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SCIENTIFIC AND TECHNICAL PRESENTATIONS TO THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE AT ITS THIRTY-THIRD SESSION

Report by the Secretariat

1. During the thirty-third session of the Scientific and Technical Subcommittee, the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU) and the International Astronautical Federation (IAF) organized, in liaison with Member States, a symposium on the theme "Utilization of micro- and small satellites for the expansion of low-cost space activities, taking into account the special needs of developing countries", to complement discussions within the Subcommittee on that theme. This symposium was organized in accordance with the recommendation of the Subcommittee at its thirty-second session (A/AC.105/605, para. 136), which was subsequently endorsed by the Committee on the Peaceful Uses of Outer Space at its thirty-eighth session[1] and by the General Assembly in its resolution 50/27 of 6 December 1995.

2. The symposium was the twelfth to be organized by COSPAR and IAF during the annual meetings of the Scientific and Technical Subcommittee, the topic for each year being selected by the Subcommittee at the previous session. The symposium was held in two parts, on 12 and 13 February 1996, following the completion of debate in the afternoon meetings of the Subcommittee during the first week of its session.

3. In addition to these special presentations organized by COSPAR and IAF at the request of the Subcommittee, delegations of Member States provided a number of scientific and technical presentations by specialists in space science and applications relating to various items on the agenda of the Subcommittee. Several national and international organizations also made special presentations on their scientific and technical activities.

4. In order to make more widely available the information on recent developments in space science, technology and applications, presented during the symposium and the other presentations, the Secretariat has prepared a summary of that information, which is presented below.

5. The annex contains a more detailed description of the scientific and technical presentations made before the Scientific and Technical Subcommittee at its thirty-third session. The annex is in English only. A list of the presentations and the speakers is contained in the appendix to the annex.

I. SUMMARY OF PRESENTATIONS

Symposium on Utilization of Micro- and Small Satellites for the Expansion of Low-cost Space Activities, taking into Account the Special Needs of Developing Countries

6. It was stated that, in most developing countries, at least two categories of needs for small satellites and microsatellite systems could be identified. The first group might be classified as direct needs, related to social and economic problems that might be addressed through various applications of space technology. The second group of needs had an indirect nature and dealt with attaining the condition of taking full advantage of the country's investments in acquisition of space systems and services.

7. The use of Low Earth Orbit Communications (LEOCOM) systems allowed many services; one of the most interesting was the communication between a portable terminal and a normal telephone of the existing fixed telecommunication network. In that case, the two users might be located anywhere in the territory and particularly in remote areas or regions lacking a communications infrastructure. The communication between two mobile users as well as between a mobile user and a user of the fixed network system anywhere around the globe was also possible.

8. The use of automatic data collection platforms (DCP), in conjunction with the two-way characteristics of LEOCOM, allowed for installation of a data collection network that featured a wide coverage and provided real-time service. In addition, the LEOCOM system could provide the location of any user of mobile terminals with an accuracy in the 100 metre range. The LEOCOM mobile terminal could also be coupled to a facsimile machine for the transmission of graphical data. Thus, it allowed a user, for instance, to send a fax of an electrocardiogram in the case of a medical emergency in a remote area.

9. Telemedicine was an application that would increase efficiency of medical services by allowing the transmission of information obtained by inexpensive and simple sensors directly to complex processing units in large medical centres where it could be interpreted by specialized physicians. That would make it possible for powerful and effective emergency services to reach poor and undeveloped areas, saving many lives and avoiding unnecessary displacement of patients. The Healthsat project was a good example of telemedicine application that used a 60 kg microsatellite in Low Earth Orbit (LEO) to relay medical data information between Nigeria and North America. Mobile communication might also play an important role in cases of natural disasters, allowing help to reach the disaster victims earlier and providing logistical support to the rescue teams.

10. Many developing countries had had early access to the benefits of satellite remote sensing, but still had a long way to go in order to maximize the benefits of the existing capabilities. There were, however, unique needs at both national and regional levels that demanded new solutions. Brazil and the Republic of Korea, for instance, were already developing new satellite programmes to address their specific needs. Developing countries in Latin America, South-East Asia and in other regions required special sensor parameters such as spectral bands, spatial resolution, time resolution, cost of image, investment level in the ground equipment, and expertise required for utilization.

11. Cooperative space activities were often supported by some kind of technology transfer. A successful technology transfer in the development of the small satellite project implied a process by which a team acquired sufficient momentum to be able to produce the next generation of small satellites. There were several mechanisms whereby technology transfer could be achieved, but to be successful, the transfer should be a transfer of knowledge, not the transfer of a technology package (know-why as well as know-how). Examples of programmes where engineers from developing countries were trained on small satellite design, production and operations were numerous. The University of Surrey in the United Kingdom of Great Britain and Northern Ireland had, for example, provided such assistance in the development of small satellites below 100 kg to Chile, Pakistan and the Republic of Korea, and even to small countries in Europe that decided to initiate a space programme.

12. A small satellite project in Argentina, Scientific Applications Satellite B (SAC-B,) was being prepared in cooperation with the United States of America (Pegasus launcher). The main purpose of the project was to design

a satellite with a scientific payload to advance the study of solar physics and astrophysics. The mass of the satellite was about 180 kg with an expected active lifetime minimum of three years. The launching of the satellite was scheduled for 1996. A new generation of satellites, SAC-C and SAC-D, aimed for scientific research and remote sensing, was being prepared for launching from 1999 to 2006.

13. In Brazil, great significance was attached to the collection of data from remote platforms using space technology. The Brazilian Complete Space Mission (MECB) was successfully started in February 1993 with the launch of the Satellite de Coleta de Dados (SCD 1). The satellite had remained operational two years after its expected useful life. At least two similar satellites would be launched to ensure continuity of the mission. In addition, the improved SCD 3 satellite (200 kg) would also be used in the mission to demonstrate the concept of voice and data communication in the equatorial region.

14. In Chile, the first operational satellite would be FASat-Bravo, developed in cooperation with the University of Surrey (United Kingdom). The 46 kg microsatellite would be put into circular orbit at 650 kilometres with an inclination of 82.5 degrees in August 1996. It would carry an ozone layer monitoring experiment, data transfer experiment, experimental Earth imaging system and some other equipment, including an educational experiment. Using the communications link provided by the satellite, students would be able to engage in study activities (orbital mechanics, satellite communications analysis, telemetry analysis etc.) one or two days per month.

15. The Satellite Research Center of the Korea Advanced Institute of Science and Technology (KAIST) began its programme to develop space technology with the launch of two scientific and experimental microsatellites, KITSAT 1 and 2, in 1992/93. Currently, KAIST was involved in designing its new indigenous satellite KITSAT 3 to enhance the capabilities of the previous two microsatellites. A primary objective of the programme was to develop a microsatellite system that had highly accurate attitude control, high-speed data transmission and the ability to provide hands-on experience to Korean space industries and research institutes. The remote sensing payload of KITSAT 3 would be able to monitor environmental disasters such as floods, volcanic eruptions and earthquake damages in the region of Asia and the Pacific.

16. In South Africa, the SUNSAT microsatellite project had been established in 1992 to increase engineering design opportunities for graduate students and to foster industrial and international interaction with Stellenbosch University. The 60 kg microsatellite would be able to provide images of cultivated fields, natural vegetation and pollution around the globe. The satellite would also be an electronic mailbox that would orbit the Earth to receive and deliver messages, as well as speech and data relay experiments to schools. SUNSAT should be launched by the United States Delta launcher in March 1997 into polar orbit at 450 to 850 kilometres, together with the Danish magnetospheric research satellite Oersted. SUNSAT would also carry the global positioning system (GPS) navigational receiver of the National Aeronautics and Space Administration (NASA) and a set of laser reflectors for precise positioning experiments.

17. A Spanish space project, MINISAT, was entrusted to the Instituto Nacional de Técnica Aerospacial (INTA), Madrid by the Spanish Inter-ministerial Commission for Science and Technology (CICYT) in 1992. Modular satellites of 180 to 500 kg mass (depending on the number of modules used) would be launched by the Pegasus airborne launchers starting in 1996. The first satellite MINISAT 01 would consist of the basic platform and would be used for scientific research. Satellite MINISAT 1 would be an upgraded version, equipped for remote sensing observations and MINISAT 2 would use the basic platform to provide long-distance communications even from the geostationary orbit.

18. A small scientific sub-satellite MAGION 4 was launched on 3 August 1995 together with the INTERBALL 1 "mother" satellite. MAGION 4 separated from the mother satellite after reaching the planned orbit (apogee 191,907 kilometres, perigee 793 kilometres, inclination 63.0 degrees). The satellite had a mass of 60 kg and had been developed in cooperation by the Institute of Atmospheric Physics (Czech Republic), Technical University, Graz (Austria) and the Space Research Institute (Russian Federation). Its scientific payload was aimed at studying of the geomagnetic field, wave phenomena and plasma parameters of the ionosphere within the framework of the

INTERBALL space project. Simultaneous measurements by two satellites at a small distance from each other allowed for temporal and spatial resolution of the observed phenomena.

19. The Central European satellite for advanced research (CESAR) was a spacecraft of about 300 kg planned for 1998 that would fly in an orbit with a perigee of 400 kilometres, an apogee of 1,000 kilometres and an inclination of 70 degrees. The scientific mission would be related to the study of the magnetospheric, ionospheric and thermospheric environment. Ten different experiments, provided by scientists from Austria, Czech Republic, Hungary, Poland and Slovakia, would be accommodated on board the spacecraft that was being constructed by the Italian Space Agency (ASI).

20. A working group on small satellites was created in the French space agency CNES at the end of 1993 to propose recommendations for the development of a series of small satellites complementing the Satellite Système probatoire d'observation de la terre (SPOT) system, at a cost of less than 300 million French francs per mission and a development time of two years. The recommended programme was called Plateforme reconfigurable pour l'observation, les télécommunications et les usages scientifiques (PROTEUS). The first flight was envisaged in 1999 as a continuation of the successful France-United States altimetric satellite project Topex-Poséidon.

21. The missions that were being considered by the Small Missions Opportunities (SMO) initiative of the European Space Agency (ESA) might be classified by the following parameters: 150-500 kg launch mass, orbit between 600 and 900 kilometres, development time of about two years, cost of less than 40 million European currency units for platform and integration, delivery on orbit, commissioning and user ground station. The basic concept of the SMO initiative was to have a common procurement of part or all of the following mission elements: launch, platform integration and ground segment. That approach should achieve the low-cost benefits for those recurrent elements of the mission.

22. In addition to the support (technological assistance and launching arrangements) provided to emerging space-faring nations, described in other parts of the present report, NASA had adopted its own Small Spacecraft Technology Initiative (SSTI). The technology programme should reduce the cost and development time of space missions for scientific and commercial applications. It should achieve a payload/total mass fraction of up to 70 per cent and times, from development to flight readiness, of two years. To achieve those goals, new design and qualification methods for small spacecraft should be demonstrated using commercial and performance-based specifications, integration of small instrumentation technology into the satellite bus design and end-to-end product development and flight verification. The future NASA mission capability should result in a 30-60 per cent reduction of costs and new technology insertion into missions.

23. NASA was also preparing a series of small, low-cost planetary science missions under its Discovery programme. They were designed to provide frequent investigative opportunities (one launch every 12-18 months) to the planetary research community, while encouraging partnerships with industry. All solar system targets and objectives were valid candidates for the Discovery programme, but the spacecraft cost should be low and the launch vehicle would be limited to Delta class or smaller. A total of 28 proposals were received in response to the first announcement of opportunity, covering the full range of planetary science objectives (the next announcement of opportunity was to be released in May 1996). The first four missions were fully funded, and their development was on schedule and within cost guidelines.

II. OTHER SCIENTIFIC AND TECHNICAL PRESENTATIONS

A. Space debris

24. Objects moving in the near-Earth space were regularly tracked and catalogued by the United States Space Command Space Surveillance System. That system operated more than 24 radar and several optical facilities to monitor near-Earth space and maintained a catalogue of orbital elements of all tracked objects (currently over 8,000).

The minimum diameter of observable objects was about 10 centimetres for LEO and 1 metre for geostationary-satellite orbit (GSO). Objects in GSO were tracked mainly by the dedicated optical system Geosynchronous and Deep Space Surveillance (GEODSS). In addition, a special radar located at Haystack (near Boston, Massachusetts) was capable of detecting objects less than 1 centimetre in diameter in LEO and obtaining statistical information on number, flux, size and altitude. There seemed to be over 100,000 space debris in LEO at sizes down to 1 centimetre.

25. The largest radar tracking facility in western Europe at the Research Establishment for Applied Science (FGAN) in Wachtberg-Werthhoven (Germany) was using a 34 metre parabolic dish antenna. Data from that site were an important addition to the catalogue data in case of re-entry predictions for high-risk space debris. The ESA had sponsored research on the feasibility of detecting and tracking medium-size debris (1-50 centimetres). Regarding the debris measurement by optical telescopes, ESA would use a one-metre Zeiss telescope that was currently being installed at the Teide Observatory on Tenerife (Canary Islands, 28.3 degrees north latitude) for other purposes. The minimum size of detectable objects would be 2-6 centimetres in LEO and 20-40 centimetres in GSO. The telescope should be operational for space object observations at the beginning of 1997.

26. Information on particles smaller than about 1 millimetre was obtained mostly through special detectors carried by spacecraft or through the analysis of impacts on material that had been exposed to the space environment. Many European researchers had analysed impact features on the NASA long duration exposure facility (LDEF) after its retrieval in January 1990, on the European recoverable carrier (EURECA) spacecraft and on the solar array retrieved from the Hubble space telescope (HST). The largest hole diameters were about 5 millimetres. Results of these analyses would be used to validate the present reference flux models for small-size meteoroids and space debris.

27. Examination of windows, radiator panels and other surfaces of the United States space shuttle orbiters showed that environmental models underestimated microdebris population and that the population was growing with time. While the NASA space debris damage model Bumper predicted 13 window replacements in 12 shuttle missions, the actual number of replacements was 19. In France, additional data from one year of exposure to space environment on board the Mir station (ARAGATZ mission) were used for comparison with space debris environment models.

28. Unique debris hazards associated with the proposed satellite constellations had been studied in the United Kingdom. A satellite constellation was a distributed architecture of satellites that provided global positioning, Earth observation, hand-held personal communications, messaging or data transfer. There were proposals for a large number of new systems, which would mean that over 1,000 new satellites would be placed into high inclination orbits at altitudes of 700-800 kilometres and 1,200-1,400 kilometres within 4-6 years. Realization of such projects would result in concentrations of satellite mass at certain regions of space around the Earth.

B. Use of nuclear power sources in outer space

29. A numerical analysis related to possible collisions of nuclear power sources (NPS) with space debris had been performed by the Russian Federation. The following contingencies had been examined in particular: destruction of NPS structure; change of orbital parameters of NPS after collision; their entry into the atmosphere; possible atmospheric destruction; and fallout of radioactive toxic material particles and parts of NPS structure. Collisions with space debris had been considered for reactors launched in the period 1970-1988 and injected into orbits within the altitude range of 700-1,000 kilometres. The probability of collisions with space debris, capable of considerable NPS damage, was sufficiently high and reached one in over 55 years.

30. Research on aerodynamic destruction of NPS and of the fuel rod assembly during their descent into the atmosphere after collision at the initial re-entry trajectory (altitude: 160 kilometres) confirmed that the NPS structure was destructed and the reactor fuel pins (uranium-molybdenum alloy) melted down to particle dimensions of less than 1 millimetre. The results had shown that fallout of such nuclear fuel particles, allowing for uranium fission product decay at the moment of collision, would not lead to a significant change in the radiation levels over the fall-out territory. The fall of the beryllium reflector parts and partially failed radiation shield of lithium hydride might constitute a threat from the point of toxicity, which would prompt search and clean-up (removal) measures.

31. In the United Kingdom, studies continued on possible supplements to the Principles Relevant to the Use of Nuclear Power Sources in Outer Space, adopted by the General Assembly in its resolution 47/68 of 14 December 1992. While the resolution included valuable consensus agreements on topics such as consultation, assistance to States affected by an accident, liability and compensation, it suffered from a number of limitations. Among those were the exclusion of propulsion and extraterrestrial bases; their formulation in terms of particular technologies; ignoring the potential effects of space debris; and inconsistencies with the more mature safety principles developed for the terrestrial applications of nuclear power. Therefore, a revision was suggested which generalized the intentions embodied in General Assembly resolution 47/68 in a way that was consistent with subsequent international developments under the aegis of the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA).

C. Remote sensing

32. With the successful design, development, launch and in-orbit performance of the first generation of the Indian remote sensing satellite (IRS), India was surging ahead to provide improved and enhanced data services from the second generation remote sensing satellites, IRS-1C and IRS-1D. IRS-1C, which was launched on 6 December 1995, was characterized by an improved spatial resolution, extended spectral bands, stereo viewing and faster revisit capability. Besides cartographic applications, the IRS-1C mission mainly addressed the following areas: crops and vegetation applications with specific reference to mixed crops and vegetation discrimination; biological parameters and oceanographic applications, in particular observations of physical oceanographic parameters such as winds, sea surface temperature, waves etc.; and atmospheric applications for monitoring global changes such as the depletion of the ozone layer over the Antarctic region.

33. The space research activities in Morocco, related to remote sensing and environmental monitoring, were characterized by an active, realistic and long-term policy at both the national level (coordination, information, training and project formulation) and the international level (participation in forums, international committees and bilateral and multilateral projects). The use of outer space in Morocco was becoming ever more developed, extensive and diversified. With regard to satellite data, stations were currently in operation to receive METEOSAT weather satellite data, for example, at the National Department of Meteorology (DMN). There were plans to set up two National Oceanic and Atmospheric Administration (NOAA) stations, one for meteorological studies at DMN and the other at the Royal Centre for Spaceborne Remote Sensing (CRTS) of Morocco for receiving advanced very high resolution radiometer (AVHRR) data. This station was to be set up within the framework of the GLOVE project, which was co-financed by the European Community.

34. GEOSPACE, a company located in Austria, was conducting a global mapping project to produce a digital atlas of the world. The global satellite image mapping project aimed to develop a global geographic information system, which was easy to use, cost-effective and easily accessible for frequent updates. Studies were being performed at the local, regional and international level.

35. The status of new commercial remote sensing satellites was reviewed by the Secretary General of the International Society for Photogrammetry and Remote Sensing (ISPRS). These new satellites were intended to provide high resolution data, up to 2-5 metres, in the fields of meteorology, cartography, natural resources and commercial imaging. Countries that, in the recent past, had been involved in the development of such commercial remote sensing satellites were France, Germany, India, Japan, Russian Federation and United States. Furthermore, ESA was playing a major role in the development of new remote sensing satellites. An outlook for the next decade indicated that 99 Earth observation satellite payloads were planned to be implemented, of which 57 payloads should be established within the next five years. The new payloads would play a significant role in the development towards digital photogrammetry and remote sensing.

D. International Space University

36. The International Space University (ISU), established in 1988, placed emphasis on an interdisciplinary, international and intercultural space education programme. ISU contributed to the development of professionals required in the international space arena, such as creators, innovators, managers and leaders. ISU was dedicated to the education of professionals of all disciplines in space-related fields, the creation and expansion of knowledge through research, and the exchange and dissemination of knowledge and ideas.

37. During the course of the summer session programmes of ISU, comprehensive lectures were provided in all space-related disciplines and their interactions. Furthermore, an international space project was designed during the summer curriculum, resulting in a professional report with practical utility for the international space community. In addition to the summer session programmes, ISU had recently launched a Master of Space Studies programme, held at Strasbourg, France. The one-year graduate programme comprised three major elements: (a) sciences and applications; (b) engineering, systems and technology; and (c) management and social sciences.

E. Space transportation

38. The Russian Federation continued the use of the middle- and heavy-class launchers of the Soyuz, Molniya and Proton type to launch communication, scientific and many other payloads into different orbits (including GSO). Launchers Tsiklon and Zenit were produced in cooperation with Ukraine. The most used cosmodrome in the world - the cosmodrome at Plesetsk - was responsible for 60 per cent of Russian launchings and 10 per cent worldwide. During the 30 years of its existence (from March 1966), there had been almost 1,500 successful launchings. Plans were progressing for a possible gradual building of the new Russian cosmodrome at Svobodny (Amur region) in the eastern part of the country.

39. Converted military rockets Start-1 and the more powerful Start and Rokot used solid fuel and would also be used in the space programme. A Russian space corporation, a Ukrainian research and production centre Yuzhnoe, a United States company and a Norwegian shipbuilding company, were all cooperating within the framework of an international consortium on the preparation of commercial launchings from a sea-based platform near the equator.

40. The Association of Space Explorers (ASE) supported and endorsed the concept of the "X-Prize", a prize of US$ 10 million that would promote private industry development of a reusable, single stage, sub-orbital vehicle capable of carrying three adults (300 kg) to an altitude of at least 100 kilometres above the Earth. The Association believed that the X-Prize would stimulate public interest in space exploration and development, and lead to the capability to fly many people into space, goals which the ASE promotes.

F. Astronomy and planetary exploration

41. In early 1995, the international astronomical community was dismayed by the publication of a proposal on behalf of the United Nations Educational, Scientific and Cultural Organization to mark its fiftieth anniversary by a launch of a solar reflector, the "Star of Tolerance". It was to have been in the form of a double star comprising two reflecting balloons (one of 50 metres, the other of 30 metres in diameter, both connected by a 2-kilometres tether). It would orbit the Earth at 1,250 kilometres and appear as bright as the star Sirius, or even as the planet Jupiter. Fortunately the project was abandoned. The "Star" itself would not be a disaster for astronomy, although it would be a significant hazard. What did cause major concern within the astronomical community was the precedent it would set, if implemented. It would be a clear signal that it was culturally, scientifically and educationally acceptable to use spaceborne solar reflectors to convey messages on an international scale.

42. In the field of radio astronomy, there were problems with artificial radio transmissions from orbiting satellites. The interference caused by the Global Orbiting Navigation Satellite System (GLONASS) at 1612 MHz had recently been resolved. Thus, the conditions for observing the important oxygen-hydrogen maser line at that frequency would rapidly improve. However, a newly proposed satellite communication system, Iridium, was again threatening radio astronomical use of that band. Although Iridium and the United States National Radio Astronomy Observatory had reached a memorandum of understanding, the remainder of the radio astronomical community, with good reason, regarded that bilateral agreement as a poor basis for the future. What was needed was some kind of operational mandate that would allow astronomy, civilization, industry and commerce to coexist.

43. Another mobile communication project, Teledesic, was looking for an allocation of frequency in the very high frequency range in the 19 to 29 GHz band, hitherto an unallocated millimetre wavelength. That spectral region was one of particular importance to radio astronomy since there were many interstellar line emissions. The detection of those signatures of the nature of cosmic chemistry would be of crucial importance in discerning how large chemical molecules could be constructed and where in the Universe such processes took place. Great care would have to be exercised in assigning the millimetre frequency range for communications, if access to such far-reaching astronomical information was to be maintained.

44. The International Conference on Near-Earth Objects was held in New York from 24 to 26 April 1995. It was co-sponsored by the Explorers Club, the Planetary Society and the United Nations. The subject of the conference, Near-Earth Objects (NEO), was based on comets and asteroids whose orbits could intersect the orbit of the Earth around the Sun. Since it has been generally understood that the impact of a kilometre-size NEO would have severe consequences on the terrestrial biosphere, it was of some interest to estimate its probability. Astronomy and planetary science had shown that craters were an ubiquitous, if not dominant, feature on planets, moons and asteroids within the inner solar system. Detailed studies of the cratering record indicated that the impact of NEO 1 kilometre or greater in size was a regular occurrence, with continuity over large time scales.

45. The main focus of NEO research at the present time should be towards generating more knowledge about the origin, evolution and dynamical and material characteristics of asteroids and comets that could interact within the immediate space environment of Earth. Heightened public awareness about NEO and hazards associated with possible impacts must be met with a responsible explanation based on scientific knowledge. From that perspective, NEO research provided an opportunity to pursue interdisciplinary scientific research in the basic space sciences through international cooperation.

Notes

[1]*Official Records of the General Assembly Fiftieth Session, Supplement No. 20* (A/50/20), para. 102.