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UN/ESA workshops on basic space science: an initiative in the world-wide development of astronomy

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Abstract
In 1990, the United Nations in cooperation with the European Space Agency initiated the organization of a series of annual Workshops on Basic Space Science for the benefit of astronomers and space scientists in Asia and the Pacific, Latin America and the Caribbean, Africa, Western Asia, and Europe. This article summarizes accomplishments of seven of these Workshops and their follow-up projects with a view to enhance the world-wide development of astronomy and space science. The Workshops are being considered unique and a model for such an endeavour.

Key words: *astronomy, development, world-wide, UN, ESA*

1 INTRODUCTION

During the last decade of the twentieth century astronomers are using telescopes in space, in aircraft, on the ground, and even underground to address fundamental questions concerning our place in the Universe. Do planets orbit nearby stars? What triggers the formation of stars? How do life-giving elements such as carbon and oxygen form and disperse throughout the galaxy? Where can black holes be found, and do they power luminous galaxies and quasars? How and when did galaxies form? Will the Universe continue to expand forever, or will it reverse its course and collapse in on itself? What is the physical nature of dark matter? These questions, the instruments devised to investigate them, the associated observations that have been carried out, and the resulting conclusions (some of them still tentative), are explored in a book titled *The Decade of Discovery in Astronomy and Astrophysics* (Bahcall, 1991) and in other publications (e.g. Brown, 1990). The remarkable developments in planetary exploration, astronomy, and astrophysics during the 1980s and 1990s can be comprehensively assessed by looking through the pages of these publications.

Astronomy has traditionally been an international enterprise, because it has deep roots in virtually every human culture; because it helps us to understand our place in the vast scale of the Universe; and because it teaches us about our origins and evolution. By virtue of these facts, the astronomical community has long shown leadership in creating international collaborations and cooperation. The International Astronomical Union (IAU) was the first of the modern international scientific unions organized under the Treaty of Versailles. Names like the European Southern Observatory, the International Ultraviolet Explorer, and the World Space Observatory are well-known, but despite this the level reached in practicing and teaching astronomy is surprisingly unequal across countries around the world (e.g. see Percy and Batten, 1995).

Of the 185 Member States of the United Nations (UN), nearly 100 have professional or amateur astronomical organizations. In only about 60 of these countries, however, has professional astronomical research and education been developed to such a level that they have joined the International Astronomical Union as members. And only about 20 countries, representing 15% of the world's population, have access to the full range of modern front-line astronomical facilities and

information. This does not include most of the Eastern European, Baltic, and former countries of the Soviet Union, whose fragile economies keep them from achieving their full potential, despite the excellence of their astronomical heritage and education.

This paper provides details of an initiative led by the United Nations (UN) and the European Space Agency (ESA) to assist the development of astronomy on a world-wide basis by focusing on developing nations.

2 UN/ESA INITIATIVES IN BASIC SPACE SCIENCE

Since 1991, the UN and the ESA, working in collaboration and separately, have been involved in a number of different Space Science projects. These are discussed below.

2.1 Workshops on Basic Space Science for Developing Countries

In 1991, the UN, in cooperation with the ESA, held its first Workshop on Basic Space Science (hereafter 'Workshop') in India for Asia and the Pacific region (Haubold and Khanna, 1992; UN GA doc. of 17 September 1991). Since then, Workshops have been held annually in different regions around the world (see Table 1 for a complete list and Figure 1 for their geographic distribution),[1] in order to make a unique contribution to the world-wide development of planetary exploration and astronomy, particularly in developing countries (Haubold *et al.*, 1995; Haubold, 1996; Haubold and Wamsteker, 1997).

Table 1. UN/ESA Workshops on Basic Space Science.

Year	City	Region	Host Institution	P	C	Follow-up Project(s)
1991	Bangalore, India	A/P	Indian Space Research Organization	87	19	Establishment of an astronomical facility for Sri Lanka
1992	San José, Costa Rica and Bogotá, Colombia	L/C	University of Costa Rica, and the University of the Andes	122	19	Establishment of an astronomical observatory for Central America; radio telescope for Colombia
1993	Lagos, Nigeria	Afr.	University of Nigeria, and Obafemi Awolowo University	54	15	Establishment of an inter-African astronomical observatory and science park in Namibia
1994	Cairo, Egypt	WA	National Research Institute of Astronomy and Geophysics	95	22	Refurbishment of the Kottamia Telescope; participation of Egypt in the 2001 Mars Mission
1995	Colombo, Sri Lanka	A/P	Arthur C. Clarke Centre for Modern Technologies	74	25	Inauguration of an astronomical facility in Sri Lanka
1996	Bonn, Germany	Eur	Max-Planck-Institute for Radioastronomy	120	34	Assessment of previous Workshops; foundation of an African working group on space science
1997	Tegucigalpa, Honduras	CA	Observatorio Astronómico de la Universidad Nacional Autónoma de Honduras	75	28	Inauguration of an astronomical observatory for Central America, in Honduras; first light, Kottamia Telescope; African Skies issued
1999	Mafraq, Jordan	WA	Al al-Bayt University	—	—	
1999	Vienna, Austria	All	UN Office at Vienna	—	—	

Key:
P = Number of participants
C = Number of countries involved
A/P = Asia and the Pacific
L/C = Latin America and the Caribbean
Afr. = Africa
WA = Western Asia
Eur = Eastern and Western Europe
CA = Central America
All = all regions

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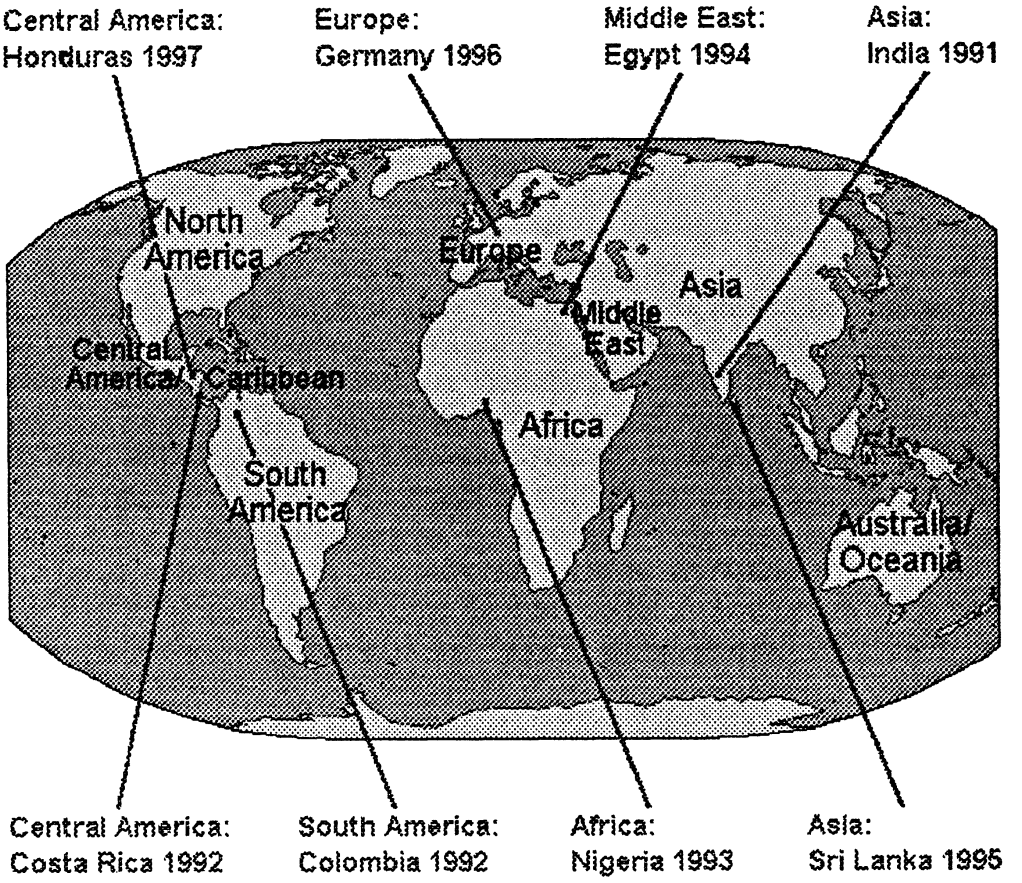

A Series of Workshops Devoted to the Worldwide Development of Astronomy and Space Science, co-organized by
ASA, CNES, DARA, ESA, IAU, ICTP, ISAS, NASA, TPS, UN

Figure 1. Map showing the location of UN/ESA Workshops devoted to the world-wide development of astronomy and space science.

As Table 1 indicates, Workshops were held in Costa Rica and Colombia in 1992, for Latin America and the Caribbean (Fernandez and Haubold, 1993; Haubold and Torres, 1994; UN GA doc. of 20 January 1993); in Nigeria in 1993, for Africa (Haubold and Onuora, 1994; UN GA doc. of 26 May 1994); in Egypt in 1994, for Western Asia (Haubold and Mikhail, 1995a, b; UN GA doc. of 11 August 1994); in Sri Lanka in 1995 (Haubold, 1999; UN GA doc. of 14 May 1996); and at Tegucigalpa, Honduras, in 1997 (Haubold, 1999; UN GA doc. of 20 January 1998). These last two Workshops were timed to coincide with the opening of astronomical telescope facilities. A month-by-month update with results and new developments relating to each of these Workshops was made available on the Workshops' homepages. [2]

For all of these Workshops, a unanimously-adopted formula was established, which stipulated that the host country covered a major part of the local expenses while the UN and the ESA provided international air travel for up to 25 astronomers and space scientists from developing nations. Co-organizing entities[1] and many other institutions and universities from around the world paid the expenses of distinguished

scientists from industrialized countries. The total number of Workshop participants was limited to around 75, in order to secure intense and lively interaction among all those participating at and contributing to the Workshops. Needless to say, astronomers and space scientists from any country in a region were able to attend a regional Workshop. To emphasize a high commitment from all parties concerned, the Governments of the host countries of the Workshops entered into a finely-tuned 'Memorandum of Understanding' with the UN in respect to legal and logistic matters relevant to the Workshops.

The selection of astronomical topics for the scientific programme of each Workshop depended upon the interests of the local organizers and the level of astronomical development in the region. A vital part of the programme of each Workshop was the late afternoon working group sessions, which provided all participants with a common platform from which to make constructive observations and recommendations addressing the status of astronomy in their region. Region by region, these observations and recommendations have been collected and published as part of UN documents and Proceedings of the Workshops (Haubold and Khanna, 1992; UN GA doc. of 17 December 1991; Fernandez and Haubold, 1993; Haubold and Torres, 1994; UN GA doc. of 20 January 1993; Haubold and Onuora, 1994; UN GA doc. of 26 May 1994; Haubold and Mikhail, 1995a, b; UN GA doc. of 11 August 1994; UN GA doc. of 14 May 1996; UN GA doc. of 20 January 1998; Haubold and Mezger, 1998; UN GA doc. of 13 December 1996a, b).

2.2 The European Workshop: Evaluation and Forward-Planning

As a result of a request from the UN, the Foreign Office of the Government of Germany, through the German Space Agency (DARA), made it possible for the Max-Planck-Institute for Radioastronomy (MPIfR) to hold a UN/ESA Workshop in Bonn, Germany, in 1996.

Although this Workshop was ostensibly for the benefit of Europe, it also analyzed the results of all previous Workshops – and particularly the follow-up projects (which are reviewed in Sections 3 and 4 of this paper) – and charted the course to be followed in the future. In addition, the 1996 Workshop took advantage of the host country's high standing in astronomy and astrophysics and addressed scientific topics at the forefront of research in such diverse fields as photon, neutrino, gravitational wave, and cosmic ray astronomy (see Haubold and Mezger, 1998; UN GA doc. of 13 December 1996a). Because Europe does not include developing countries, a special appeal to a number of European countries had to be initiated, leading to the generous concurrence of Germany to host a Workshop of this nature. Some individuals did not agree with such a decision (Elsaesser, 1995), while others praised the achievements of the Workshop (Kogure, 1997).

2.3 A Case for Planetaria

The Universe is more than just a distant wonder; it gives to every human the gift of the starry night-time sky. This gift is free to all, except when veiled by clouds or masked by human lights. It is an environmental treasure that can be shared by all people and hoarded by none. In an era when the light-saturated sky of cities has transformed the stars into an 'endangered species', the beauty and mystery of the night sky is preserved upon the domes of the world's planetaria. A planetarium is therefore a theatre that can preserve cultural heritage unique to every nation and retell the ancient stories as well as modern science. Planetaria are centres of science education for the public and the professional, and have a broad impact on public education. Many young people are drawn to careers in science and technology by an early interest in astronomy and space, frequently facilitated through the activities of planetaria.

A wide variety of national and international space organizations, including the UN, decided to recognise 1992 as 'International Space Year' (ISY). To help generate

interest in and support for planetaria as centres of culture and education, the UN and the International Planetarium Society,[3] decided to publish a guidebook titled *Planetarium: A Challenge for Educators* (Smith and Haubold, 1992)[4] as part of their ISY activities. National planetarium associations subsequently translated this book from English into Japanese, Slovak, and Spanish. Copies are still available from the UN, and it is currently being translated into Arabic. Since the initial publication of this book, more than 4000 copies have been distributed world-wide, and the UN has become involved in facilitating the establishment of planetaria (Kitamura, 1994; Vietnam, 1995).[5]

2.4 Donation of Computers to Astronomical Institutions

In 1993, the ESA, through the UN, donated 30 personal computer systems for use at universities and research institutions in Cuba, Ghana, Honduras, Nigeria, Peru, and Sri Lanka (Haubold *et al.*, 1995; Wamsteker, 1994).[6]

2.5 The International Conference on Near-Earth Objects

The odds of our international society being obliterated by an asteroid impact in the next 50 years has been estimated at 6000 to 1. That probability and its consequences, as well as the methods for discovery and mitigation, are described in a textbook by 120 authors in 46 chapters (see Gehrels, 1994). The first step in mitigation is to use astronomical telescopes to discover the estimated 1700 near-Earth objects that are larger than one kilometre in diameter, the ones energetic enough to cause serious damage on a world-wide scale.

In 1995, scientists from around the world gathered at the UN Headquarters in New York to discuss a broad range of scientific issues associated with near-Earth objects. This gathering became known as the first United Nations International Conference on Near-Earth Objects (Haubold and Remo, 1998; Remo, 1997).[7] One of the topics addressed by those at the Conference was the establishment of adequate observational facilities in both the northern and southern hemispheres for the successful detection and monitoring of near-Earth objects. As a first step, these facilities should be improvements of existing telescopes, particularly small ones, including those in developing nations. Observational programmes at professional observatories could be coordinated with those of amateur astronomy groups, and organized on an international level. The establishment of a network of moderately-sized amateur and professional telescopes was discussed at a number of UN/ESA Workshops, and is supported by the European Spaceguard Foundation and the Japanese Spaceguard Association (UN GA doc. of 14 May 1996; UN GA doc. of 20 January 1998).

3 ASTRONOMY BENEFITS FROM FOLLOW-UP PROJECTS OF THE UN/ESA WORKSHOPS

In addition to the general benefits of Workshops, the UN/ESA series has lead to the implementation of a number of follow-up projects in developing countries where the respective Governments and astronomical communities actively participated in the organization of the Workshops (Haubold *et al.*, 1995; Haubold, 1996; Haubold and Wamsteker, 1997). Examples of these are discussed below.

3.1 Sri Lanka's Telescope Facility

Interest in the design and construction of very large space-based and ground-based telescopes has never been greater than at the present time and there is no shortage of research projects for such instruments. The excitement and opportunities associated with these very large instruments is limitless, but can easily obscure the fact that small telescopes also have an increasingly important place in modern astronomical research. It is vital that this assertion is widely understood and accepted, for there are many

institutions, and even entire countries, which cannot afford to enter the race for giant telescopes, and at the same time there *are* astronomical observational programmes that are better pursued with small telescopes. Currently, there is a need for more small telescopes, for better use of existing ones, for more effective networking, and for continual upgrading of the instrumentation used with them (see Warner, 1986).

In 1991, scientists who represented Sri Lanka at the UN/ESA Workshop at Bangalore, India, stressed the importance of acquiring an astronomical telescope for Sri Lanka. At this Workshop it was recommended and widely supported that three observatories should be established in Sri Lanka. Subsequently, the United Nations Office for Outer Space Affairs recommended that the Government of Japan consider the donation of a telescope to Sri Lanka in order to implement this programme (Kitamura, 1992; Wickramasinghe, 1993). The Government of Japan favourably analyzed the request and offered a 45-cm Cassegrain reflecting telescope to the Government of Sri Lanka through the Cultural Grant-In-Aid Scheme.[8] A team of officials from the Government of Japan and the UN visited Sri Lanka in 1992 and a meeting was held at the Sri Lankan Association for the Advancement of Science in Colombo. A decision was taken to install this telescope at the Department of Meteorology in Colombo, but because of financial, technical, and scientific constraints the project was taken over by the Arthur C. Clarke Centre for Modern Technology (ACCMT)

The ACCMT was established in 1984 with the objective of accelerating the process of introduction and development of modern technologies in Sri Lanka, particularly in the fields of computers, communications, space technologies, robotics, and energy (Gehrels, 1984; Gehrels, 1988). At the time the Japanese telescope was on offer, a new four storey building was being constructed at the ACCMT, and the top floor could be modified to accommodate an observatory. Furthermore, the ACCMT had the capability to handle the repair and maintenance of the telescope, including the fully-automated electronic equipment. It was also decided to construct an observatory with a sliding roof instead of a rotating dome, because lower costs were involved. In 1994, the Board of Governors of ACCMT formed a Steering Committee consisting of astronomers, physicists, and engineers, in order to implement the project. The Cabinet of Sri Lanka eventually approved the project and the 45-cm reflecting telescope from the GOTO Manufacturing Company of Japan arrived in Sri Lanka in mid-1995. The astronomical telescope facility was inaugurated during the fifth UN/ESA Workshop, hosted by the Government of Sri Lanka, in 1996 January, at the ACCMT.[9] At present, the Space Applications Division of the Space Applications Centre of the ACCMT is responsible for managing and operating the telescope (Haubold, 1999; UN GA doc. of 14 May 1996).

3.2 The GEM Project and the Colombian Radio Telescope

On the occasion of the second UN/ESA Workshop at Bogotá, Colombia, in 1992, the Galactic Emission Mapping (GEM) project was established with the aim of conducting an accurate, full sky survey of the galactic radio emission from 408 to 5000 MHz (Haubold and Torres, 1994; UN GA doc. of 20 January 1993). The antenna consists of a 5.5-metre parabolic reflector mounted on a rotating alt-azimuth base, and allows for the possibility of having receivers placed at its primary or secondary focus. In order to achieve a homogeneous and calibrated survey, the GEM radio telescope has been designed for observations with the same instrument from sites at different latitudes. Since 1994, it has been located for various periods at Owens Valley (California, USA), Villa de Leyva (Colombia), Canary Islands (Spain), and in Brazil.

The availability of galactic emission data in the 408-5000 MHz frequency range has important applications in cosmic ray physics and indirectly in cosmology. Information about the energy spectrum of relativistic cosmic ray electrons can be inferred from a measurement of the radio spectrum. This fact follows from the

magnetobremsstrahlung nature of the radio emission in the galaxy. Important contributions to cosmology can also be made using galactic emission data to correct for galactic contamination in maps of the microwave cosmic background radiation (CBR). Studies of anisotropies in the CBR are a powerful tool to test cosmological models, especially since its detection by the DMR receivers on board the Cosmic Background Explorer (COBE) satellite. However, the use of CBR data to extract information about the early universe is severely hampered by the presence of galactic contamination (Haubold and Torres, 1994; Torres, 1995).

3.3 The Central American Astronomical Observatory in Honduras

In Central America, the initiative to establish the first astronomical observatory was born in Honduras at the beginning of the last decade of the twentieth century, and was pursued by a team of scientists which attended the second UN/ESA Workshop, held at Costa Rica and Colombia in 1992 (UN GA doc. of 20 January 1993). Following a strategy, based upon the regional cooperation of Central American national universities and at the international level on establishing close contact with other astronomers and prestigious astronomical research centres, the first steps for the establishment of this astronomical observatory were taken (UN GA doc. of 18 January 1995).

Since 1994, an observatory has operated in Tegucigalpa, at the Universidad Nacional Autonoma de Honduras (UNAH), for the six Central American countries, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama. The observatory is equipped with a 42-cm computerized telescope and other facilities, and has started a programme for the training of researchers and technicians from the Central American Isthmus. In addition, several important agreements of co-operation are making progress in order to contribute to the development of basic space science in the region (Haubold and Onuora, 1994).

In the short period of time from 1992 to 1997, under the leadership of astronomers from UNAH, an Assembly of Central American Astronomers and Astrophysicists (AAAC) has been established, and annual meetings have been held in Honduras (1993), Costa Rica (1994), El Salvador (1996), and Panama (1998). Simultaneously, Central American Courses in Astronomy and Astrophysics (CURCAA) were organized in Honduras (1995), El Salvador (1996), Guatemala (1997), and Panama (1998). At the XXIIIrd General Assembly of the IAU at Kyoto, Japan, the six Central American countries became jointly a member of the IAU. A crucial role in all of these developments was played at the seventh UN/ESA Workshop, held at Tegucigalpa, Honduras, in 1997, with the dedication of the Telescopio Rene Sagastume Castillo and the inauguration of the Suyapa Observatory at the UNAH (Haubold, 1999; UN GA doc. of 20 January 1998).[10]

3.4 Modernizing Egypt's Kottamia Telescope

In order to maintain Egypt's position in the international astronomical community it was considered desirable to make use of recent developments in mirror-making technology to modernize the 35-year old 1.88-m Kottamia telescope. Supported by one of the major resolutions of the fourth UN/ESA Workshop, which was hosted by the Government of Egypt in 1994 at Cairo, the question of modernizing the telescope was raised with the Egyptian Government. The modernization of this telescope was seen as especially important in view of the fact that it is the largest telescope in North and Central Africa, as well as in Western Asia, and would support major experimental capabilities for basic space science in the region (Haubold and Mikhail, 1995a, b; UN GA doc. of 11 August 1994; Hassan, 1998). After extensive discussions between the National Research Institute of Astronomy and Geophysics (NRIAG) at Helwan and the Egyptian Government, this project was approved and funded. The refurbished Kottamia telescope saw first light in 1997 September.

3.5 The *African Skies* Newsletter

The Working Group on Space Sciences in Africa is an international, non-governmental organization founded by African delegates at the sixth UN/ESA Workshop, held at Bonn, Germany, 1996 (UN GA doc. of 13 December 1996a). The scientific scope of the Working Group's activities is defined to encompass (i) astronomy and astrophysics, (ii) solar-terrestrial interaction and its influence on terrestrial climate, (iii) planetary and atmospheric studies, and (iv) the origin of life and exobiology.[11] The Working Group seeks to promote the development of space sciences in Africa by initiating and coordinating various capacity-building programmes throughout the region. These programmes fall into a broad spectrum ranging from the promotion of basic scientific literacy in the space sciences to the support of international research projects. The Working Group also promotes international co-operation among African space scientists and acts as a forum for the exchange of ideas and information through its publications, outreach programmes, workshops, and scientific meetings.

In 1997 May, the Working Group launched a newsletter, *African Skies*, and the second issue was published in 1998 April (a third issue is scheduled for 1998 November). This newsletter is jointly produced by astronomers from the Observatoire de Midi-Pyrenees (France) and the South African Astronomical Observatory (South Africa) and is distributed world-wide, but preferentially to a scientific institution in the region of Africa, by the United Nations Office for Outer Space Affairs. The publication of such a newsletter for Africa was long overdue according to observations and recommendations made at UN/ESA Workshops since 1991. While, for example, the number of astronomical papers published annually by members of the American Astronomical Society is numerically almost equal to the number of members (in 1990 about 5500, and growing by 5% each year), world-wide the number of astronomical papers (14,300 in 1985) is not quite keeping up with the number of members of the IAU. Therefore the growth in astronomical papers is simply due to the growth in numbers of astronomers (Abt, 1993). In the case of Africa (with the exception of South Africa and a number of northern African countries), neither an association of astronomers nor appropriate means for pursuing astronomy, not to speak of publications in astronomy, exists. The *African Skies* newsletter is supposed to be a very first step to improve this situation for African nations.[12]

3.6 Astrophysics for Physics Courses at Universities in Developing Nations

In all UN/ESA Workshops, questions on how to teach astronomy and "teaching astronomy ... but at what level?" naturally arose in working group sessions, and were frequently discussed in relation to already-existing and recommended teaching materials (Narlikar, 1990). All Workshops made observations and recommendations on how to introduce the teaching of astronomy as part of the curriculum for graduate and post-graduate studies, depending upon the status of development of astronomy in the respective regions (UN GA doc. of 17 December 1991; UN GA doc. of 20 January 1993; UN GA doc. of 26 May 1994; UN GA doc. of 11 August 1994; UN GA doc. of 14 May 1996; UN GA doc. of 20 January 1998; UN GA doc. of 13 December 1996a). To meet the spirit of all these observations and recommendations, a number of participants of the Workshops, particularly during the sixth Workshop held in Germany in 1996, have become involved in (i) preparing a booklet titled *Developing Astronomy and Space Science World-wide* (Haubold, 1999); (ii) developing a 'Manual on the Role of Small Telescopes in Education and Research'; and (iii) working on a basic "unit" about the essentials of astronomy (and including a 'kit' of simple hands-on materials), which could be adapted by local educators for effective, appropriate, local use (Motz and Duveen, 1977; Percy, 1996).

For practical reasons, project (iii) will initially be limited to introducing astrophysics for university physics courses. This limitation was mainly based upon the notion that physics and mathematics curricula are well developed at almost all

universities, while this has not been accomplished at the public school and college levels, respectively, in a large number of countries. The booklet *Astrophysics for University Physics Courses* (Wentzel and Haubold, 1998) presents an array of astrophysical problems, any one or a few of which can be selected and used within existing physics courses on elementary mechanics, or on heat and radiation, kinetic theory, electrical currents, and in some more advanced courses. These astrophysics problems are designed to be an interesting and challenging extension of existing physics courses, to test the student's understanding of physics by testing it in new realms, and to stretch the student's imagination. A brief tutorial on astrophysics is provided with each problem, enough so that the physics professor can present the problem in class. All the problems seek compact algebraic and numerical solutions that can easily be translated into physics. The booklet has been exposed to an extensive refereeing process by physics professors at universities around the globe, but particularly in developing nations, to ensure that it addresses the needs and the available curricula and resources at such universities.

4 LONG-TERM PROJECTS OF THE UN/ESA WORKSHOPS

Since 1991, a number of projects have been pursued within the framework of the UN/ESA Workshops on a long-term basis. These have relevance to the forthcoming UNISPACE III Conference,[13] and are briefly reviewed below,

4.1 World Space Observatory

Based upon deliberations of the UN/ESA Workshops, held in Sri Lanka (1995), Germany (1996), and Honduras (1997), a recommendation was made to explore the feasibility of the establishment of a World Space Observatory (WSO). The basic idea behind the WSO is that general facilities in the windows for astronomical observations which require satellite observatories are better achieved through a project with world-wide support, participation, and contribution, rather than individual projects defined on a more confined national basis. The reasons for this are various (e.g. see Bahcall *et al.*, 1989; Labeyrie and Léna, 1990; Sage, 1994; Wamsteker, 1998):

1. The needs are essentially similar in most countries, while specific study areas tend to show regional trends, of equivalent scientific value.
2. The needs for the stimulation of intellectual capabilities in developing countries cannot be supported in their national environments alone with any other possible astronomical facilities (e.g. ground-based or otherwise), at economically-viable costs.
3. The continued need for studies bearing on the relevance of our place in the Universe requires continued support and can not be driven by addressing the currently popular questions with high prestige projects only.
4. A large community of astronomers and astrophysicists will continue to demand support for their science and an extensive interruption of this support over a period of more than a generation can have very dramatic effects on the evolution of knowledge, which is an essential part of our cultural environment in the next millennium.

The WSO concept could in the long run include space observatories for different wavelength domains, including X-rays and gamma rays, and even take over the operations of projects launched by major agencies with funding for a limited operations duration. WSOs should not be viewed as technology development projects for the industrialized countries, but as low-cost projects where the main emphasis is on the required sensitivity and the stability of operations. Since many aspects of the

necessary observatories would possibly not involve the development of the most advanced technologies, but rather rely on well-established technologies (as on communications satellites), these projects can be developed in a more cost-effective manner than the science projects normally taken on by the major space agencies.

The current momentum in time is especially suited to the initiation of such a concept for the following reasons:

1. The concentration of facilities in astronomy to a limited number of high quality facilities is an unstoppable trend.
2. A mechanism for indigenous development of science is a necessary prerequisite for the developing world.
3. The technology available for communications is sufficiently developed so that the concept can be implemented without disastrous economic burdens for all parties involved.
4. Technology for a spacecraft required for such an observatory is today mature technology.
5. Application of new high-technology detectors could be an intricate part of such a project without creating a total dependence on new technologies.
6. The chance to develop in this context local capabilities for direct and essentially local participation for all countries, presents an enormously attractive possibility to stimulate participation in all levels of society in the exploration of the Universe, especially if it is combined with an assertive public outreach programme.
7. A scientific community which has shown to be extremely vigorous, appears to be left without observational opportunities.

The concept of the WSO has been prepared for presentation to the United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) (UN GA doc. of 20 January 1998; Wamsteker, 1998).

4.2 Egypt's Mars Drill Project

During the fourth UN/ESA Workshop, held at Cairo, Egypt, in 1994, the possible participation of Egypt in a future Mars rover mission was discussed (UN GA doc. of 13 December 1996b). One concept suggested was that Egypt participate in such a mission through involvement in the design, building, and testing of a drill which would be used to obtain sub-surface samples (Haubold, 1999).

The Planetary Society, a major sponsor of the UN/ESA Workshops, followed up these discussions. The Society informed the Space Research Institute (IKI) of the Russian Academy of Sciences of this project, and they, in turn, formally invited the Egyptian Ministry of Scientific Research to study the concept for potential use on the Russian Mars 2001 Mission. Of the many important scientific objectives of the Marsokhod mission, among the most interesting is the analysis of sub-surface samples. Inclusion of some sort of drilling mechanism in the payload of such a mission would assist scientists in the investigation of volatile organic materials and mineralogy.

Twenty years ago, the arm on the Viking Mars lander was able to obtain samples from depths of up to 10-cm. Today, a drill with the capability of boring at least an order of magnitude deeper (more than one metre) would be essential to further research and investigation.

Egypt has expertise in drilling technology. Years ago, as part of the archaeological exploration of the Pyramids, a sophisticated drilling system was developed to drill into and deploy a camera within a sub-surface chamber without allowing air into the chamber. The drill perforated the limestone to a depth of 2 metres without the use of lubricants or cooling fluids that might have contaminated the chamber's environment, and successfully collected six samples (El-Baz, 1997; El-Baz *et al.*, 1997).

This experience, as well as more common terrestrial applications, suggests that the necessary technological basis for a drill development can be brought together. In the proposed application for the Mars 2001 Mission, a study team of Egyptian scientists, collaborating with American, Russian, and European scientists, is now pursuing the project.

4.3 A Network of Oriental Robotic Telescopes

The mooted Network of Oriental Robotic Telescopes (NORT) will deal mainly "... with red giants, planetary nebulae, and post-novae; to stimulate asteroseismology of long-period variables and to contribute to progress in our understanding of these objects." (Querci and Querci, 1988:18). Examples of scientific objectives for robotic telescopes are widely appreciated (e.g. see Filippenko, 1992). As various characteristic times of variation have to be searched for, continuous monitoring of selected typical objects is required. This requirement can only be satisfied through having telescopes at the 'best' sites, in semi-desert countries, around the world.

A number of such countries is located along the tropic of Cancer, from Morocco to China. Although some of these oriental countries had great astronomers in the past, few are now actively participating in astrophysical research. However, their universities, their sites (high mountains in a semi- desert climate) and their desire for development, can provide strong support for progress in this project (Querci and Querci, 1998).

In the NORT project, it is proposed

1. to collaborate in astronomy and astrophysics education;
2. to help in the development of research laboratories and student observatories at the university context;
3. to promote the training of engineers and technicians in French observatories such as Haute-Provence Observatory (OHP), Midi-Pyrenees Observatory (OMP); and
4. to collaborate in setting up the network and in the scientific choice of the objects to be observed.

All the equipment will be fully robotic. Each day, all the collected observations will be transmitted directly to all the universities and members of the network via the Internet and/or ARABSAT. The data reduction and interpretation could be done in joint efforts, thus further promoting shared scientific and technical progress.

4.4 Southern African Large Telescope

As a result of the work of the third UN/ESA Workshop held in Nigeria in 1992, a proposal was drawn up for an Inter-African Astronomical Observatory and Science Park on the Gamsberg in Namibia. Because of its unique geographical location, southern Africa can make an immense contribution to astronomy. Observation of certain time-critical phenomena and 24-hour coverage can be ensured only through astronomical observatories in continents (excluding Antarctica) south of the equator. The Gamsberg has been identified as one of the most suitable sites for an observatory in southern Africa. It is a table mountain 120 kilometres south-west of Windhoek above the Namibian desert at an altitude of 2350 metres above sea level. It experiences a large number of cloudless nights, a dark sky, excellent atmospheric transparency and low humidity (Birkle *et al.*, 1976). The development of an astronomical facility on the Gamsberg can only be achieved, however, through broad international collaboration. After pursuing this project over the period of time from 1992 to 1996, a conclusion was drawn that financial and in-kind support was not sufficient to successfully implement this project (Elsaesser, 1996).

Also part of the deliberations of the UN/ESA Workshop in Nigeria was the discussion of the Southern African Large Telescope (SALT) project which was being

developed by South African astronomical observatories since 1989 (Cherry, 1998; Stobie *et al.*, 1993; Warner 1995). South African astronomers plan to build a 10-m telescope for optical and infrared astronomy. This telescope will be based upon the revolutionary Hobby-Eberly Telescope (HET) nearing completion at McDonald Observatory. Because HET is a specialist design optimized for spectroscopic survey work and imaging over a limited field, it has been built at a fraction of the cost of a conventional 8-m class telescope. SALT will be built near Sutherland, at the observing station of the South African Astronomical Observatory (Stobie, 1997). South Africa cannot fund this telescope alone and is seeking international support for its implementation. On 1998 June 1 the South African Cabinet approved the building of SALT. Since 1995, the United Nations has supported SALT by disseminating information on the project to 111 universities in Africa through the Association of African Universities in Ghana.

5 CONTINUATION OF UN/ESA INITIATIVES INTO THE NEXT MILLENNIUM: THE SHORT-TERM PERSPECTIVE

5.1 Workshops

The next UN/ESA Workshop has been scheduled to be held in 1999 March at the Al al-Bayt University, Mafraq, Hashemite Kingdom of Jordan, inaugurating an astronomical facility at this university.[13]

5.2 Astronomical Telescope Projects

Following the example of the establishment of an astronomical telescope facility in Sri Lanka, the science faculty of the Universidad Nacional de Asuncion at Asuncion, Paraguay, is currently making efforts to establish a similar facility for educational purposes for students in physics and astronomy, engineering, meteorology, and geography at this university (Troche-Boggino, 1998). Under the leadership of astronomers and the Government of Japan, a committee was established to explore the possibility of accommodating an astronomical telescope, that might be donated by the Government of Japan to the Government of Paraguay through the Japanese Cultural Grant Aid Programme (Kittamura, 1992). The Facultad Politecnica of the Universidad Nacional de Asuncion will contribute the construction of the observatory building, office space, and an auditorium for the 'Centre for Astronomy at Paraguay', as this project has been dubbed by the Paraguayan authorities.

In creating this project, scientists in Paraguay proudly refer to an early history of astronomy in the country. Buennaventura Suarez was the pioneering astronomer in Paraguay, and he built a sort of astronomical observatory during the 18th century. He was born in Santa Fe in 1678 and had studied at Cordoba, both cities now located in Argentina. He did most of his work in San Cosme y Damian, one of thirty Jesuit communities for Guarani Indians in the Great Province of Paraguay, until his death in 1750. With the help of local artisans, Suarez built various astronomical instruments, including some Kepler-type refractors with lenses polished from local crystalline rocks, sundials, a quadrant with degrees divided into minutes, and a pendulum clock with a dial divided into minutes and seconds. All of Suarez's instruments were lost, with the exception of a sundial at San Cosme y Damian which now serves as a lonely testament to this exceptional man and early history of astronomy at Paraguay.

The United Nations is in close contact with astronomers and the Governments of Paraguay and Japan, respectively, to bring the establishment of the Centre for Astronomy at Asuncion, Paraguay, to a fruitful conclusion. Similar projects involving an optical telescope in the Philippines (The Necessity ..., 1998) and a radio telescope in Egypt (Mosalam Shaltout, 1998) are under investigation, and have been promoted at recent UN/ESA Workshops.

5.3 Regional Centres for Space Science and Technology Education

A major prerequisite to successful space science and technology applications in developing countries is the development of human resources within each region. In recognition of such a need, the UN General Assembly, in its resolution 45/72 of 1990 December 11, endorsed the recommendation 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.

The UN has been active in the field of space science, primarily through promoting the participation of scientists from developing countries in front-line research and education and through its complementary initiative aimed at establishing regional Centres for Space Science and Technology Education in developing countries and its series of seven UN/ESA Workshops (*Centres for Space Science* ..., 1996).

The concept behind these regional Centres is based upon the fundamental notion that it is vital for developing nations to educate personnel in space science and in the use of space technology, particularly those applications relevant to remote sensing, satellite meteorology, and satellite communications. The establishment of such Centres in the Asia-Pacific region (in India), Latin America and the Caribbean (Brazil and Mexico), and in the French-speaking (Morocco) and English-speaking (Nigeria) regions of Africa, is under way.

The regional Centre for Space Science and Technology Education for Asia and the Pacific (CSSTE-AP) was established in Dehra Dun, India, in 1995. From 1998 June 1 to November 30, the fifth postgraduate course, focusing on basic space science, was conducted at the Physical Research Laboratory, Navrangpura, Ahmedabad, India.[14] This course justifies the decision of the UN and ESA not to organize a Workshop in 1998, although one originally was scheduled to be held in Tunisia.

5.4 The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III)

The forthcoming United Nations Conference on the Exploration and Peaceful Uses of Outer Space, to be held from 1999 July 19 to 30 at Vienna, Austria (also the site of the two previous Conferences, in 1968 and 1982), will comprehensively assess the achievements of the UN/ESA Workshops (UN GA doc. of 20 January 1998).[15] In conjunction with UNISPACE III, the International Astronomical Union (IAU) will hold a UN/IAU Special Environmental Symposium (Preserving the Astronomical Sky) and a UN/IAU/COSPAR Special Workshop on Education which will address scientific topics not uncommon to the UN/ESA Workshops (IAU, 1998).

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7 NOTES

1. Subsequently, these Workshops were co-organized by the Austrian Space Agency (ASA), French Space Agency (CNES), German Space Agency (DARA), European Space Agency (ESA), International Astronomical Union (IAU), International Centre for Theoretical Physics Trieste (ICTP), Institute of Space and Astronautical Science of Japan (ISAS), National Aeronautics and Space Administration of the United States (NASA), The Planetary Society (TPS), and the United Nations (UN).
2. http://www.seas.columbia.edu/~ah297/un-esa/index.html
3. http://www.ips-planetarium.org/
4. http://www.seas.columbia.edu/~ah297/un-esa/planetarium.html
5. The Government of Japan has donated the following planetaria to developing countries in the Asia-Pacific region: (i) GX-type GOTO planetarium to the Youth Culture Centre of Burma (Myanmar) in 1985; (ii) E-5 type GOTO planetarium to the Institute of Marine Technology of Burma (Myanmar) in 1988; (iii) Minolta planetarium to the Space Science Education Centre of Malaysia in 1988; (iv) GE-II type GOTO planetarium to the Haya Cultural Centre of Jordan in 1990; and (v) GS-type GOTO planetarium to the Burdowan University of India.
6. The computer systems shipped from ESA to the UN were checked for performance by the UN computer department, and were picked-up by the Permanent Missions of the respective countries for delivery to: (i) the University of Nigeria (Department of Physics and Astronomy, Nsukka, Nigeria); (ii) the Cuban Academy of Sciences (Institute for Astronomy and Geophysics, La Habana, Cuba); (iii) the Universidad Nacional Mayor de San Marcos (Seminario de Astronomia y Astrofisica, Lima, Peru); (iv) the University of Ghana (Department of Physics, Accra, Ghana); (v) the Institute of Fundamental Studies (Earth and Space Science Division, Kandy, Sri Lanka); and (vi) the Universidad Nacional Autonoma de Honduras (Observatorio Astronomico Centroamericano de Suyapa, Tegucigalpa M.D.C., Honduras).
7. http://www.seas.columbia.edu/~ah297/un-esa/neo.html
8. The Government of Japan has supported the establishment of moderate-size research telescopes or planetaria for education in south-Asian developing nations (Myanmar, Indonesia, Malaysia, Singapore, and Thailand) through the cultural grant-in-aid scheme of the Government of Japan.
9. http://www.slk.lk/accmt/page5.html
10. http://www.unah.hondunet.net/
11. http://da.saao.ac.za/~wgssa/
12. A similar regional astronomical newsletter (in Spanish and English) exists for Latin America and the Caribbean: Astronomia Latino Americana (ALA). This newsletter is edited and distributed by astronomers from the Universidad de Guanajuato and INAOE in Mexico, and is available electronically (http://www.astro.ugto.mx/~ala/). The publication of a regional astronomical newsletter (in Arabic and English) for the of Western Asia is in preparation by astronomers in Jordan.
13. http://www.seas.columbia.edu/~ah297/un-esa/ws1998-jordan_astronomy.html
14. http://www.seas.columbia.edu/~ah297/un-esa/regional_centres.html
15. http://www.un.or.at/OOSA/index.html

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