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Report on the Tenth United Nations/European Space Agency Workshop on Basic Space Science: Exploring the Universe; Sky Surveys, Space Exploration and Space Technologies

(Reduit, Mauritius, 25-29 June 2001)

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I. Introduction

A. Background and objectives

1. The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) and the Vienna Declaration on Space and Human Development recommended that activities of the United Nations Programme on Space Applications promote collaborative participation among Member States at both the regional and international levels, emphasizing the development of knowledge and skills in developing countries.[1]

2. At its forty-third session, in 2000, the Committee on the Peaceful Uses of Outer Space endorsed the programme of workshops, training courses, symposia and conferences planned for 2001.[2] Subsequently, the General Assembly, in its resolution 55/122 of 8 December 2000, endorsed the United Nations Programme on Space Applications for 2001.

3. Pursuant to resolution 55/122 and in accordance with the recommendation of UNISPACE III, the Tenth United Nations/European Space Agency (ESA) Workshop on Basic Space Science: Exploring the Universe; Sky Surveys, Space Exploration and Space Technologies was organized by the United Nations, ESA and the Government of Mauritius at the University of Mauritius, in Reduit, Mauritius, from 25 to 29 June 2001. The workshop was co-organized by the Centre national d'études spatiales of France, the German Space Agency (DLR), the National Aeronautics and Space Administration (NASA) of the United States of America, the National Astronomical Observatory of Japan and the Planetary Society.

4. The workshop continued the series of United Nations/ESA workshops on basic space science organized for the benefit of developing countries that was initiated in 1991 (see table 1).

5. The main objective of the workshop was to provide a forum to highlight recent scientific results obtained using ground-based and space-borne observatories in studies of the stars and the far reaches of the universe. Satellite missions constitute an impressive means of studying all aspects of basic space science from space as a complement to studies being done from the ground. The question of the large volumes of data generated by such missions was discussed in relation to changing research needs within the scientific community, as was how access to the important databases maintained by major space agencies could be facilitated. The importance of data research and education based on space missions was discussed, together with the relevance of such missions to the needs of developing countries wishing to participate actively in the voyage of discovery through the universe.

6. The present report was prepared for submission to the Committee on the Peaceful Uses of Outer Space at its forty-fifth session and to its Scientific and Technical Subcommittee at its thirty-ninth session. A number of papers presented at the workshop will be published in *Seminars of the United Nations Programme on Space Applications: Selected Papers from Activities Held in 2001* (ST/SPACE/7).

7. During the workshop, the National Commission on Space Activities (CONAE) of Argentina announced that it would be prepared to host the Eleventh United Nations/European Space Agency Workshop on Basic Space Science at the Mario Gulich Institute for Higher Space Studies in Cordoba, in cooperation with the University of La Plata, Cordoba, Argentina, from 9 to 13 September 2002.

B. Programme

8. At the opening of the workshop, introductory statements were made by representatives of the Government of Mauritius, the University of Mauritius, ESA and the United Nations. The workshop was divided into scientific sessions, each focusing on a specific issue. Presentations by invited speakers describing the status of their findings in research and education were followed by brief discussions. Fifty-two papers were presented by invited speakers from both developing and industrialized countries.

9. The workshop sessions focused on (a) sky surveys; (b) from solar/planetary systems to galactic/extragalactic systems; (c) data manipulation, databases and multi-wavelength analysis; (d) education with and networking of telescopes, with special reference to the southern hemisphere; and (e) utilization of space science and technologies and their benefits to society. Poster sessions provided an opportunity to focus on specific problems and projects in basic space science.

C. Attendance

10. Researchers and educators from developing and industrialized countries in all economic regions were invited by the United Nations and ESA to participate in the workshop. Participants held positions at universities, research institutions, observatories, national space agencies, international organizations and in private industry and were involved in all the aspects of basic space science covered by the workshop. Participants were selected on the basis of their scientific background and their experience with programmes and projects in which basic space science played a leading role.

11. Funds provided by the United Nations, ESA and the University of Mauritius were used to cover travel and living costs of participants from developing countries. Some 65 specialists in basic space science attended the workshop.

12. The following 28 Member States were represented at the workshop: Austria, Canada, Chile, China, Denmark, Egypt, Ethiopia, France, Germany, Hungary, India, Italy, Japan, Mauritius, Mexico, Netherlands, Norway, Romania, Russian Federation, South Africa, Spain, Sri Lanka, Syrian Arab Republic, Uganda, United Kingdom of Great Britain and Northern Ireland, United States of America, Yemen and Zambia.

II. Observations and recommendations

13. The important initiatives arising from previous United Nations/ESA workshops on basic space science and their fruitful promotion in Africa were noted by the participants, as also the importance of the regional centres for space science and technology education affiliated with the United Nations in providing the essential knowledge for promoting various programmes in space science and technology.

14. Participants of the workshop reviewed in four working groups the observations and recommendations of past United Nations/ESA workshops on basic space science: (a) space exploration; (b) sky surveys; (c) education, training and services; and (d) space technologies.

A. Space exploration

15. Given the steady progress in space science and technology in the past decades, the scientific goal is the quest for knowledge about the structure and evolution of the universe, in particular, to learn more about the solar system, which is fundamental for humanity. The technical gains, technological challenges and spin-offs of space exploration for both industrialized and developing countries are enormous.

16. Space exploration by individual developing countries alone is very often difficult to achieve. Cooperation between developing and industrialized countries is essential, in particular in view of the fact that the international space community is witnessing a large influx of data from different space probes where space scientists from developing countries can contribute in an important way.

17. Associated with the concept of the world space observatory (for the ultraviolet region of the electromagnetic spectrum) (WSO/UV), an international centre for astronomy could be established—similar in spirit to the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy—that would provide opportunities to space scientists from developing and industrialized countries alike to undertake joint research projects.

18. Participants noted that nearly all the data by spacecraft operated by ESA, NASA and the Institute of Space and Astronautical Science of Japan in the field of solar physics were available in public archives. Solarsoft, a solar data analysis package, was widely used. To allow a wider distribution, the participants recommended reviewing the possibilities of developing Solarsoft into a complete package that could be made available eventually as a freeware set of solar data analysis tools.

B. Sky surveys

19. Participants noted the importance of sky surveys. In particular, the emerging need for multi-wavelength astronomy, ranging from radio, infra-red, optical, X-rays to gamma rays, including neutrino and gravitational wave astronomy, provides a rich opportunity for astronomers from developing countries to be encouraged to carry out research, training and

education. South-South collaboration involving the Indian Ocean countries on the rim and African countries could be envisaged; for example, collaboration between the Mauritius Radio Telescope and the Southern African Large Telescope or other optical/radio observatories in southern Africa, could be explored.

20. Participants welcomed the establishment of an international implementation committee, the World Space Observatory Implementation Committee, for the WSO/UV and the progress made in discussions among several space agencies and interested countries. Further development of the project, including wider participation, should be encouraged.

C. Education, training and services

21. Participants recognized that the area of space science was of a multidisciplinary nature, since it involved modern technologies in electronics, sensor devices and imaging, information technologies, World Wide Web-based technologies, basic science, analytical techniques and so on. Therefore, the introduction of the subject at the primary, secondary and tertiary levels of education should be addressed by all countries in order to face future challenges. Education, training and research should not be compartmentalized. They were interconnected and neglecting any one of them would lead to deficiency in the development of space science in a country.

22. Mauritius carried out diverse activities, which could be used as an example for other developing countries on the range of space activities that could be used to develop a rich basic space science programme. Such activities were (a) the Mauritius Radio Telescope project (since 1989), being undertaken in collaboration between India and Mauritius (detailed information in sect. IV below); (b) the Mapping Mauritius Project, using remote sensing and geographic information systems (GIS) (since 1997), in collaboration between the University of Mauritius and Phillips University, Marburg (Germany); (c) the interconnection of education, research and training at the University of Mauritius at both the undergraduate and the postgraduate level; and (d) the development of new tools for handling astronomical data based on image-processing techniques using GIS for the classification of galaxies using dynamic neural networks.

23. However, one should caution that a particular role model should not be pushed in other countries or regions. What worked in one region at one point of time would not necessarily suit another region at some other point of time. Developing basic space science education should be encouraged. In addition, if adequate research facilities were not available in a country, students would not find required challenges and would have no role models to look up to for further motivation. Thus, careful career planning for scientifically educated people, keeping in mind the local environment, must be an integral part of the development process.

24. The establishment of an African institute of space science as a distributed organization would act as a source of vision and strategy to promote the development of basic space science throughout Africa and would be a major step towards extending the participation of developing countries in Africa in basic space science, which could possibly in turn accelerate the integration of spin-off benefits of space science into society. The institute could benefit from the previous experience obtained in the regional centres for space science and technology education affiliated with the United Nations. Participants recommended that African Governments, while developing and fostering national basic space science programmes, give due consideration to supporting the establishment of an African institute of space science, as appropriate to their needs, and that serious consideration be given to the possible benefits of affiliating national programmes to the institute.

25. The participants noted the great value of NASA's Astrophysics Data System in providing access to astronomical literature. Participants urge industrialized countries to ensure continuing support for free access to the system and urged developing countries to utilize fully the services provided by it.

26. Having in mind the observations and recommendations of past United Nations/ESA workshops on basic space science, participants discussed the Network of Oriental Robotic Telescopes project and made the following observations and recommendations:

(a) Many countries affiliated to the Network project were progressing in terms of education by developing youth programmes, scientific clubs, secondary school programmes and courses at university levels;

(b) However, more countries, with well developed activities in astronomy, astrophysics and space science, should introduce basic space science courses into their university curricula and should train young space scientists, astronomers, astrophysicists, programmers, engineers and technicians in their laboratories or observatories for appropriate periods of time. It was appreciated that the development of cooperative scientific projects through PhD work and continuous collaborations between universities in developing and industrialized countries was the best way to develop basic space science;

(c) French and Libyan astrophysicists were developing an educational and scientific cooperative programme for the 2.3-m national telescope at the University of Benghazi. The Islamic Republic of Iran had joined the Network of Oriental Robotic Telescopes with a project of a 2-m telescope with around 40 scientists, including MSc and PhD students;

(d) Eastern African countries (such as Ethiopia, Kenya and Madagascar) should carry out analysis of meteorological satellite data and site prospecting investigations on their high mountains in an effort to locate the best observational sites for middle- or large-size telescopes.

27. The participants noted that regional astronomical newsletters were published and distributed electronically through the World Wide Web and in hard copy on a regular basis, as recommended and supported by the United Nations/ESA workshops since 1996:

(a) *Africa*. The newsletter *Africa Skies/Cieux Africains* (http://www.saao.ac.za/~wgssa/) was published in a collaborative effort by the South African Astronomical Observatory and the Observatoire Midi-Pyrénées (France);

(b) *Asia and the Pacific*. The newsletter *Teaching of Astronomy in Asia-Pacific Region* was published by the National Astronomical Observatory of Japan;

(c) *Latin America and the Caribbean*. The newsletter *Astronomia Latino Americana* (http://www.astro.ugto.mx/~ala/) was published by the University of Guanajuato (Mexico);

(d) *Western Asia*. Preparations were progressing for the publication of a regional astronomical newsletter under the editorial supervision of an astronomical institute in Saudi Arabia.

D. Space technologies

28. Participants observed that the coordinated effort of the series of workshops on basic space science held under the auspices of the United Nations and ESA served as a catalyst:

(a) To promote the development of space technology in developing countries;

(b) To make possible cooperative efforts between countries, which would minimize the investment required by individual countries.

29. Participants noted that the cost of space technology had decreased considerably during the past decades and felt that Governments of developing countries should be encouraged to fund appropriate space science programmes for their respective countries in order to enjoy the benefits to be derived from them.

30. Participants recommended the development of on-line modular courses in space technology at the undergraduate and graduate levels to meet developing countries' needs for basic space science education, preferably in local languages.

31. Participants also recommended that developing countries implement curricula to prepare personnel to operate space science programmes.

32. The participants of the workshop recommended considering low-cost nano-satellites as a viable start-up for space projects for developing countries. Such projects could have a direct impact on the decision makers of developing countries and could provide a boost for furthering space science research projects.

III. Overview of the series of United Nations/European Space Agency workshops on basic space science

33. At the request of the international organizing entities (see para. 3), principal national organizers (see table 4) and participants of United Nations/ESA workshops on basic space science, respectively, information on the workshops held between 1991 and 2000 was gathered for the preparation of an assessment of the achievements of the workshops that could be finalized in 2001-2002. Subsequently, the results of such an assessment exercise could be brought to the attention of countries interested in the development of space science at the national, regional and international levels. Tables 1-4 have been compiled by participants of the workshops in cooperation with the principal national organizers of the host countries of all past United Nations/ESA workshops on basic space science.

A. United Nations/European Space Agency workshops on basic space science, 1991-2001

34. Table 1 contains information on host countries, their regional distribution, the number of participants and countries participating in United Nations/ESA workshops on basic space science between 1991 and 2001. The document symbols of the United Nations reports on the workshops and their titles are also provided.

B. Regional distribution of countries or areas and number of individuals who requested and received information on the results of the United Nations/ European Space Agency workshops on basic space science in 2001

35. The regional distribution of countries or areas and the number of individuals who requested and received information on the results of the United Nations/ESA workshops on basic space science in 2001 are shown in table 2. The addresses of the individuals in their respective countries have been used for the mail and electronic mail (e-mail) distribution of regional astronomical newsletters as described in paragraph 27. The same addresses have been provided to national and international astronomical organizations for dissemination of scientific information.

C. Projects pursued through the series of United Nations/European Space Agency workshops on basic space science, 1991-2000

36. Projects worked on at and follow-up projects pursued through the series of United Nations/ESA workshops on basic space science from 1991 to 2000 are identified in table 3. If available, World Wide Web addresses are provided from which detailed information on the respective project can be retrieved. Information on the projects is also contained in the United Nations reports on the workshops listed in table 1.

D. Contact addresses and published results of United Nations/European Space Agency workshops on basic space science, 1991-2000

37. The principal national organizers and participants of workshops have reported, on a continuous basis, on results addressed at and achieved through the workshops. Contact addresses of the principal national organizers at the host institutions can be used to receive updated information on all aspects of the workshops and their results published and reviewed in the international scientific literature. Relevant information is summarized in table 4.

IV. Mauritius Radio Telescope

38. The Mauritius Radio Telescope was designed primarily to undertake a survey of the southern sky at 151.5 megaHertz (MHz) with a sensitivity of 150 milliJansky. It is also meant to map the Milky Way. A point source catalogue of around 100,000 objects will be produced. The Mauritius Radio Telescope also makes observations of pulsars. Three surveys of the southern sky have already been finalized, with about 300 gigabytes of raw data collected.

Table 1
United Nations/European Space Agency workshops on basic space science, 1991-2001

Year	*City*	*Target region*	*Host institution*	*Number of participants*	*Number of participating countries*	*Workshop title*	*Report*
1991	Bangalore (India)	Asia and the Pacific	Indian Space Research Organization	87	19	Basic space science	A/AC.105/489
1992	San José and Bogotá	Latin America and the Caribbean	University of Costa Rica and University of the Andes	122	19	Basic space science	A/AC.105/530
1993	Lagos	Africa	University of Nigeria and Obafemi Awolowo University	54	15	Basic space science	A/AC.105/560/Add.1
1994	Cairo	Western Asia	National Research Institute of Astronomy and Geophysics	95	22	Basic space science	A/AC.105/580
1995	Colombo	Asia and the Pacific	Arthur C. Clarke Institute for Modern Technologies	74	25	Basic space science: from small telescopes to space missions	A/AC.105/640
1996	Bonn	Europe	Max Planck Institute for Radioastronomy	120	34	Basic space science: ground-based and space-borne astronomy	A/AC.105/657
1997	Tegucigalpa	Latin America and the Caribbean	Universidad Nacional Autónoma de Honduras	75	28	Basic space science: small astronomical telescopes and satellites in education and research	A/AC.105/682
1999	Mafraq (Jordan)	Western Asia	Al al-Bayt University	95	35	Basic space science: scientific exploration from space	A/AC.105/723

Year	*City*	*Target region*	*Host institution*	*Number of participants*	*Number of participating countries*	*Workshop title*	*Report*
1999	Vienna	All regions	United Nations Office at Vienna			(a) Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III);	United Nations publication, Sales No. E.00.I.3
						(b) International Astronomical Union (IAU)/Committee on Space Research (COSPAR)/United Nations Special Environmental Symposium "Preserving the Astronomical Sky";	Ibid., annex III, sect. II
						(c) IAU/COSPAR/United Nations Special Workshop on Education in Astronomy and Basic Space Science	Ibid., annex III, sect. VIII
2000	Toulouse (France)	Europe	Centre national d'études spatiales	80	34	Basic space science: satellites and networks of telescopes; tools for global participation in the study of the universe	A/AC.105/742
2001	Reduit (Mauritius)	Africa	University of Mauritius	65	28	Basic space science: exploring the universe; sky surveys, space exploration and space technologies	A/AC.105/766

Table 2

Regional distribution of countries or areas and number of individuals who requested and received information on the results of the United Nations/European Space Agency workshops on basic space science in 2001

Africa		*Asia and the Pacific*		*Eastern Europe*		*Latin America and the Caribbean*		*Western Europe and other States*	
Algeria	31	Bahrain	1	Bulgaria	2	Argentina	6	Australia	4
Angola	1	Bangladesh	1	Croatia	2	Bolivia	1	Austria	6
Botswana	3	Brunei Darussalam	1	Czech Republic	6	Brazil	3	Belgium	7
Burkina Faso	1	China	13	Hungary	1	Chile	3	Canada	11
Burundi	2	India	38	Lithuania	2	Colombia	2	Denmark	3
Cameroon	6	Indonesia	8	Poland	5	Costa Rica	7	France	38
Central African Republic	1	Iran (Islamic Republic of)	2	Romania	3	Cuba	5	Germany	49
Côte d'Ivoire	3	Iraq	2	Russian Federation	16	Ecuador	2	Greece	5
Egypt	45	Japan	13	Slovakia	4	El Salvador	6	Ireland	1
Eritrea	1	Jordan	14	The former Yugoslav Republic of Macedonia	1	Guatemala	4	Israel	6
Ethiopia	3	Kazakhstan	3	Ukraine	2	Honduras	24	Italy	15
Gabon	1	Kuwait	9			Mexico	13	Malta	1
Ghana	10	Lebanon	5			Nicaragua	4	Netherlands	4
Guinea	4	Malaysia	2			Panama	3	New Zealand	1
Kenya	12	Mongolia	5			Paraguay	1	Norway	1
Liberia	1	Oman	4			Peru	4	Portugal	2
Libyan Arab Jamahiriya	11	Pakistan	7			Uruguay	6	Spain	14
Madagascar	4	Palestine	1			Venezuela	2	Sweden	3
Malawi	4	Papua New Guinea	3					Switzerland	3
Mali	1	Philippines	3					Turkey	8
Mauritania	3	Qatar	5					United Kingdom of Great Britain and Northern Ireland	15
Mauritius	4	Saudi Arabia	12					United States of America	110
Morocco	23	Singapore	2						
Mozambique	5								
Namibia	4								

Africa		*Asia and the Pacific*		*Eastern Europe*	*Latin America and the Caribbean*	*Western Europe and other States*
Niger	2	Sri Lanka	6			
Nigeria	77	Syrian Arab Republic	6			
Rwanda	1	Taiwan Province of China	3			
Senegal	2	Tajikistan	1			
Sierra Leone	2	Thailand	4			
South Africa	113	United Arab Emirates	2			
Sudan	4	Uzbekistan	1			
Swaziland	2	Viet Nam	4			
Togo	1	Yemen	2			
Tunisia	8					
Uganda	3					
United Republic of Tanzania	5					
Zaire	2					
Zambia	8					
Zimbabwe	11					

Total number of countries: 124

Total number of individuals: 1,024

Table 3
Projects pursued through the United Nations/European Space Agency workshops on basic space science, 1991-2000

Year	*Country*	*World Wide Web site*	*Projects worked on at the workshop*	*Recommended follow-up projects*
1991	India		Telescope donation programme of the Government of Japan: Sri Lanka 1995, Paraguay 1999 and the Philippines 2000	Establishment of an astronomical facility at the Arthur C. Clarke Institute for Modern Technologies (ACCIMT) in Sri Lanka
1992	Costa Rica and Colombia	Galactic emission map (Colombia): http://aether.lbl.gov/www/projects/GEM/	Education and career development in basic space science "ISY92: Planetarium; A Challenge for Educators"	Establishment of an astronomical observatory for Central America in Honduras Donation of computer equipment by the European Space Agency (ESA): Cuba, Ghana, Honduras, Nigeria, Peru and Sri Lanka Establishment of a 5.5-m radio telescope in Colombia
1993	Nigeria	Inter-African astronomical observatory and science park (Namibia): http://home.t-online.de/home/a.masche/ and http://www.mpia-hd.mpg.de/Public/PUBREL/booklet01.html Southern African Large Telescope (South Africa): http://www.salt.ac.za	Southern African Large Telescope (South Africa)	Establishment of an inter-African astronomical observatory and science park on the Gamsberg in Namibia
1994	Egypt	Kottamia Telescope (Egypt): http://www.sti.sci.eg/scrci/nriag.html	Kottamia Telescope (Egypt) Egyptian drill project for the Mars mission	Refurbishment of the Kottamia Telescope Participation of Egypt in the Russian Federation/United States of America Mars mission 2001
1995	Sri Lanka	ACCIMT telescope facility (Sri Lanka): http://www/slt/lk/accimt/	Inauguration of a telescope facility (Sri Lanka) World space observatory (WSO/UV)	Evaluation of the feasibility of a world space observatory
1996	Germany	Working Group on Space Science in Africa: http://www.saao.ac.za/~wgssa/ Network of Oriental Robotic Telescopes (NORT): http://www.saao.ac.za/~wgssa/as2/nort.html	Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) Assessment of the achievements of the United Nations/ESA workshops	Establishment of NORT

Year	*Country*	*World Wide Web site*	*Projects worked on at the workshop*	*Recommended follow-up projects*
		Pierre Auger cosmic ray project: http://www.taridar.cnea.gov.ar/~auger/	Foundation of the Working Group on Space Science in Africa NORT 100-metre Effelsberg radio telescope Education and research using small astronomical telescopes Developing astronomy and space science worldwide Two air shower detectors, one situated in the northern hemisphere (United States of America) and one in the southern hemisphere (Argentina)	
1997	Honduras	Observatorio Centroamericano de Suyapa (Honduras): http://www.unah.hn Space Guard Foundation (Italy): http://spaceguard.ias.rm.cnr.it/	UNISPACE III First issue of the newsletter *African Skies/Cieux Africains* published Inauguration of the Central American Astronomical Observatory in Honduras NORT Observation of near-Earth objects	Joint membership of Central American countries in the International Astronomical Union
1999	Jordan	Maragha Astronomical Observatory (Jordan): http://www.aabu.edu.jo/ Hands-on astrophysics: http://www.aavso.org/ Astrophysics education module for university physics courses: http://www.seas.columbia.edu/~ah297/un-esa/astrophysics/index.html	UNISPACE III WSO/UV Operation of the Maragha Astronomical Observatory in Jordan Baquaa radio telescope Hands-on astrophysics Astrophysics for university physics courses	Operation of the astronomical telescope facility at Al al-Bayt University Planning of the 31-m Baquaa radio telescope at the University of Jordan
2000	France	World space observatory/UV: http://www.seas.columbia.edu/~ah297/un-esa/wso.html	UNISPACE III WSO/UV NORT Regional newsletters on astronomy	WSO/UV assessment study completed

Table 4

Contact addresses and published results of the United Nations/European Space Agency workshops on basic space science, 1991-2000

Year	*Principal organizer*	*Published review of workshop*	*Working papers published in* Seminars of the United Nations Programme on Space Applications: Selected Papers from Activities	*Workshop proceedings*
1991	S. C. Chakravarty Indian Space Research Organization Antariksh Bhavan New BEL Road Bangalore 560 094 India scc@isro.ernet.in	*Astrophysics and Space Science*, vol. 193, 1992, p. 161.	One working paper each in Nos. 3 (1992) and 4 (1993)	*AIP Conference Proceedings*, vol. 245, 1992, pp. 1-350.
1992	Walter Fernandez School of Physics University of Costa Rica 2060 San José Costa Rica wfer@cariari.ucr.ac.cr	*Earth Space Review*, vol. 2, No. 2, 1993, pp. 25 and 26. *COSPAR Information Bulletin*, vol. 2000, No. 149, pp. 82-84.	No working papers published	*Earth, Moon, and Planets*, vol. 63, No. 2, 1993, pp. 93-179.
1992	Sergio Torres Observatoria Astronómico Nacional Universidad Nacional de Colombia P. O. Box 2584 Santa Fe de Bogotá Colombia verada@earthlink.net	*Earth Space Review*, vol. 2, No. 2, 1993, pp. 25 and 26. *COSPAR Information Bulletin*, vol. 1999, No. 144, pp. 13-15.	No working papers published	*Astrophysics and Space Science*, vol. 214, 1994, pp. 1-260.
1993	Pius N. Okeke Space Research Centre University of Nigeria Nsukka Nigeria misunn@aol.com	*Earth Space Review*, vol. 3, No. 3, 1994, pp. 26 and 27. *COSPAR Information Bulletin*, vol. 1999, No. 144, pp. 28-30.	Three working papers in No. 5 (1994)	*AIP Conference Proceedings*, vol. 320, 1995, pp. 1-320.

Year	*Principal organizer*	*Published review of workshop*	*Working papers published in* Seminars of the United Nations Programme on Space Applications: Selected Papers from Activities	*Workshop proceedings*
1994	Joseph S. Mikhail National Research Institute of Astronomy and Geophysics Helwan Cairo Egypt	*Earth Space Review*, vol. 4, No. 2, 1994, pp. 28-30. *COSPAR Information Bulletin*, vol. 2000, No. 148, pp. 41 and 42.	Three working papers in No. 6 (1995)	*Earth, Moon, and Planets*, vol. 70, Nos. 1-3, 1995, pp. 1-233. *Astrophysics and Space Science*, vol. 228, 1995, pp. 1-405.
1995	Padmasiri De Alwis Arthur C. Clarke Institute for Modern Technologies Katubedda, Moratuwa Sri Lanka asela@slt.lk	*COSPAR Information Bulletin*, vol. 1996, No. 136, pp. 8-11. *ESA Bulletin*, No. 81, February 1995, pp. 18-21.	Three working papers in No. 8 (1997)	
1996	Rolf Schwartz Max Planck Institute for Radioastronomy Auf dem Hügel 69 D-53121 Bonn Germany rolf@mpifr-bonn.mpg.de	*COSPAR Information Bulletin*, vol. 1997, No. 138, pp. 21-24. *AAS Newsletter*, No. 79, 1996, pp. 18 and 19.	Two working papers in No. 8 (1997)	*Astrophysics and Space Science*, vol. 258, 1998, pp. 1-394.
1997	Maria Cristina Pineda de Carias Observatorio Astronómico Universidad Nacional Autónoma de Honduras Apartado Postal 4432 Tegucigalpa M.D.C. Honduras Mcarias@hondutel.hn	*COSPAR Information Bulletin*, vol. 1998, Issue 141, pp. 9 and 10. *Annals of the New York Academy of Sciences*, vol. 822, 1997, pp. 621-630.	Six working papers in No. 9 (1998)	
1999	Hamid M. K. Al-Naimiy Higher Institute of Astronomy and Space Sciences Al al-Bayt University P. O. Box 130302 Al Mafraq Jordan Alnaimiy@yahoo.com	*COSPAR Information Bulletin*, vol. 1999, Issue 146, pp. 9 and 10.	Six working papers in No. 11 (1999)	*Astrophysics and Space Science*, vol. 273, 2000, pp. 1-343.

Year	*Principal organizer*	*Published review of workshop*	*Working papers published in* Seminars of the United Nations Programme on Space Applications: Selected Papers from Activities	*Workshop proceedings*
2000	François R. Querci Observatoire Midi-Pyrénées 14, avenue Édouard Belin F-31400 Toulouse France fquerci@ast.obs-mip.fr	*COSPAR Information Bulletin*, vol. 2000, No. 149, pp. 66 and 67. *AAS Newsletter*, No. 100, June 2000, p. 21. *AAS Newsletter*, No. 102, October 2000, p. 14.	Thirteen working papers in No. 12 (2001)	

39. The Mauritius Radio Telescope is a synthetic radio telescope that is utilized to take images of the sky at a frequency of 151.5 MHz (or 2-metre wavelength). It can detect objects that are too faint to be seen by large optical telescopes.

40. The telescope is a joint project of the Indian Institute of Astrophysics and the Raman Research Institute, both in Bangalore, India, and the University of Mauritius in Reduit. It is located in the Bras d'Eau forest in the rocky north-eastern part of Mauritius (20.14° S and 57.73° E).

41. The original idea of a southern sky survey at a frequency of 150 MHz was put forward by Ch. V. Sastry of the International Institute of Astrophysics. He had the intention of undertaking a survey equivalent to the Cambridge 6C survey of the northern sky. Mr. Sastry and V. Radhakrishna of the Raman Research Institute visited Mauritius in 1987 to set up the telescope. Its further development remains a joint project of the three institutions mentioned. The final construction was completed in 1992 and the telescope has been operational since then. The receiver system was donated by W. C. Erikson from the defunct Clarke Lake Observatory, University of Maryland (United States). The antenna system was designed and built in India.

42. At present, there are 17 individuals employed for the day-to-day operation of the Mauritius Radio Telescope. They have completed three surveys and a low-resolution map of the southern sky. The processing of data for the final map has been completed. Observations of specific southern sky pulsars were made.

43. As one result of the establishment and operation of the telescope, four PhDs, one MPhil and a number of BSc theses have been completed. Engineers and technicians have been trained in the establishment and operation of the telescope. Subsequently, research papers have been published and, in 1997, a conference on low-frequency radio astronomy was organized by the staff. The Mauritius Radio Telescope has achieved international recognition.

44. The Mauritius Radio Telescope is a T-shaped array consisting of 1,020 fixed helical antennas arranged in 32 groups in the east-west arm (2 km long) and 64 helical antennas on 16 movable trolleys in the north-south arm (880 m long). There is a single trolley in the northern arm of the telescope. The antennas collect the radio waves coming from space. The signal from each group is filtered, amplified and sent to the telescope building where it is combined with the signals from other groups. The signal is processed in a correlator and computer programs transform it into images or profiles.

45. The Mauritius Radio Telescope uses the technique of synthetic aperture to simulate a 1 km by 1 km filled array. Observations are made with the trolleys in the south arm at their nearest position from the centre of the array. The trolleys are then moved further south and the observations repeated 62 times. This process continues until the end of the south arm is reached. A computer system, operating with Linux OS, is used to collect the observations to produce a map of the sky. Unlike most radio telescopes, the Mauritius Radio Telescope can see very extended radio sources. Also, the non-coplanarity of the east-west arm has led to the development of new imaging techniques used in cleaning the raw data.

46. Although the telescope was designed primarily to conduct the 151.5 MHz survey, it has also been used for pulsar observations, for which only the east-west arm is used. The group outputs are added together with a tracking capability of about 20 pulsars for a source transiting at meridian. This corresponds to eight minutes for an equatorial source. Data are recorded at a fast rate over a bandwidth of 1 MHz. The data processing is done to produce an output in the desired format, including the profile unique to each pulsar.

Notes

[1] See *Report of the Third United Nations Conference on the Exploration and Peaceful Ues of Outer Space, Vienna, 19-30 July 1999* (United Nations publication, Sales No. E.00.I.3), chap. I, resolution 1, part I, para. 1 (e) (ii), and chap. II, para. 409 (d) (i).

[2] *Official Records of the General Assembly, Fifty-fifth Session, Supplement No. 20* (A/55/20), para. 37.