UNITED
NATIONS

A

General Assembly

Distr.
GENERAL

A/AC.105/703
16 June 1998

COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE

REGIONAL CENTRES FOR SPACE SCIENCE AND TECHNOLOGY EDUCATION (AFFILIATED TO THE UNITED NATIONS)

CONTENTS

V.98-54416 (E)

INTRODUCTION

1. Between 1985 and 1989, the Office for Outer Space Affairs of the Secretariat, through the United Nations Programme on Space Applications, organized three regional meetings and one international meeting on the subject of the development of indigenous capability in space science and technology at the local level. Those meetings were held at Ahmedabad, India (1985), at Mexico City (1986), at Lagos, Nigeria (1987), and at Dundee, United Kingdom of Great Britain and Northern Ireland (1989). The participants in those meetings concluded that in order for developing countries to effectively contribute to the solution of global, regional and national environmental and resource management problems, there was an urgent need for a higher level of knowledge and expertise in the relevant disciplines by educators as well as by research and application scientists in those countries. Such capabilities, they further noted, could only be acquired through long-term intensive education.

2. In support of the above-mentioned objectives, the General Assembly, in its resolution 45/72 of 11 December 1990, endorsed the recommendation of 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” (A/AC.105/456, annex II, para. 4 (n)).

3. In order to translate the recommendations of the Committee and the General Assembly into an operational programme, the Programme on Space Applications initiated a project aimed at the establishment of regional centres for space science and technology education at existing research and higher-education institutions in each of the following regions covered by the United Nations regional economic commissions: Africa; Asia and the Pacific; Latin America and the Caribbean; and western Asia. A network of space science and technology education and research institutions was established in 1996 for Member States of central eastern and south- eastern Europe.

4. Each centre is conceived as an institution that should offer the best possible education, research and applications programmes, as well as opportunities and experience to the participants in all its programmes. Thus, the principal goal of each centre is the development of the skills and knowledge of university educators and research and applications scientists, through rigorous theory, research, applications, field exercises and pilot projects in those aspects of space science and technology that can contribute to sustainable development in each country.

5. The initial programmes of each centre should focus on: remote sensing; meteorological satellite applications; satellite communications; and space and atmospheric sciences. Its data management unit should be linked to existing and future relevant global databases. Each centre should also foster continuing education programmes for its graduates and awareness programmes for policy and decision makers and for the general public.

6. In order for the centres to become model institutions that are respected both within their regions and around the world, they would need to meet internationally recognized standards. To promote the achievement of those aims, the United Nations Programme on Space Applications has developed model curricula on the basis of input made by prominent educators participating in the United Nations/Spain Meeting of Experts on the Development of Education Curricula for the Regional Centres for Space Science and Technology Education, held at Granada, Spain, from 27 February to 3 March 1995. The model curricula were published in a booklet entitled “Centres for space science and technology education—education curricula” (A/AC.105/649) in 1996.

I. INFRASTRUCTURE AND ORGANIZATION OF THE CENTRES

A. Work programme and model curricula

7. As laid out in document A/AC.105/649, the activities at each centre will be undertaken in two major phases. Phase 1 will emphasize the development and enhancement of the knowledge and skills of university educators and research and applications scientists in both the physical and natural sciences as well as in analytical disciplines. Those activities will be accomplished through rigorous theory, research, applications and field exercises over a nine-month period. Phase 2 will focus on ensuring that all participating scholars make use of the skills and knowledge gained in phase 1 in their pilot projects.

8. Each centre will also foster continuing education programmes for its graduates and awareness programmes for policy and decision makers and the general public in its region.

9. The model curricula for the centres provide for a two- to three-month obligatory common curriculum for all participating scholars, and a six- to seven-month individual curriculum in remote sensing, meteorological satellite applications, satellite communications, and space and atmospheric sciences. Thereafter, each participating scholar will carry out a 12-month project in his or her own country, where and when the knowledge gained at the centre would need to be put into practical use.

10. In addition to providing opportunities for each scholar to gain necessary knowledge, research experience and application skills in his or her chosen area of space science and technology, the programme of each centre also requires the scholars to complete an obligatory common assignment, which is the same for all participating scholars; that is a prerequisite for the enrolment of each scholar in his or her chosen field of study. The common module will provide all the scholars with an overview of the observation of the Earth and its environment from space and the use of data collected in such a process in atmospheric and terrestrial analysis. The obligatory programme will also expose the scholars to the physical principles of remote sensing, satellite orbital characteristics, operational sensors, satellite and ground-based communications, the impact of global positioning satellites on the integration and construction of remote sensing and geographical information system databases and the demonstration of selected environmental applications.

11. Each centre will aspire to be a highly reputable regional institution, which, as the needs arise, and as directed by its governing board, will grow into a network of specialized and internationally acclaimed affiliate nodes. The centres and their nodes will earn that badge of honour through their contributions to the development of technologies that are appropriate to the solutions of the problems of their respective regions and to the advancement of knowledge in the ever-expanding field of space science and technology. The model curricula for the centres provide the benchmark of the academic and performance level necessary to maintain the international standard and character needed for the attainment of international recognition.

B. Data management

12. An integral part of each of the centres for space science and technology education is a data management unit. Through such a unit, each centre will have direct linkages with existing relevant global data centres. Such linkages will enable the participating scholars to gain access to and utilize the data in the archives of a variety of databases, particularly when undertaking projects and activities that could benefit from such access. The functions of the data management unit would also include data collection, key entry, programming, operations and maintenance of data files, programs and hardware. To promote the achievement of those functions, the United Nations Programme on Space Applications recommended software packages for data analysis and image processing on the basis of input made by research and applications scientists at the United Nations/European Space Agency/Committee on Space Research Workshop on Data Analysis Techniques, hosted by the Brazilian National Institute for Space Research on

behalf of the Government of Brazil, held at São José dos Campos, Brazil, from 10 to 14 November 1997. The recommendations of the Workshop are contained in document A/AC.105/687.

C. Participating scholars

13. A sound academic background, experience and aptitude of each aspiring applicant for engaging in the different activities of the centre cannot be overstressed. The richness of those attributes will have a positive impact on the performance of the applicant at the centre. To that end, each applicant (university educator and research or application scientists) should have obtained, from an internationally recognized university/institution, a minimum of a master’s degree relevant to his or her chosen field of study, followed by a minimum of five years of relevant practical/working experience. An applicant with a Ph.D. degree, relevant to his or her chosen field of study, and from an internationally recognized university/institution, should also have completed a minimum of three years of practical/working experience.

14. Of equal importance is the future of the participating scholars in their own countries upon completion of their studies at the centres. It should be emphasized that the overall mission of the centres is to assist participating countries in developing and enhancing the knowledge and skills of their citizens in relevant aspects of space science and technology in order that such individuals can effectively contribute to national development programmes. In order to ensure that appropriate and rewarding employment opportunities exist for the returning scholars, the sponsoring Governments and institutions are obliged to: sponsor development-oriented activities that will gainfully utilize the newly acquired knowledge and skills of the returning scholars; and provide appropriate infrastructure and undertake requisite preparations and plans for their career on a long-term basis. The sponsoring Governments are also obliged to guarantee that a returning scholar would remain in such a position with commensurate and progressive remuneration and other entitlements for a minimum of three to five years.

D. Governing board

15. Because resolution 45/72 specifically limits the role of the United Nations to lead international efforts to establish the centres, it is apparent that once any of the centres is inaugurated, its governing board will assume all decision-making and policy formulation responsibilities for the centre.

16. In the context of the centres, the governing board of each centre oversees all aspects of the centre. It consists of member States (within the region where the centre is located) that have agreed, through their endorsement of the agreement establishing the centre, to the goals and objectives of the centre, and are committed to work, in cooperation with one another, for the well-being of the centre. A governing board is necessary for each of the centres because member States and their own citizens are more familiar with their own peculiar needs, aspirations, capabilities and resources and are better equipped to find solutions to local problems that may surface. And because such a centre has evolved through the efforts of the United Nations, the latter, including the relevant regional economic commissions, will serve the centre and its governing board in an advisory capacity.

II. CURRICULA FOR SPACE SCIENCE AND TECHNOLOGY EDUCATION

17. At any given point in the history of humankind, scientists and engineers possess an array of knowledge, skills and practices and a variety of instruments, all of which are built up over time. Over the last 50 years, there has been an accumulation of knowledge and an enormous corpus of scientific literature on space science and technology. The transmission of such knowledge and information to students via education and training demands that a vibrant curriculum of studies be organized at all levels within educational systems. It must be noted, however, that the condition of education (elementary, secondary and tertiary) varies significantly across countries, and across institutions within the same country. Those different conditions lead to differences between countries, and within each country, in space science and technology curricula in terms of course content and modes of presentation of

course materials. From time to time, elements of space science and technology have become a part of regular education curricula in industrialized (especially spacefaring) countries. In other countries, it is necessary to prepare remedial and enrichment packages based on specific areas in this discipline to complement existing curricula in the sciences.

18. Education and training at the tertiary level, especially at the postgraduate level, often place emphasis on the new developments in space science and technology, the applications of new technologies and the acquisition, processing, interpretation and management of data. Training at the graduate level also requires motivation of students to infuse the knowledge acquired into research projects. Students at that level are often from varying intellectual origins and are at different levels of preparedness. Remedial measures aimed at filling the gaps in background knowledge are therefore required to ensure that students benefit from the course. Diagnostic tests and exploratory lectures can be given to assess specific areas of inadequacy. What is expected of all the students is cognitive and linguistic capacities, ability for reflective thinking and a general background in science subjects. In science-based programmes in general, there is always a gap between original ideas that guide the development of the curriculum and the translation of the curriculum into practical terms. The gap varies from country to country depending on the availability of instructional materials necessary to translate ideas into practice.

19. The following four major disciplines are commonly identified in the education and training programmes of space science and technology at the postgraduate level: remote sensing; satellite communications; meteorological satellite applications; and space and atmospheric sciences.

A. Remote sensing

20. A remote sensing applications programme is a particularly important component in space science and technology education. It stresses the fact that remotely sensed data provide an ideal view of Earth for many studies that require synoptic or periodic observations, such as inventory, surveying and monitoring in agriculture, forestry, range management, geology, water resources and the urban environment.

21. Remote sensing observations make use not only of visible light, but also of several other regions of the electromagnetic spectrum, such as the infrared, thermal and microwave regions. Different techniques may be required to handle and analyse the different types of data. Much of the data is in digital form and can be processed using digital imaging and data analysis techniques to improve the visual appearance or to extract the required information.

22. Such a programme covers the technology of image acquisition, digital image processing, geographical information systems, ground data collection and use, image interpretation, project planning and management. The programme also includes practical work and offers participants the opportunity to acquire proficiency in the use of image processing and geographical information systems software.

23. Commonly, the first part of the programme is broadly based in order to give participants exposure to different techniques, instrumentation and types of data. A thorough background in the physical principles involved is provided. In the second part of the programme, participants explore different applications of remote sensing and specialize in specific applications to suit their own experience or needs.

B. Satellite communications

24. The satellite communications programme is suited to developing the skills of university educators, researchers, telecommunication professionals, government personnel and others in the field of satellite communications and its applications to broadcasting, telecommunications, health care, education, disaster management and mitigation, positioning and search and rescue operations. It aims at assisting in the preparation of satellite-based communications projects, the definition of policy, the establishment of communications systems and the integration of advances in communication technology into day-to-day activities. A major element of the programme consists in

ways and means of developing and enhancing public awareness regarding the benefits of satellite-based communications technologies in the improvement of the quality of life.

C. Meteorological satellite applications

25. The meteorological satellite applications programme is a specific component of space science and technology education. It stresses the fact that, while meteorological satellites have operated in space for over three decades, the majority of the scientific, professional and educational communities of the world are still unaware that observations from those satellites are freely accessible, and that they can be applied, directly or combined with other information, to benefit large segments of the population of a country or to help resolve specific problems affecting those populations, especially where the saving of lives, the protection of property or the responsible management of natural resources may be involved.

26. Meteorological satellites have been operating almost continuously since the beginning of the space age. Their continuing presence in space for decades to come is virtually assured, because of the importance that society at large places on the observation and forecasting of weather phenomena. The spacecraft have been launched by various States specifically to meet their own needs. However, most weather-satellite-launching States have designed their satellites to operate in such a manner that anyone, anywhere on Earth, who is within radio receiving range of the satellites can acquire the data free and use the data thus obtained. Real-time, direct read-out observations from those satellites are therefore being used as educational or training resources in schools. Such observations can also be used as a tool for analysing weather patterns; for weather forecasting and forest-fire detection, to support air, sea and land transportation; to support agricultural and fishing interests; and for a wide range of other purposes, including the planning of construction activities.

27. As practised today, the global access to meteorological satellite data was an initiative of the World Meteorological Organization; it was conceived to help ensure that knowledge of aerospace sciences and technologies that have evolved as a result of free access to meteorological satellite observations can, and will be, utilized by many more individuals, organizations and States, particularly developing countries. That is achieved by endowing a core group of specialists in different countries with the analytical skills and technical knowledge that will enable them to instigate and sustain a wide variety of indigenous programmes in which technology supports scientific, economic, educational and humanitarian programmes that will enhance the quality of life for broad segments of the population.

D. Space and atmospheric sciences

28. With the rapid degradation of the environment, it has become vital for all countries of the world to concentrate on a better understanding of atmospheric dynamics, including the interaction of the atmosphere with land mass and oceans. Realizing the gravity of the situation, the United Nations Conference on Environment and Development, held at Rio de Janeiro, Brazil, from 3 to 14 June 1992, proposed as part of its Agenda 21 a series of measures for addressing environmental conservation. The curriculum developed for the centres outlines basic elements in that field which can be introduced into educational curricula at the postgraduate level.

29. Yet on another level, space technology has made tremendous strides and its impact has been felt in a broad variety of sectors, especially those relating to natural resources and environment, meteorology and communications. Because spacecraft operate in space and receive, as well as transmit, electromagnetic signals through space and the atmosphere, the development of space technology and consequently its applications can be greatly enhanced through a deeper understanding of atmospheric science.

30. The atmosphere of Earth is opaque to most types of electromagnetic radiation. Only visible light and radio waves from the cosmos can be detected at sea level. Even from mountain tops, access is gained only to some infrared and microwave radiation. For most of the infrared and the ultraviolet, X-rays and gamma rays, instruments need to be placed just above the atmosphere. The problem arises principally from absorption by the various gases that make

up the atmosphere, including the minor constituents such as carbon dioxide, ozone and water vapour. The atmosphere also presents several other problems. Perhaps the most obvious is cloud cover, obviated in part by choosing a mountain-top observatory site in a temperate climate zone. Also, the atmosphere has a brightness all of its own, owing in part to scattering of electromagnetic radiation from various sources (such as city lighting, Moon light, auroral-type phenomena and lightning). The atmosphere itself radiates at particular wavelengths (especially in the infrared). The detection of faint cosmic objects against the atmospheric background obviously presents a problem. It is clearly important to put a ground-based optical observatory as far as possible from sources of spurious light (for example, on a remote mountain top, where altitude also provides a clearer atmosphere), but from the surface of Earth it is not possible to escape them entirely. Radio observatories also need to avoid spurious emissions (interference from television and radio stations, radar installations and car ignitions).

31. The atmosphere degrades the image of any celestial object. Degradation arises from turbulence in the night air, causing the image of a star to twinkle. For an extended object (such as a galaxy or nebula) the sharpness of the image is lost and fudged out. At high altitude and with an exceptionally stable atmosphere, the conditions of observation can be very good, but for atmospheric distortion effects to be avoided entirely, it is necessary get above the atmosphere into space.

III. STATUS OF THE CENTRES

32. In 1993 and 1994, the United Nations Programme on Space Applications undertook a series of evaluation missions to the countries that offered to host the centre in their respective regions in order to assess the viability of the potential host institutions and to conduct detailed analyses of the offers. After a careful study of each of the evaluation reports prepared by international groups of experts who participated in the evaluation missions, host countries and institutions have been identified for the regional centres in three regions. As of May 1998, the status and location of the regional centres were as described below.

A. Asia and the Pacific

33. In 1994, under the auspices of the United Nations, an evaluation mission to China, India, Indonesia, Malaysia, Pakistan and Thailand was conducted with respect to the establishment of the regional Centre for Space Science and Technology Education in Asia and the Pacific (affiliated to the United Nations).

34. On 1 November 1995, the Centre was inaugurated at New Delhi, India, with the signing of the agreement on the Centre by 10 countries of the region. The first meeting of the Governing Board of the Centre was held at New Delhi on 2 November 1995. All States of the region were invited to sign the agreement, join the Governing Board, and participate in the activities of the Centre. To date, 13 countries of the region have signed the agreement on the Centre. Basic facts about the Centre are as follows:

(a) *Address.* Centre for Space Science and Technology Education in
Asia and the Pacific (CSSTE-AP)
Indian Institute of Remote Sensing (IIRS)
4 Kalidas Road, Dehra Dun—248 001, India
Phone: 91-135-740-737; Fax: 91-135-740-785
E-mail: cssteap@del2.vsnl.net.in

(b) *Inauguration.* 1 November 1995;

(c) *Institutions affiliated to the Centre.* Indian Institute of Remote Sensing (IIRS), Dehra Dun, India; Space Applications Centre (SAC), Ahmedabad, India; and Physical Research Laboratory (PRL), Ahmedabad, India;

(d) *Postgraduate courses conducted and planned at the Centre*.

(i) Remote Sensing and Geographic Information Systems, 1 April-31 December 1996 (25 participants from 14 countries);

(ii) Satellite Communications, 1 January-30 September 1997 (13 participants from nine countries);

(iii) Remote Sensing and Geographic Information Systems, 1 October 1997-30 June 1998 (23 participants from 14 countries);

(iv) Satellite Meteorology and Global Climate, 1 March-30 November 1998 (18 participants from 10 countries);

(v) Space Science, 1 June-30 November 1998;

(vi) Remote Sensing and Geographic Information Systems, 5 October 1998-30 June 1999;

(e) *Personnel utilized at the Centre*.

(i) At the teaching/instruction level—150;

(ii) At the research level—50;

(iii) At the technical assistance level—150;

(iv) At the administrative level—50;

(f) *Computer facilities*.

Training unit	*Computer facilities made available to the Centre*
IIRS, Dehra Dun	
Remote Sensing and Geographic Information Systems course	4 SGI workstations R-5000 3 multimedia Pentium computers I66 MHz 13 Pentium computers 100 MHz Additional computers of IIRS divisions are provided when needed
SAC, Ahmedabad	
Satellite Communications course	2 Pentium computers 100 MHz 5 Pentium computers 133 MHz
Satellite Meteorology course	10 SGI workstations R-5000
PRL, Ahmedabad	
Space Science course	5 Pentium computers 166 MHz connected to IBM R-6000 system Internet facility is also available

B. Africa

35. In 1993, under the auspices of the United Nations Programme on Space Applications, an evaluation mission to Ghana, Kenya, Morocco, Nigeria, Senegal and Zimbabwe was conducted with respect to the establishment of the regional Centre for Space Science and Technology Education in Africa (affiliated to the United Nations). The mission consisted of two parts, one to English-speaking and the other to French-speaking countries.

36. On the basis of reports of the evaluation missions, a favourable response was given to the proposal to establish a centre in Morocco for French-speaking African countries, and in Nigeria for English-speaking African countries.

1. Centre for French-speaking African countries

37. Morocco has circulated the draft agreement on the Centre to be hosted by it, for review and comments by, and concurrence of, French-speaking African countries. Basic facts about the Centre are as follows:

(a) *Address.* Centre for Space Science and Technology Education in
Africa (CSSTE-AF)
École Mohammadia d'Ingénieurs
Avenue Ibn Sina
B.P. 765
Agdal, Rabat, Maroc

(b) *Prospective inauguration date*. 1998.

2. Centre for English-speaking African countries

38. Nigeria has completed the circulation of the draft agreement on the Centre to be hosted by it on behalf of the English-speaking African countries. Basic facts about the Centre are as follows:

(a) *Address.* Centre for Space Science and Technology Education

in Africa (CSSTE-AE)
Obafemi Awolowo University
Ile-Ife, Nigeria

(b) *Prospective inauguration date*. 1998;

(c) *Postgraduate courses planned at the Centre*. Initially, the Centre will organize postgraduate courses in the field of remote sensing;

(d) *Personnel utilized at the Centre*.

(i) At the teaching/instruction level—10;

(ii) At the research level—10;

(iii) At the technical assistance level—5;

(iv) At the administrative level—10;

(e) *Computer facilities*.

Sun Workstation
Three personal computers, model 386, thermal image printer, laserjet printer
One personal computer, model 486, laserjet printer
Two Pentium computers, laserjet printer

C. Latin America and the Caribbean

39. In 1993, under the auspices of the United Nations Programme on Space Applications, an evaluation mission to Argentina, Brazil, Chile and Mexico was conducted with respect to the establishment of the regional Centre for Space Science and Technology Education in Latin America and the Caribbean (affiliated to the United Nations).

40. On the basis of the report of the evaluation mission to the Latin America and the Caribbean region, Brazil and Mexico were identified as the co-hosts of the Centre to be established in the region.

41. In December 1997, the Brazilian Congress approved the agreement on the Centre for the Latin America and the Caribbean region, which had been signed by the Governments of Brazil and Mexico. The same agreement had been ratified by the Mexican Senate. Basic facts about the Centre are as follows:

(a) *Address.* Centre for Space Science and Technology Education in
Latin America and the Caribbean (CSSTE-LAC)
Instituto Nacional de Pesquisas Espaciais (INPE)
Av. Dos Astronautas, 1758
12201-010 São José dos Campos
São Paulo, Brazil

(b) *Prospective inauguration date*. 1998;

(c) *Postgraduate courses planned at the Centre*. Initially, the Centre will organize postgraduate courses in the fields of remote sensing and satellite meteorology;

(d) *Personnel utilized at the Centre*.

(i) At the teaching/instruction level—20 (staff members of INPE);

(ii) At the research level—20 (staff members of INPE);

(iii) At the technical assistance level—1 (one specialist in informatics with knowledge of networks);

(iv) At the administrative level—10 (including one trilingual secretary, two bilingual secretaries, one secretary, one driver, one administrative assistant, one person responsible for didactic material, one internship for secretary and one internship for informatics);

(e) *Computer facilities*.

(i) Available for the Centre: Three personal computers, model 486, printer;

(ii) Requested by INPE: One Pentium computer, ink-jet printer; Pentium MMX 233—server, one workstation Sun Ultra 60;

(iii) Funds requested to acquire (these computer facilities currently shared with INPE): one workstation Sun Ultra 60—server, four workstations Ultra 10, 20 Pentium computers, three laser printers, three ink-jet printers;

(iv) Network equipment: Two plotters AO, four digitalized tables A1, one table scanner A4.

D. Western Asia

42. An evaluation mission to Jordan and the Syrian Arab Republic was scheduled to take place in the second quarter of 1998 with a view to assessing the prospective countries, after which one of them will be selected to host the regional Centre for Space Science and Technology Education in Western Asia (affiliated to the United Nations).

E. Central eastern and south-eastern Europe

43. In 1996, Bulgaria, Greece, Hungary, Poland, Romania, Slovakia and Turkey proposed that an educational system should be established consisting of a network of space science and technology education institutions and that the activities of each member of the network would be in harmony with existing institutions in Europe and open to international cooperation. Following that offer, meetings of experts on the establishment of a network of space science and technology education and research institutions for central eastern and south-eastern European countries were held at Vienna in 1996 and 1997 with the participation of representatives of Bulgaria, Greece, Hungary, Poland, Romania, Slovakia and Turkey. As a result of those activities, a technical study mission is planned for the third quarter of 1998 on the implementation of the network. The mission will focus on the technical requirements, design, operating mechanism and funding of the proposed network.

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