events accounted for about 70 per cent of all events recorded as natural disasters. During the same period, about 3.5 million people were killed by meteorological and hydrological events, while some 2.8 billion were affected by them. With the advent of satellite technology, enormous progress has been achieved in ensuring the safety of human lives and of property. Images from meteorological satellites have contributed to the improved monitoring and forecasting of natural disasters and to the successful implementation of the International Decade for Natural Disaster Reduction.

29. About 80 tropical cyclones occur around the world each year. Average annual damage estimated at about US$ 1,500 million has been accompanied by great loss of life. Since the 1960s, the number of fatalities due to hurricanes has been significantly reduced. While 1,100 fatalities were reported prior to the 1960s, the average number of fatalities has dropped to over 300 in the United States of America. This can be attributed in part to the availability of the polar orbiting Television Infrared Observation Satellite (TIROS) and the launch of the Advanced Technology Satellite (ATS-1), the prototype of the geostationary satellite series.

30. Floods are among the most violent of natural disasters and are notorious for causing the greatest damage. In 1991 the floods on the Yangtze River in China destroyed over 4 million dwellings, while the damage caused by the Mississippi floods in the United States is estimated at over US$ 10 billion.

31. Hydrologists collaborate with meteorologists to ensure that they have access to the real-time weather data needed to provide forecasts with as much lead time as possible. Satellite imagery from geostationary satellites such as Meteosat and remote-sensing data from land remote-sensing satellites (LANDSAT) form an intrinsic part of the data needed for accurate hydrological forecasts, which can contribute significantly to lessening the devastating impact of floods and to improving the management of water resources. Case studies in several countries have shown that flood forecasts and warnings can reduce damage by between 6 and 40 per cent.

32. In central and south-east Asia alone, over 400 million people live in cities that are threatened by earthquakes with a magnitude of 7 on the Richter scale. Satellite observations offer a powerful means of obtaining information about the location of earthquakes on Earth. Precise measurements make it possible to monitor the earth movements associated with earthquakes and may also make possible the prediction of such natural phenomena.

33. Bordering the world's deserts is a wide zone of semi-arid and sub-humid land supporting a large human population. That zone is prone to situations of acute distress and tragic famine. Space technology can be used in the monitoring and management of such areas that are subject to drought and desertification. In fact, the successful implementation of the United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa, depends to a large extent on the application of space technology.

F. Agriculture and food security

34. Agriculture is weather-sensitive and a major user of meteorological services. Satellite information, in the form of vegetation indices, helps to determine the vegetation cover and the state of natural pastureland. Such information over large pasturelands allows proper planning of the land's animal-carrying capacity in order to avoid overgrazing

and subsequent desertification. The use of satellite information could result in eliminating the use of expensive ground patrols over vast desert and semi-arid areas.

35. By using meteorological satellite and *in situ* data, it is possible to predict the yield rates of various crops. Such a development serves as a vital tool for the planner and decision maker in determining the fluctuations of a nation's agricultural production and in assessing the level of its food security.

G. Atmospheric pollution

36. The total ozone measurements made by payloads on board various satellites have contributed to the continuous monitoring of the ozone layer. The information acquired contributed to the adoption of the Vienna Convention for the Protection of the Ozone Layer and has also contributed to the subsequent Montreal Protocol on Substances that Deplete the Ozone Layer and the amendments to it.

37. In recent years, there have been several incidents when materials released into the atmosphere have affected large numbers of people, as was the case in the Bhopal and Chernobyl accidents. The hazardous materials emitted during those accidents were dispersed by the varying levels of wind in the atmosphere. National plans to respond to such emergencies and to predict in advance the areas that will be affected require substantial assistance from the meteorological community. Tests have shown that notification of a nuclear accident transmitted to the World Meteorological Organization's (WMO) Global Telecommunication System by the International Atomic Energy Agency in Vienna can be received by most members of WMO within half an hour. The Global Telecommunication System of the WMO World Weather Watch programme is highly dependent on satellite-based links and connections.

H. Oceanographic monitoring

38. Satellite-acquired data can also be used to exploit the world's oceans, which are among the most valuable of nature's resources. Data obtained from satellite observations can be used with increased accuracy to monitor ocean current circulation, wind velocity, ice coverage and wave height and direction. Such facilities have spawned a number of new applications, such as providing information for long-term weather forecasting, fishing, ensuring the safety of shipping, monitoring pollution to support the protection of coastal and maritime wildlife, and monitoring of ocean current movements to support deep-water oil exploration and other drilling operations at sea.

39. The continuous monitoring of the Earth by satellites has resulted in the availability of a large quantity of data about the planet's climate system. Furthermore, the continuous monitoring of the temperature of the sea's surface over the oceans of the world, in particular the Pacific, has enabled researchers to understand better the El Niño phenomenon and to apply the knowledge gained to the production of more accurate forecasts.

III. COMMUNICATIONS

A. Space communications for development

40. Satellites now constitute a prime vehicle for long-distance communications, television broadcasting, private data networks, maritime communications and disaster relief networks. Despite the initial financial costs, the establishment of a satellite system can be an efficient and economical solution to the problem of providing communications to vast areas, because distance has no effect on the cost of providing a satellite service. It is far easier and more cost-effective to build satellite ground stations and to use satellite links than to establish the infrastructure for ground-based microwave systems, in particular over large geographical distances and in difficult terrain. In addition, the implementation of a satellite system offers enormous social and economic benefits. Communications satellites can provide tele-education and tele-medicine services by transmitting educational programmes and medical information directly to remotely located rural villages. In terms of national sovereignty, satellites can be used to transmit vital information as well as to promote social integration by providing a means for

the exchange of information between people in remote and urban areas. Satellites have become indispensable elements for the expansion of integrated digital networks, video programme delivery and land and maritime mobile communications.

41. Communications are no longer only a medium of interpersonal expression but have also become the means to gain access to information throughout the world. There is a strong correlation between telephone density and development. Today's communications markets clearly demonstrate the importance of establishing and maintaining a communications infrastructure as a key to the societal and economic development of a country.

42. Currently, practically every country in the world benefits from a variety of communications services through participation in international, regional or domestic satellite communications systems. Indeed, satellite communications technology is now recognized as a critical tool for social and economic development as advances in technology continue to lower the cost of its applications.

43. Communications satellites are used for a wide variety of purposes, including rural and wireless communication, news and data dissemination, emergency communications, navigation, disaster warning, distribution of television and radio programmes, search and rescue, tele-medicine and remote education. Satellite communication has created an enormous number of opportunities that can enhance economic development. Moreover, those benefits have the potential to be accessed by all sections of society and to further their sustainable development.

44. Communications satellites epitomize the reality of two phenomena, the "global village" and the "information age". Satellites can bring the power of information to virtually everyone on Earth and enable individuals to share experiences instantaneously. Modern telecommunications and electronic information systems are an indispensable tool in the continuing quest to meet basic human needs. Information technology, in general, is a great social leveller, which can help eliminate social barriers and overcome economic inequalities. Modern telecommunications are as critical and fundamental to the sustainable development of developing countries as any other basic necessity.

45. In many developing countries where terrestrial systems are underdeveloped or even non-existent, satellite communications services, which have witnessed rapid advances in the last three decades, are of particular importance. The most significant contribution of satellites is to bring basic communications to the people. Accordingly, the developing countries could disregard the costly wired infrastructure typical of the twentieth century and proceed directly to the global information infrastructure of the twenty-first century. This approach to information flow will stimulate the economy and the national growth of each country. Satellite communications have been a major factor in facilitating the establishment and continuing expansion of the Internet and the WorldWide Web it has created.

46. As noted above, the satellite market combined with the deregulation of the world's telecommunications and the instant infrastructure offered by satellites are together creating an unprecedented growth for satellite telecommunication services. The deployment of geostationary satellite systems and constellations of low-Earth-orbit satellite systems promises to bring low-cost access to even the most remote areas of the world. Such access by the world's population to telephony, high-speed data, the Internet, the distribution of video signals for cable and television programmers and other multimedia services will make the "global village" a reality. Society at large will greatly benefit from remote access to a large variety of services in the fields of medicine (tele-surgery and tele-diagnosis) and education (tele-teaching).

B. Education and awareness

47. In comparing the rate of illiteracy with the national per capita gross income, there is a clear indication of the strong linkage between socio-economic factors and illiteracy. Least developed countries with illiteracy rates of 70 to 80 per cent have a national per capita gross income below US$ 200 per year. Developing countries with 30 to 50 per cent illiteracy rates show a national per capita gross income of US$ 600 per year. Industrialized countries, where illiteracy is less than 2 per cent, have a national per capita income of more than US$ 8,000 per year. Industrialized

countries that have a clear appreciation of the role of education in socio-economic development are spending a considerable amount of resources to accelerate the development of education at all levels. Thus existing socio-economic imbalances between industrialized and developing countries are intimately related to significant variances in investment in education.

48. Education is essential for human improvement and the eradication of illiteracy. Poor educational facilities and non-availability of trained teachers, combined with rampant poverty, have further contributed to the continued growth of illiteracy. The fact that the majority of the illiterate in developing countries live in dispersed and remote rural areas makes eradication of illiteracy one of the greatest challenges facing humanity. Sustained training programmes are needed at different levels, starting from the schools to the professionals involved in developmental activities. Multi-tiered training and education programmes of different duration, and in different areas, may be called for, which may in turn require the establishment of operational training facilities within a region. Moreover, the contribution of space applications to capacity-building will only function if individuals are trained and educated in the basics of specific space application technologies. The involvement of end-user agencies to ensure that space applications are a part of the mainstream of developmental and implementation activities would also be necessary. This would entail making the user agencies aware of the potentials of the technology and involving them in the overall system and conduct of projects in a collaborative manner.

49. Education is very critical for sustainable development, economic growth and poverty reduction. Changing technologies and economic reforms have created dramatic shifts in the structure of economies, industries and labour markets throughout the world. The Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82), held at Vienna from 9 to 21 August 1982, considered the implications of satellite communications technology and, in particular, of direct-broadcasting satellite technology, which remains a primary means of delivering instructional television programmes for educational purposes, and the possibility of regional or international cooperation. In order to improve the educational infrastructure in developing countries, UNISPACE 82 noted that the requirements were not only to educate the young, but also to provide continuing sources of information and knowledge to the adult population.

50. Satellite broadcasting has made major strides since UNISPACE 82. Direct-to-home systems are now operational, so television channels can be received using small parabolic dishes.

51. Following the conclusion of UNISPACE 82 and in response to its recommendations, the Office for Outer Space Affairs of the Secretariat initiated, under the auspices of the United Nations Programme on Space Applications, the establishment of regional centres for space science and technology education in the developing countries. The General Assembly, in its resolution 45/72 of 11 December 1990, endorsed the recommendation of the Working Group of the Whole of the Scientific and Technical Subcommittee, as endorsed by the Committee on the Peaceful Uses of Outer Space, that the United Nations should lead, with the active support of its specialized agencies and other international organizations, an international effort to establish regional centres for space science and technology education in existing national/regional educational institutions in the developing countries. That decision was taken in recognition that an essential prerequisite for the successful implementation of space technology applications is the building of various essential indigenous capacities, in particular human resources, within each region.

IV. NAVIGATION

52. The use of navigation services by maritime, aeronautical and land-based system operators has been significantly affected by the expanding role of navigation satellite services. In addition, private users have begun to use navigational services for the determination of position in private yachting, cross-country recreational activities and in general aviation. Such services, originally developed for military applications, have rapidly expanded into numerous applications for the peaceful use of outer space. Commercial maritime fleet operators, rail and trucking system operators and, in some countries, automobile manufacturers have made increasing use of navigational satellite services to support their commercial operations. Recreational uses have grown more rapidly than any forecasts had predicted. Several nations are now investing in new and expanded systems to provide global position-determination services on a regular and possibly competitive basis.

53. In developing countries, in particular those of the Pacific Basin, the use of navigational satellites has expanded to support local and regional commercial fishing operations. Some commercial airlines now offer passengers continual visual displays showing the aircraft location, air and ground speeds and anticipated time of arrival of transoceanic flights at their intended destinations. Search and rescue operations are greatly enhanced by the ability to fix precisely the location of rescue teams in relation to rescue calls in remote areas.

54. The entire scope of navigational satellite services is being determined by a user community that is still learning the potential applications of the new technology. In developing countries, the technology can assist the development of fishing industries, the more precise management of rolling stock on rails or roads and the better management of maritime and aeronautical operations. Navigational services are available at a fraction of the costs that once prevailed, primarily because of the cost-effectiveness of satellite systems providing services to large areas of the Earth's surface where such services were not previously available or were of relatively low precision compared with the services available by satellite today.

V. SPACE EXPLORATION PROGRAMMES

55. The synergies of advanced research in biology, chemistry and physics necessary for human space flight have generated an extraordinary number and range of inventions, stimulated thought about the meaning of life, history and our common future and created many opportunities for peaceful international cooperation. Space-related inventions have created new industries and tax sources for social programmes, improved living standards, expanded access to tools by miniaturization and production processes that have lowered the cost of many technologies from satellite communications to medical diagnostic techniques and information-processing systems.

56. However, it is more difficult to justify human space flight based on direct economic benefits alone. The high cost of putting payloads into space has been identified as one of the biggest barriers. New technology allows reductions in the mass, size and cost of robotic spacecraft. However, there are fundamental problems in applying the same approach to human space missions. The primary reasons are safety and security for the human crew, which should not be compromised at any cost and the minimum physical size and mass required to sustain a human crew.

57. Since the Apollo missions to the Moon, human activities in space have been confined to low-Earth-orbit research where they have focused mainly on learning how to live and work in space, a precondition for future long-duration space travel, a possible return to the Moon and venturing out to establish outposts on other planets. Unless we succeed in drastically reducing the cost of launching payloads into space and learning to utilize *in situ* resources for planetary missions or for large-scale manufacturing in space, it will be difficult to conduct human space missions on a reasonably cost-effective basis.

58. Human spaceflight catches the imagination of people around the world. Former adversaries are now working together to build mankind's largest outpost in space, the international space station. That undertaking, while not without its problems, will ultimately teach us how to work and live routinely in space and will prepare for our venture into outer space.

59. An increasing number of private ventures are working actively on how to provide cheap access to space. It is anticipated that a cost reduction by a factor of 10 will contribute to encouraging the development of a space tourism industry and possibly lay the foundation for larger-scale manufacturing and resource utilization of space with direct benefits to Earth.

VI. TECHNOLOGY SPIN-OFFS

60. In addition to the impact of space activities on business and on our daily lives, there are numerous socio-economic benefits, intangible by nature, that are derived directly from scientific and space exploration missions. Based on the acquisition and the transfer of scientific knowledge, understanding of basic phenomena and mechanisms of physics can be improved and better strategies developed to understand, monitor and protect man's environment. As regards the indirect effects of such scientific programmes, there are a large number of technologies that have a spin-off towards applications in medicine, information technology and industrial productivity.

Medical industry

61. For nearly 30 years, the National Aeronautics and Space Administration of the United States has established a bridge between space activities and research in the medical field. Very often ignored, a number of applications derived from space technology have influenced areas such as biomedical instrumentation, cardiology, surgery and medical imagery.

62. The Spacelab laboratory, placed in the cargo bay of the United States Space Shuttle, and the manned space programme on the Russian Mir station have both contributed to developing European expertise and knowledge in space life science and in particular in human physiology. Scientists have acquired a better understanding of the effects of low gravity on the physiological and neurophysiological system, such as variation in bone density and bone loss during missions of long duration.

63. One example of a successful case is the articulated wrist, developed on the basis of a small robot used to manipulate samples during an experiment in space. The instrument will be adapted as a medical tool in endoscopic surgery.

64. Another example is the "mama goose pyjama", designed for astronaut suits and equipped with body position sensors, which has been adapted for monitoring the position of newly born babies exposed to the risk of the sudden death syndrome. The equipment monitors the position of the subject in relation to vital parameters, such as heart pulse rate, respiration and blood pressure.

65. To facilitate the dialogue between physicians and space industry, in early 1996 the European Space Agency created an association named Promotion of Medical Use of Space (PROMEDUS), which disseminates information about space technology and ongoing projects with the space industry, with the objective of stimulating technology transfer from space to medical applications. The Agency has invited physicians, medical research organizations, hospitals and the biomedical industry to become active members of this association, and thereby to interact with the space industry.

Automotive industry

66. The dialogue between the space industry and the automotive industry has existed for many years. However, apart from a few well-known examples, such as the air bag, the anti-brake-locking system and the electromagnetic compatibility test facilities, technology transfer from aerospace to the automotive sector has been marginal. Economic constraints driven by tight production costs and short design and manufacturing lead time have contributed in making space technology inaccessible for production in mass series. Only sport cars, experimental electric cars and luxury vehicles have so far been targeted as test beds for new technologies emerging from space. Such technologies are very specialized and usually only interest the car component companies in specific fields such as motorization, batteries, brakes, sensors and navigational systems. In initiating an effort to promote the transfer of

technology from space to the automotive sector, the space agencies and the manufacturers of car components have identified three major areas of interest: energy and environment, safety and security, and comfort and ergonomy. Space technology is already taking part in the challenge of developing the "car of tomorrow" for the new millennium: a zero-emission car that will operate with significantly reduced impact on the environment and fully exploit telematics technology and advanced information systems.

Other sectors

67. Several other targeted initiatives are in the field of textile manufacture and textile design. Among other more "exotic" technologies is the "artificial nose", a software developed for a space experiment designed to monitor carbon dioxide emission from a plant growth experiment in microgravity. Several applications for the software have been found in the fields of cosmetics and wine and food conservation. The software has been adapted to recognize several "smell profiles" and is used to monitor the quality of fresh food or quality level of wine over long periods of conservation.

68. Initiatives started in 1997 target the fields of environment, energy and the marine industry. The objective of those initiatives is to identify the needs in those areas and the potential space technologies that could offer a technical solution or added value for operations in harsh terrestrial and marine conditions. This requires the development of new measuring techniques and instruments for oil and gas industry operations, mining operations and marine/submarine inspections and maintenance. The approach taken was to bring together experts from the various industrial domains involved and the space industry in specialized seminars to address that objective.

69. A similar approach is going to be applied in the field of detection, cartography and removal of anti-personnel landmines. The objective is to review the state-of-the-art technology already in use or proposed for demining, reviewing it in relation to the needs expressed by the different experts and demining organizations and then assessing if a particular space technology or technique or a group of technologies derived from space programmes can be proposed as complementary tools.

VII. ISSUES OF INTEREST TO MEMBER STATES

70. Developing countries need to develop their indigenous capacity-building in a continuous and systematic manner by providing the necessary education and training for their people, setting up appropriate local infrastructure and promoting a meaningful role for private industry.

71. Developing countries, in particular those faced with major social problems, need not only to formulate plans of action that promote important production objectives and improve existing living conditions, but also to draw up contingency plans for future growth that do not place further stress on already deficient infrastructures. Furthermore, developing countries must also be cognizant of and plan for increasingly acute environmental problems that can and may well inhibit their work towards sustainable development.

72. Although satellite remote sensing and other relevant space applications are not the total answer to many of the problems that plague development, that technology offers a tremendous potential to many users interested in continuing the development process. In the present age of sustainable, long-term development, it is essential for policy makers, planners and designers alike to take into account all the factors that may enhance and further the development of each and every country to the benefit of all the inhabitants of the Earth and indeed of all future generations.