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COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE
Scientific and Technical Sub-Committee

PROGRESS OF SPACE RESEARCH 1981-1982

Report submitted by the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU)

Note by the Secretariat

Annexed is a report on the progress of space research 1981-1982 submitted by the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU) in accordance with the request of the Scientific and Technical Sub-Committee for the submission of reports by COSPAR on scientific and technological developments in the exploration and peaceful uses of outer space. The report is being circulated, as received, only in the language of its submission (English).

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Annex

COSPAR

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PROGRESS OF SPACE RESEARCH

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Committee on space Research (COSPAR)
of the International Council of Scientific Unions (ICSU)

Editor:
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FOREWORD

This report is a further contribution to the series of reports "Progress of Space Research", which are prepared annually by COSPAR at the request of the Scientific and Technical Sub-Committee of the United Nations Committee on the Peaceful Uses of Outer Space. The present report is composed of contributions by a number of leading scientists from the COSPAR community and, its intent is to summarize in a succinct way the most important recent developments in the field of space research. The fields reported herein follow the subdivision of the scientific disciplines making up the seven Interdisciplinary Scientific Commissions (ISC's) of COSPAR; COSPAR Panel inputs are included in the ISC Chapter that is most fitting for the material contained in those inputs. Together, these cover the whole field of scientific space research, from life sciences to astrophysics.

The Chapters were compiled by the following scientists:

Chapter I - Mr. S. Ruttenberg (USA)
Chapter II - Dr. C.T. Russell (USA)
Chapter III - Dr. R.W. Shorthill (USA)
Chapter IV - Prof. S.A. Bowhill (USA)
Chapter V - Dr. R.M. Bonnet (France)
Chapter VI - by the editor of the report, from the inputs from Prof. T.H. Jukes (USA), Dr. G. Horneck (FRG), Prof. H. Planel (France), and Dr. R.S. Young (USA)
Chapter VII - Dr. Y. Malméjac (France)

To them, and to the several scientists who prepared inputs to the various Chapters, I wish to express my sincere thanks.

In addition, it is my particular pleasure to extend my thanks to Prof.Dr. W. de Graaff (The Netherlands), who acted as editor of the full report.

Cornelis de Jager
President of COSPAR

Chapter I

EARTH OBSERVATIONS

1. Weather

Researchers in Hungary have produced temporal analyses of the cloud fields over Europe; useful relations are being developed between the cloud field and the surface pressure. Digital information extraction algorithms are being developed for analysis of the infrared cloud images, e.g. evaluation of equivalent blackbody temperatures, and identification of cloud heights and forms. Digitized infrared images are being studied in connection with rainfall estimation algorithms. Ozone transmittances were computed and the results used for deriving the ozone profile from satellite sounding data. A number of radiation studies have been undertaken using satellite data.

Japan successfully launched GMS-2 (Himiwari-2), geostationary meteorological satellite) and stationed it at 140°E; Himiwari-1 has been moved to 160°E. Successful experimentation has been conducted in deriving stereoscopic cloud images, for height determination, using pairs of images from GMS-1 and the USA GOES-West. Further experimentation may be conducted using GMS-1 and GMS-2, now very strategically located for such analysis.

An advanced meteorological ground station has been installed in Bangladesh, to assist in montoring and studying the severe storms prevalent in the area, as well as to assist in furthering meteorological research.

The infrared sounder for temperature and moisture (VAS) has continued to operate on the USA geostationary satellites. It is being used predominantly in a research mode, but is seen as a valuable future part of the operational system.

2. Climate

Initial discussions are underway in COSPAR ISC A, IAMAP/IUGG and the JSC concerning an International Satellite Land-Surface Climatology Project (ISL-SCP); this project, for the World Climate Research Programme (WCRP), would be analogous to the International Satellite Cloud Climatology Project, organized by JSC with COSPAR and IAMAP participation. Further discussions are planned at the IUGG General Assembly, Hamburg 1983. Efforts are being made to interest UNEP in supporting the work.

Under the auspices of COSPAR and IAMAP, a small group of experts met in September at the NASA Goddard Space Flight Center, Greenbelt, Maryland, USA, to review the older Landsat data and select scenes especially important for climate studies for reprocessing into digital format. The general nature of this matter and steps being taken to preserve parts of the Landsat archive are discussed below under Land Observations.

3. Oceans

The data from the USA Seasat (1978), which had a lifetime of only three months, are now fully processed and available through means of an experimental user-interactive computer-assisted catalog, developed at the Jet Propulsion Laboratory of the California Institute of Technology. These data fields, particularly the wind fields over the ocean represent a unique but unfortunately short coherent data set. Experience with the Seasat data processing, information extraction and data archive, however, is invaluable for the development of future oceanographic satellite and information systems.

Several possible new satellite flight programmes designed for oceanography are under various stages of planning at ESA, and in France, Japan, and the USA. These would be used for marine research as well as to support several observational programmes now being discussed by the SCOR-IOC Committee for Climate Changes and the Oceans (CCCO). CCCO works closely with the ICSU-WMO Joint Scientific Committee for the WCRP. COSPAR has had a long history, since 1965, of cooperating as a technical advisory body for these kinds of programmes (e.g., for the GARP observational experiments).

Plans are being made for several expert meetings immediately following the 1983 IUGG Assembly, addressed to special topics important for the WCRP and for advancing satellite meteorology.

4. Land Observations

The Bangladesh Space Research and Remote Sensing Organization (SPARRSO) is continuing its programme of analysis of Landsat images for use in Bangladesh, with work aimed at such applications as land studies, agriculture, and hydrology.

The USA Landsat data tapes, dating from circa August 1972, are showing signs of deterioration, i.e., data loss from such processes as magnetic print-through. In addition, it is necessary to consolidate the data set and, steps are being undertaken at this time to repro-cess the older tapes (wide-band video analog) into a digital computer compatible format. The volume of the data set, its steady deterioration, and the time that it takes to reprocess the older data necessitate a stringent selection procedure to preserve only those scenes considered optimally useful for research studies. A group of experts organized under COSPAR and IAMAP auspices is advising NASA on what additions to the selection already made is needed for climate studies. The group identified several climatically sensitive zones where land observations are helpful in diagnosing the climatic effects, and developed a scheme for use of suitable calibration areas to assure good continuity of the data set, and intercomparison with later observations, such as from METEOSAT; in addition, a few areas are selected where there is a considerable amount of ground information available for validation studies. The period 1972-78 is of main concern, inasmuch as, after 1978, the Landsat scenes were recorded digitally.

Chapter II

SPACE PLASMAS IN THE SOLAR SYSTEM

The study of the physics of the plasmas, which permeate the solar system, continues to be an extremely active field of research, both because of the richness of plasma physics phenomena and also because of the wide range of parameter space covered with the presently available data. From Mercury to Saturn, the solar wind plasma density decreases by a factor of over 1000, and now the measurements extend far past Saturn. Magnetospheres under study range from that around the unmagnetized, slowly rotating planet, Venus, to that of the strongly magnetized, rapidly rotating outer planets. In deep space, both Voyager spacecraft and Pioneers 10 and 11 continue to operate. In the inner solar system, Helios 1 still returns data, as does Pioneer Venus. As a lonely sentinel in front of the Earth, ISEE-3 has, until now, circled the forward libration point. However, now nudged out of its orbit by a brief firing of its gas jets, it is on a trajectory that will take it into the distant magnetotail, and possibly past a comet in 1985. Closer to the Earth, ISEE-1 and -2, GEOS-2, SCATHA, DE-1 and DE-2, and several other spacecraft continue to probe the Earth's plasma environment. Down on Earth, plans are being made for the future generation of missions to study the plasmas of the heliosphere. The International Solar Polar Mission (ISPM) scheduled to be launched in 1986 will, for the first time, go far out of the ecliptic plane and probe the region above the poles of the Sun. The Galileo mission is also being readied for a 1986 launch to orbit Jupiter. Closer to home, and launch, are the AMPTE and VIKING missions to study the Earth's magnetospheric plasma.

1. Solar Wind

The source of the solar wind is the Sun, and it is not too surprising that phenomena on the Sun intimately control the properties of the solar wind. However, discovering what phenomena on the Sun control what properties of the solar wind is not always a simple problem. Researchers of the USA Naval Research Laboratory have been studying the effect of solar mass ejections on the solar wind. Each mass ejection detected by the P78-1 solar coronograph was found to cause an interplanetary shock wave whenever a spacecraft, such as Helios or Pioneer Venus, was in an appropriate location to see the shock. The Los Alamos solar wind group have identified the region of low solar wind abundance surrounding polarity reversals in the interplanetary field with coronal streamers. Further, this group has discovered that the solar wind is not always super-Alfvénic, but that, at times, the density can drop so low that the Alfvén velocity rises above the solar wind velocity. This result was not expected and implies that at times the Earth's bow shock disappears.

In the more distant solar wind (beyond 1 AU), the USA Goddard group have used Voyager magnetic field and plasma measurements to study the total energy, cross helicity and magnetic helicity of the solar wind. These are the so-called rugged invariants of three dimensional ideal incompressible MHD turbulence theory. These results are consistent with the expectations of the inverse cascade and selective decay hypotheses of three dimensional MHD turbulence. At 5 AU, the fluctuations are found to be propagating both outward and inward.

2. Venus, Mars and Comets

Much progress is being made in understanding the interaction of the solar wind with bodies having gaseous envelopes, principally through the studies of data obtained in the vicinity of Venus by the Pioneer Venus orbiter and the Venera 9 and 10 orbiters. In addition to the usual MHD processes operating in the plasma, there can be direct coupling with the neutral atmosphere via charge exchange and photo-ionization. The former process can remove momentum from the flow and the latter process can add mass to the flow. These processes affect both the shock shape and position. In the past, there has been much controversy as to the location of the Venus bow shock in the subsolar region as to whether it was closer to the planet than predicted by the gas-dynamic calculations which included no coupling with the neutrals. While the weight of evidence has been in favor of such a displacement, most of the evidence required extrapolation from outside the subsolar region. The evolution of the Pioneer Venus orbit has now carried it into this region, but the mapping of the subsolar region is not yet complete.

There is much evidence in the Pioneer Venus data for ion pick-up from the neutral atmosphere, whether this be a result of charge exchange or photo-ionization. The Pioneer Venus plasma analyzer team found singly-ionized oxygen flows which are strongest closer to the planet and to its wake. It has been pointed out (H. Pérez-de-Tejada) that these "minor" ion flows do not go parallel to the field, as in many cometary models, but are travelling parallel to the solar wind. The Goddard Langmuir probe team have discovered another Venus ion mechanism which they have called plasma clouds. These regions are dense, cold regions of "ionospheric" plasma at high altitudes, seemingly detached from the ionosphere.

The UCLA magnetometer group have shown that magnetic stresses may be responsible for accelerating these clouds.

On the nightside of Venus, ionospheric holes with low plasma density, and radial magnetic fields have been discovered (L. Brace, J. Luhmann, and co-workers). Although these are probably associated with some facet of the solar wind interaction, it has been postulated (Knudsen and co-workers) that the radial magnetic field in the holes is evidence for an intrinsic magnetic field. Even if that is so, the resulting magnetic field is inconsequential for the solar wind interaction.

The possibility of a Martian intrinsic field is more strongly advocated than for Venus, but here much fewer data exist. Even a re-analysis of the Viking retarding potential analyzer (Hanson and co-workers) shed little light on the problem. New data from Mars are greatly needed.

Little work, other than theory, is being done on the solar wind interaction with comets because of the lack of in situ data. However, work is feverishly underway on three missions to Halley: GIOTTO, VEGA, and Planet A. One intriguing theoretical result (V. Formisano and co-workers) is that Alfvén's critical velocity ionization process may work to ionize cometary atmospheres, albeit with slight modifications.

3. Jupiter and Saturn

Magnetic field models of the Jovian magnetosphere continue to be refined. Using the latest models and comparing Voyager and Pioneer data, no discernible secular variation could be detected by the Goddard magnetics group, confirming similar conclusions of the UCLA group. Their Voyager 1 and 2 observations of the tail current sheet reveal variations in time and distance from Jupiter. The magnetic structure of current traversals ranged from a static geometry to forms consistent with magnetic loop and/or X-type neutral line geometry. Observations from at least four experiments on board Voyager 2 provide compelling evidence for the existence of a long Earth-like Jovian magnetotail that extends at least 9,000 Jovian radii downstream from the planet. Since the tail encounters occurred about every 25 days, the tail is apparently influenced by solar wind stream effects.

It is very unlikely that a decrease in the solar wind ram pressure can account for the unexpectedly large size of Saturn's magnetic field during Voyager's outbound leg and the apparent length of time the expansion persisted. This, combined with the fact that the spacecraft was observed to be in Jupiter's tail approximately one week before the Saturn encounter, makes it very probable that Saturn was in Jupiter's tail during the Voyager 2 encounter.

The Goddard group has produced a simple three parameter axisymmetric octupole model of Saturn's planetary field with an equatorial surface field of 0.18 Gauss and north and south polar fields of 0.84 and 0.65 Gauss, respectively. This model both reconciles the in situ observations with Pioneer 11 and Voyagers 1 and 2, and also successfully accommodates the charge particle absorption features due to satellites and rings in Saturn's magnetosphere. There is no evidence for a large scale magnetic anomaly in the northern hemisphere which could be associated with periodic modulation of the Saturnian kilometric radio emissions. This remains the major outstanding puzzle connected with Saturn's magnetosphere.

Saturn's southern hemisphere radio source was observed clearly, for the first time, as it exited the magnetosphere at large negative latitudes. The source locations of the Saturnian kilometric radiation (SKR) appears to be near the polar cusps. The northern source, for example, is found to be near 11 h, local time, at $\sim 75°$ latitude. Dramatic changes in the energy output of Saturn's radio sources were found to be positively correlated with changes in the solar wind pressure. Finally, dust-plasma interactions and the spokes in Saturn's rings continues to be an active area of controversy.

4. The Earth

Much of the new observational data in the terrestrial magnetosphere comes from the ISEE-1 and -2 spacecraft and the GEOS-2 spacecraft, which continues to operate. Much of the effort that, until recently, was focussed on upstream waves has now turned to bow shock studies. The UCLA group has studied the overshoot in field strength seen behind supercritical shocks and its dependence on Mach number and beta. This has been modelled in computer simulations by the Maryland group and found to be due to reflected or gyrating ions in the foot of the shock. These ions, in turn, have been detected by the Los Alamos/MPI fast plasma experiment on board the ISEE spacecraft. Electron acceleration is also being extensively studied by the Los Alamos and Goddard groups. Field-aligned beams of electrons are seen in the bow shock.

The magnetopause is similarly under heavy attack. Both evidence of steady reconnection and transient reconnection has been found, the latter in the form of flux transfer events. Both the Imperial College (UK) group and the UCLA group find evidence for flux transfer events moving north and south from the equatorial region. The rotation of the magnetic field through the magnetopause has been studied (J. Berchem and co-workers). It can have either electron or ion polarization, depending on the direction of the magnetosheath magnetic field. This result is confirmed by computer simulations by the Alaska group.

The magnetotail is also being extensively studied with the ISEE spacecraft, with studies of tail dynamics being undertaken under the auspices of a Coordinated Data Analysis Workshop (CDAW-6). Studies of the field-aligned currents and the electric fields in the tail are also being pursued. A statistical study of substorm electric fields by the Berkeley group showed that enhancements of 1.5 to 10 nV/m, in the dawn-dusk component of the electric field, lasting for 5-15 minutes, usually occurred within 10 minutes of ground onset of the substorm. Another discovery was the existence of large spiky electric fields. The fields are associated with low frequency electrostatic turbulence and field-aligned currents.

At low altitudes, interest still continues in electric double layers and solitary waves containing magnetic field-aligned currents in the auroral plasma. These occur between altitudes of 6,000 and 8,000 km, in association with electron and ion velocity distributions that indicate the presence of electric fields parallel to the magnetic field. It has been suggested (M. Temerin and co-workers) that the double layers may account for a large portion of the parallel potential drop that accelerates auroral particles. Numerical simulations by the UCLA group and others show that ion cyclotron waves can heat the auroral ions and produce the observed ionic distributions.

At synchronous orbit, coordinated GEOS measurements of ULF waves, ion composition and energetic particles show very clearly that cold plasmaspheric He^+ is accelerated by wave-particle interactions for which He^+ also acts as a catalyst. Since the free energy source is apparently the anisotropy of energetic protons, this process represents an important exchange of energy between hot and cold plasma populations. Synoptic studies of GEOS data have focussed on a large systematic increase in O^+ density observed during the rising phase of the current solar maximum in the near equatorial kilovolt plasma population. The rise in O^+ density and lesser increases in other terrestrial species, is attributed primarily to the solar cycle increase in solar EUV and related heating and ionization in the topside ionosphere.

Chapter III

SPACE STUDIES OF THE PLANETS, SMALL BODIES OF THE SOLAR SYSTEM, AND GEODESY AND GEODYNAMICS

1. Planetary Research

During the last two years, planetary research has been centered on Saturn and Venus.

i. Saturn

Voyager 2's encounter with Saturn, in August 1981, followed Voyager 1's encounter of November 1980, completing a very successful primary mission for these two spacecraft. They now continue their exploration of the solar system, with Voyager 2 heading toward Uranus, for an encounter in 1986, followed by the possibility of an encounter with Neptune. Voyager 1 moves towards the outer solar system to investigate the interplanetary environment.

During the Saturn encounters, the surfaces of nearly all of its 17 moons were photographed in detail. New information was obtained, for example, on the storms in Saturn's atmosphere, its highly structured rings, and the complex surface features of its satellites. The analysis of the Saturn data is just beginning. The 4-day COSPAR Symposium on the Giant Planets and their Satellites, held in Ottawa in May 1982, with the presentation of many interesting results, still covered only a small fraction of the subjects under study.

ii. Venus

The successful landings of Venera 13 and Venera 14, four days apart, in March 1982, provided new insight on the surface structure of Venus. Photographs, both in colour and in black and white, were obtained. Information on chemical abundance was obtained, using X-ray fluorescence instruments. Other surface investigations were also performed, such as, a seismic experiment and an acoustic experiment. Numerous atmospheric studies were carried out during entry phase. A sample of the surface was obtained, at a depth of 3 cm, and analyzed. The experiments were carried out by scientists and engineers of the USSR Academy of Sciences' Vernadski Institute and Institute for Space Research. Studies are under way at these two Institutes which will, no doubt, be reported at the next COSPAR Meeting in 1984.

iii. Mars

The Viking 1 lander continues to return to Earth data on the surface of Mars after six years of operation. Meteorology, imaging, radio science, and engineering data will be received until December 1994, if the spacecraft systems continue their normal operation.

2. Small Bodies in the Solar System

i. Studies of Planetary Rings

After the discovery of new and unexpected phenomena in the Saturnian ring system by Pioneer 11, and Voyager 1 and 2, the scientific efforts concentrated on the development of theoretical models to explain these observations. Progress has been made in understanding some fine structure of the rings. Density wave theory, which has been developed to explain the spiral structure of galaxies, was applied to the interaction between satellites and rings. This theory can explain the observed spiral-like mass concentrations in the rings at the position of satellite resonances (i.e., the position at which the orbital period of ring particles is a simple fraction of a satellite's orbital period).

Attempts have been made to explain ring observations involving small micrometer-sized particles (e.g. in Jupiter's ring, Saturn's E ring, and the spokes of the B ring). The interaction of these small particles with the magnetospheric plasma electrically charges the dust particles, so that they interact with each other via their electric fields and become coupled to the planetary magnetic field.

ii. Preparation of Missions to Comet Halley

Three missions are currently planned to fly by the Comet Halley in 1986, and to study it closely.

The USSR Venera-Halley Project (VEGA) has two objectives: first, investigations of Venus, and second, investigations of Comet Halley. Six months after launch, in December 1984, the interplanetary automatic station, VEGA, will fly by Venus, a planetary lander will be jettisoned, later to land on Venus. The main module, with a considerable instrument package, will be used to approach the comet, and to study it with remote sensing and in situ experiments. Scientists from France, Bulgaria, Czechoslovakia, Hungary, Poland, Austria, and the FRG, will significantly contribute to the comet probe.

ESA's GIOTTO mission will fly by the nucleus of the dust comet within a distance of 1000 km. A special bumper shield is to protect the spacecraft and its instruments from being destroyed by hypervelocity dust impacts. The experiments to study the nucleus, the gas, and dust coma of the comet, are supplied by European scientists, with the cooperation of some USA groups.

The Japanese Planet A mission to Comet Halley will carry a UV imaging camera and a solar wind plasma analyzer. The comet will be studied with these instruments from a distance of several million kilometers.

Worldwide ground-based and space-borne observations of Comet Halley will be coordinated by the "International Halley Watch", organization of which is led by scientists from the USA and the FRG.

iii. Interplanetary Dust Studies

NASA hs started to use U2 aircraft for collecting extraterrestrial particles. These particles are listed in published catalogues and are available for further studies.

Dust experiments are currently being prepared the the USA Long Duration Exposure Facility (LDEF) and the Galileo mission to Jupiter, for the USSR Soyuz/Salyut programme, and for the ESA/NASA International Solar Polar Mission (ISPM).

3. Space Techniques for Geodesy and Geodynamics

i. MERIT (Monitoring the Earth Rotation and Intercomparison of Techniques)

The results of the preliminary campaign (August-October, 1980) have been fully analyzed. A first discussion of the results was prepared for a workshop held in Grasse, France (May 1981) and the final report on this preliminary campaign was published in 1982 ("Project MERIT - Report on the Short Campaign and Grasse Workshop with Observations and Results on Earth Rotation", G.A. Wilkins and M. Feissel, editors). The techniques used include astronomical observations, Doppler tracking of satellites, satellite and lunar laser ranging, connected elements and very long baseline radio-interferometry. For the main campaign, due to run in the period from 1 September 1983 to 31 October 1984, all the techniques are being upgraded, telecommunication links improved, and new equipment is being constructed. This campaign should provide adequate information to assess the suitability of different techniques for use in the future international service for Earth rotation.

ii. COTES (Conventional Terrestrial Reference System)

It was decided to use very accurate laser and VLBI data to establish (and later maintain) a conventional terrestrial reference system (COTES). This implies collocated observations and an intensive 30-60 day campaign by several such instruments, in particular during the main MERIT campaign. Preparation for this project is in progress. It should permit the detection of systematic differences between the various reference frames used and, eventually, to detect their short periodic motions.

iii. Observing Campaigns

In 1982, NASA selected Principal Investgators for its Crustal Dynamics Project. The 60 investigators represent research institutions in 16 countries; they will be interpreting data acquired by the Project in its measurements of polar motion, Earth rotation and crustal movements. Regional crustal deformation and plate stability measurements are being made in the Western USA by NASA, using two mobile VLBI systems, one mobile laser ranging system, and several fixed laser and VLBI facilities. A second mobile laser facility will be deployed in late 1982, initially to Easter Island, in order to measure movement of the Nazca Plate with respect to the South American and Pacific Plates. Other plate motion measurements (Pacific, North American, Australian, and Eurasian) are being obtained through joint programmes of laser and VLBI operations in several countries. The NASA laser stations are operating in Greenbelt, Maryland, USA; Plattville, Colorado, USA; Quincy and Monument Peak, California, USA; Fort Davis, Texas, USA; Maui, Hawaii, USA; Yarragadee, Australia; and Arequipa, Peru. Laser stations will be installed at Mazatlan, Mexico, and in the Society Islands, under agreements with the governments of Mexico and France. The laser ranging stations at Mt. Hopkins, Arizona, USA; Natal, Brazil; and Orroral Valley, Australia, operated by the Smithsonian Astrophysical Observatory, have been closed. One of these stations will be transferred to Matera, Italy, under an agreement between NASA and the Italian government.

As European participation in the Crustal Dynamics programme, the laser stations of Grasse, France; Kootwijk, The Netherlands; and Wetzell, FRG, are systematically observing LAGEOS.

STARLETTE observations were continued by the above-mentioned stations, as well as by Dionysos, Greece; Graz, Austria; Metsähovi, Finland; and San Fernando, Spain.

VLBI and Doppler observations were also made in the framework of project ERIDOC (European Interferometry and Doppler Campaign). It includes observations from collocated stations in Chilbolton, England; Effelsberg, FRG; Jodrell Bank, England; Metsähovi, Finland; Onsala, Sweden; and Westerbork, The Netherlands.

The VLBI facilities in the USA are operated in conjunction with similar facilities in the FRG, Spain, Sweden, and England. There are plans to extend these observations to include Switzerland, Italy and Japan, as well as other USA stations in Alaska and Hawaii.

In 1982, a six-station VLBI experiment was conducted by Australian scientists, using equipment on loan from NASA. This first experiment included joint observations with South Africa.

In November 1981, Shanghai Observatory carried out a VLBI experiment in cooperation with Bonn University, using the Effelsberg radio telescope and a 6 m antenna at Shanghai. The experiment will be repeated in late 1982.

A series of Doppler campaigns are being organized, in particular in Southeastern Europe, where, following the IG DOC (Italy-Greece) programme, a more ambitious project has been started: ALGEDOP (Alpine Geoid by Doppler). It is aimed at monitoring the geoid from the Alps to the Hellenic peninsula, using Doppler geodesy and altimetry data on the Mediterranean Sea.

iv. Instrumentation

In preparation for future campaigns, efforts are currently being made to upgrade existing satellite lasers. Two mobile satellite laser stations are under construction in the FRG and the Netherlands, in preparation for European participation in the Crustal Dynamics programme (Wegener project in the Eastern Mediterranean). A few fixed second-generation lasers are also being built. A mobile VLBI station is also being built in the FRG.

Europe has joined lunar laser ranging activities: the Grasse station has had its first ranges in 1981, and is now in a pre-operational phase.

Two space projects related to geodynamics are being prepared by the European Space Agency: LASSO, which was to be launched in September 1982 on the SIRIO II satellite, and to allow the possibility of synchronizing stations at intercontinental distances, with a few nanosecond accuracy, using one-way and two-way laser impulses to achieve this goal. (This mission did not reach orbit, due to the failure of the Ariane launcher.) ERS-1 satellite was decided in 1981; scheduled for 1987, it will be, essentially, an oceanographic mission and will include a radar altimeter.

A new laser ranging observatory began operation in March 1982, at Simosato, Japan, under the auspices of the Japanese Hydrographic Department. This department plans to construct a mobile laser ranging facility as part of its GS-1 Project for space geodesy; the objective of GS-1 is to determine the position of geodetic control points in Japan and its offshore islands.

A geophysical satellite, Bulgaria-1300, equipped with retro-reflectors, was launched in August 1981, within the Intercosmos scientific programme. The satellite orbit is near circular, with an inclination of 81°, and a height of near 1000 km. All the photo and laser stations of the Intercosmos network are tracking this satellite. Tracking data is utilized for precise orbit computations and station positioning.

A 25 m VLBI antenna is under construction at Shanghai Observatory, and is expected to be operational in 1985. The Institute of Seismology, State Seismological Bureau, is constructing a satellite laser ranging observatory at Wuhan, China, which will be operational in 1983.

Development of geodetic positioning systems using radio signals from the Global Positioning System satellites is continuing, with support from NASA, the US Geological Survey, the Defense Mapping Agency, and the National Geodetic Survey. Field tests of several prototype systems will be conducted in 1983.

vi. ADOS (African Doppler Survey)

In Africa, a large cooperative geodetic programme has been organized. ADOS (African Doppler Survey) is aimed at providing a zero-order control for future geodetic networks and for geodetic datum unification and strengthening. About 50 African countries may participate. At least one (in Nairobi), and possibly two, African computing centers will monitor the project and compute geodetic positions. Sixteen non-African countries have expressed interest in assisting ADOS through bilateral agreements. Local observing campaigns have already been made, but the programme itself should start at the end of 1982.

4. Dynamics of Artificial Satellites and Space Probes

The improvement of the ephemeris computation is still one of the central problems, in particular, non-gravitational forces should be correctly and precisely considered. One of the important goals is to achieve the same accuracy of position prediction (now in meters) as that of altimeter measurements (of the centimeter order), to enable the usage of altimeter data to full extent.

The fundamental constants entering orbit calculation substantially affect the final accuracy of the result of orbit determination. The problem being investigated now is their improvement and standardization, which would enable the comparison of orbital data as determined and distributed by different space agencies.

Chapter IV

PLANETARY ATMOSPHERES

1. International Reference Ionosphere (IRI)

The "International Reference Ionosphere - IRI 1979" was finally published as Report UAG-82, in November 1981, by World Data Center A (STP).

After slight improvement, the FORTRAN computer program was combined on one tape with the input data needed to apply the worldwide peak program of CCIR so as to be self-consistent. Copies were made available to competent scientific organizations in Argentina, Australia, Brazil, Bulgaria, Canada, China, Denmark, Finland, GDR, Hungary, India, Japan, Nigeria, Pakistan, Sweden, Switzerland, UK, USA, and USSR.

Topical meetings at the Ottawa Plenary Meeting of COSPAR considerably contributed to improvements in a future IRI, in particular to the description of electron density and temperature profiles. New ion composition data were presented from US satellites, S 3.

2. International Reference Atmospheres

COSPAR participates in the activities of the International Organization for Standardization (ISO). During the past year, several meetings of sub-committees of interest to COSPAR were held. The first was a meeting of ISO/TC 20/SC8, held in Cologne, in October 1981, to consider and recommend a Vocabulary of Terms for Standard Atmospheres, the draft of which was submitted to COSPAR. There were also meetings of SC6 Standard Atmosphere and SC8 Aerospace Terminology, in Paris, in April 1982, at which COSPAR was represented.

A major activity of the Task Group on the COSPAR International Reference Atmosphere (CIRA) during the past year was the planning and organization of the Workshop on Comparison of Data with CIRA and Proposed Revisions, held at Ottawa, in conjunction with the Twenty-Fourth Plenary Meeting of COSPAR. The Workshop consisted of five sessions, including papers and discussion on measurements and models of the density, composition, temperature and winds of the stratosphere, mesosphere, and thermosphere. The sessions were well attended and the discussions were particularly stimulating and constructive.

Accompanying the Workshop were planning sessions of the Task Group. As a result, the Task Group decided that plans should be initiated for the development of a new set of models to be presented to COSPAR at the 1984 meeting, for recommendation for adoption as a new version of CIRA. To achieve this goal, two sub-groups were named to be responsible, respectively, for the development of middle atmosphere and thermospheric models. COSPAR acted favorably on these recommendations and appointed a successor organization to the previous Task Group, named Sub-Commission C.4 on the COSPAR International Reference Atmospheres (CIRA), and established, as part of Sub-Commission C.4, a Task Group on Reference Middle Atmospheres and also a Task Group on Reference Thermospheric Models. The Thermospheric Model Task Group held an initial planning meeting at Ottawa, on 27 May 1982, and the Chairman is circulating periodic Task Group news bulletins.

3. Satellite Launches

The satellites, Intercosmos Bulgaria 1300, and the Dynamics Explorers, DE-1 and -2, were launched in the summer of 1981, to investigate the coupling between the magnetosphere and ionosphere, and the energy input to the ionosphere and atmosphere from particles and electric currents originating at higher altitudes. Global auroral imaging from DE-1 at several wavelengths in the visible and ultraviolet are revealing structure and motions that are being directly correlated with the in situ particle, electric and magnetic field measurements on the other spacecraft. The predicted "polar wind" of low energy plasma has now been observed directly, but there also has been found an unexpected flow upwards of particles of varying composition, with energies in excess of 20 eV. Global neutral wind measurements have suggested the existence of two different systems in the thermosphere: a pressure-driven system at low and mid-latitudes, and a high latitude system resulting from electric-field-driven ions generating neutral winds at speeds up to a few km/sec. These results complement the data being evaluated from the sounding rockets, balloons, and ground-based investigations of the Energy Budget Campaign.

The Solar Mesosphere Explorer (SME) was successfully launched into a sun-synchronous near polar Earth orbit. It makes simultaneous measurements of ozone, NO_2, H_2O, and solar irradiance to explicate the inter-relation between solar activity and the response of the chemistry of the middle atmosphere.

4. Rocket and Ground-Based Ionospheric Electrodynamics

The Energy Budget Campaign, a coordinated set of measurements using rocket and ground-based equipment, took place in November 1980, at Kiruna, Sweden, and Andoya, Norway, to investigate mechanisms by which energy may be exchanged between the middle atmosphere and the thermosphere, including solar radiation, particle precipitation, electric field, and wave dissipation. The results of this successful campaign are being analyzed and preliminary results were presented at the topical meeting, "Energy Budget of the Mesosphere and Thermosphere", held at Ottawa during the XXIV COSPAR Plenary Meeting in May 1982. The joint analysis of the data continues, with the aim of publishing a coherent set of papers in the Journal of Atmospheric and Terrestrial Physics.

Sounding rockets and a small electron accelerator on the third flight of the Space Shuttle have been used to perform active experiments to examine the stimulation of wave emissions and the precipitation of particles. There is some evidence that a shaped-charge high velocity (neutral) barium release from a sounding rocket produced ionization by the Alfvén criticial velocity effect (kinetic energy of neutrals in excess of ionization energy).

The international EISCAT radar facility is now in operation, and coordinating its activities with a number of other radars (coherent and incoherent), as well as selected satellite overpasses. In this way, it is hoped to study, systematically, the current-driven dynamics of the upper atmosphere and magnetosphere.

5. Middle Atmosphere Program (MAP)

The middle atmosphere (height range 10-100 km) is the center of interest of COSPAR Sub-Commission C.2. Two international research projects are currently being planned as part of MAP, Cold Arctic Mesopause Project (CAMP) and Winter in Northern Europe (WINE). CAMP was to be carried out in the period 26 July - 16 August 1982. Altogether, eight rockets, instrumented by different European countries, were to be launched in noctilucent cloud conditions, from Northern Scandinavia. WINE comprises rocket, balloon, satellite, and ground-based measurements during the winter 1983-1984. It aims at a study of the winter variability in the high latitude middle atmosphere, with emphasis on conditions during a major stratospheric warming. Sub-Commission C.2 has proposed a topical meeting, "Remote Sensing of Atmospheric Structure and Composition", for the next COSPAR Plenary Meeting, in Graz, Austria, in 1984, and, jointly with COSPAR Sub-Commission A.2, and SCOSTEP, it has proposed a symposium, "First Achievements of MAP", for that Meeting.

A number of sounding rocket flights have now establshed the existence of large electric fields (volts/meter) in the lower mesosphere, when electrical conductivities are below a threshold value, whose magnitude is still the subject of debate. When these fields are predominantly horizontal, they seem to be anti-correlated with the local wind direction, suggesting local dynamo generators as a field source competing with the more permanent thunderstorm-driven global electrical circuit. These "dynamos" seem to be subject to control by solar and geomagnetic activity. X-ray detectors flown on sounding rockets have observed the precipitation of particles at mid-latitudes, stimulated by VLF radio transmissions. These results suggest that VLF waves generated by lightning can induce significant precipitation of radiation belt electrons, but more work is needed to quantify this effect.

The coupling of electric fields from lightning discharges into the ionosphere has been measured for the first time from sounding rockets. The E region, near 100 km, is more correctly considered as a "shunt", rather than a "short".

6. Planetary Upper Atmospheres

The USSR space missions, Venera 13 and Venera 14, encountered Venus this year. Two probes descended through the atmosphere to the surface, measuring the atmosphere and clouds. Water vapor measurements reproduce the earlier findings from Venera 11 and 12 of only 10-20 ppm at the surface. The cloud particle composition was found to be dominated by sulfur, and not chlorine, as was reported by Venera 11 and 12: this finding is much easier to understand in that the cloud tops visible from Earth are sulfuric acid.

The US spacecraft, Voyager 2, flew by Saturn. This second flyby was, in many ways, complementary to the flyby of Voyager 1 a year earlier. The encounter allowed further studies of clouds, atmospheric motions, and auroral activity. Intermittent eruptions of convective clouds were observed, similar to the Jovian "plumes". Tracking of small irregular cloud features shows a pattern of zonal winds that is symmetric about Saturn's equator, and appears to extend to great depth. Analysis of He (584 A) emission implies vertical mixing is twice as strong in Saturn's upper atmosphere as in Jupiter's. Voyager photopolarimetric observations of Titan's atmosphere seem to indicate that the cloud particles are not spherical; further, the aerosols become larger with depth.

The Pioneer Venus orbiter continues to observe remotely the atmosphere of Venus as the altitude of periapsis rises. The continued operation allows long-term studies of cloud motion and atmospheric constituents like SO_2. Already, these studies show a long-term decrease in the Venus haze layer (its thickness has decreased by a factor of five since the beginning of the mission). A concurrent decrease has also occurred in the amount of SO_2 visible at the cloud tops.

Re-analysis of older Pioneer Venus data sets give the first measurements of deuterium in the atmosphere of Venus. The D/H (deuterium/hydrogen) ratio is approximately 100 times enriched, compared to the Earth: an implication is that Venus has lost a considerable amount of water over the age of the solar system.

This year, COSPAR has published the Mars Reference Atmosphere (Advances in Space Research, vol. 2, n° 2, Pergamon Press, 1982). This is an up-dated compilation and summary of Viking data, including six years of meteorological data from the Viking landers.

Chapter V

SPACE ASTROPHYSICS

1. Non-Solar Ultraviolet and Optical Astronomy

Non-solar ultraviolet astronomical research is characterized by the very successful International Ultraviolet Explorer (IUE) mission.

IUE is now in its fifth year of continues operations, and is currently being used by some 200 to 300 guest observers a year. The 45-cm aperture, quasi-geosynchronous satellite observatory, a joint USA/UK/ESA project, yields spectra of astronomical sources in the range 1150-1900 A and 1900-3200A in high (0.1 to 0.3 A) and low (6 to 10 A) resolution modes.

Types of objects that have been studied by IUE to date include solar system objects (planets, satellites, asteroids, comets), the interstellar medium (local, galactic, and circumgalactic), various stellar objects (hot stars, cool stars, interacting binaries, intrinsic variable stars), and extragalactic sources (both normal and active galaxies, including Seyferts, quasars, and BL lac objects). Highlights of recent IUE results were presented at the third

European IUE conference, which took place in Madrid (May 1982), and at the IUE symposium held at Goddard Space Flight Center (March-April 1982).

Among the most noteworthy results obtained with IUE are:

-the detection of C_2H_2, C_2H_6, and possibly H_2O, in the high stratosphere of Jupiter and Saturn and of less C_2H_2 in the high stratosphere of Uranus.

-the investigation of the mechanisms responsible for driving "stellar winds" in hot stars.

-the influence of hot stars on the ultraviolet flux of elliptical galaxies.

-the existence of hot gas outside our galaxy.

The IUE continues to be in great demand by USA and European scientists. In the coming year, in addition to its normal observing programme, some simultaneous and coordinated IUE-Exosat observations have been scheduled, provisionally, in the March-April 1983 period, following the planned launch of Exosat in October-November 1982.

Japan has continued its sounding rocket programme, for studying the diffuse extreme ultraviolet radiation and the stellar ultraviolet radiation. The data analysis is in progress.

France and the USSR are participating in a joint venture on board a Prognoz spacecraft and have observed the hot galactic halo, or corona, through its ultraviolet emission, much more intense than predicted. High resolution imagery of galaxies and the large Magellanic cloud has been performed in France from high altitude balloons, revealing the presence of many young stars.

Under study at NASA are two projects of the Explorer class: the Extreme Ultraviolet Explorer (EUVE) and the Far-Ultraviolet Spectroscopic Explorer (FUSE).

In parallel, the European Space Agency (ESA) is proceeding with the phase A of study of Magellan, a simple reflection objective grating instrument especially devoted to the investigation of the interstellar medium. As all ESA projects presently undergoint phase A studies, the Magellan study will be submitted to a competitive solution process early in 1983. If selected, it will be launched in the last quarter of the present decade.

Finally, a tripartite agreement has recently been reached between Australia, Canada, and the USA, for a collaborative study of the Shuttle-borne ultraviolet STARLAB facility, which is intended to provide high resolution imaging in the 1200 to 3000 A spectral range. The preliminary definition of STARLAB is now complete and both Canada and Australia have entered the detailed definition phase. The facility is expected to be launched no earlier than 1990-91, contingent on the availability of funds.

The 2.3 meter-diffraction-limited Space Telescope continues to be developed by NASA, with a significant contribution (~15%) by ESA, in preparation for a 1985 Space Shuttle launch. It is anticipated that the ST will represent a quantum jump in capability beyond any currently available ground and space-based optical facilities and that it will routinely achieve limiting magnitudes, $M_V \sim 28$ on point sources, as well as being able to resolve fine detail on spatially extended sources. The telescope, with its initial complement of five scientific instruments (a Wide-Field/Planetary Camera, a Faint Object Camera, a Faint Object Spectrograph, a High Resolution Spectrograph, and a High Speed Photometer), is now in an advanced hardware development stage, and spacecraft integration is scheduled to begin in 1983. The accompanying ground systems and software are now entering an advanced design phase.

The Space Telescope is the first major space observatory of the Shuttle era, and is planned to have a 15 year or longer operational life. This extended life is facilitated by in-orbit maintenance and refurbishment from the Space Shuttle and by ground based refurbishment of the retrieved telescope as required. The observatory will be operated by the Space Telescope Science Institute, which is located at Johns Hopkins University (Baltimore, USA). Scientific staff selection for the Institute (both USA and ESA) is now well underway.

In January 1982, ESA started the detailed definition of its space astrometry satellite, Hipparcos. An "all-reflective Schmidt" optical configuration has been selected for the mission, which is intended to provide accurate measurement of the trigonometric parallaxes, proper motions, and positions of 100,000 stars brighter than tenth magnitude to an expected accuracy of 0.002 arc-second.

2. Non-Solar Infrared and Submillimetric Astronomy

The joint USA/Netherlands Infrared Astronomy Satellite (IRAS) is to produce the first all-sky unbiased survey from 8 to 120 μm. This 60 cm cryogenically-cooled telescope, with its 62 photoconductor detectors, has been delayed by technical problems, and is currently scheduled for launch in the December 1982-February 1983 time frame. The cryogenics problems which were encountered earlier in the development phase have now been overcome. During its approximately one year lifetime, IRAS is expected to observe more than a million sources and will be a major source of information on cosmology, and on stellar formation and evolution.

The Infrared Telescope Experiment, which is being developed by USA scientists for flight on Spacelab 2, is now undergoing environmental testing in preparation for a late autumn 1984 launch. The instrument is intended to determine the suitability of the Shuttle environment for infrared astronomy as well as conducting astronomical research. As yet, no follow-on flights are planned for this instrument, which should, however, set the stage for the Shuttle Infrared Telescope Facility (SIRTF).

The Cosmic Background Explorer (COBE) is designed to play a unique role in observational cosmology by making definitive measurements of the 3°K cosmic background radiation and diffuse infrared cosmic background. The spacecraft will carry three experiments: a cryogenically-cooled far-infrared absolute spectrophotometer, to measure cosmic background radiation from 100 μm to 1 cm; four differential microwave radiometers to measure the large scale isotropy of the cosmic background radiation, and a cryogenically-cooled diffuse infrared background experiment. COBE has recently been approved by NASA and has entered the hardware development phase in July 1982. It is currently scheduled for launch in 1988.

Further flights of a 60 cm stabilized balloon-borne telescope system, built in the United Kingdom, have occurred, providing photometry, spectroscopy, and polarimetry on a number of extended objects, in particular, the Orion Nebula.

Japanese scientists have mapped the galaxy in the near infrared and far infrared ranges on the basis of balloon and rocket observations. Selected regions of the near infrared anomaly have been observed by ground based telescopes. The distribution of near infrared surface brightness is thus interpreted in terms of a superposition of red giant and supergiant stars, which is modified by a patchy structure of extinction.

The first measurement of the diffuse emission from the galactic disk has been made by French scientists from a balloon-borne telescope equipped with detectors operating in the far infrared between 70 and 200 μm.

Several projects are also under study or in the stage of definition in the various space agencies or institutes, giving evidence that infrared astronomy clearly is, at present, in a rapidly developing phase.

CNES (France) and IKI (USSR) have proceeded with the definition of a 1 m class telescope, to operate in the range 100 μm to 1 mm (submillimetric). The telescope is to be launched in the second half of this decade by a Soviet rocket.

The FRG is proceeding with the development of GIRL, an infrared laboratory for Spacelab. GIRL is a liquid helium cooled 50 cm telescope equipped with a detector array, a photopolarimeter, an Ebert-Fastie spectrometer, and a Michelson interferometer covering the wavelength range, 3 to 120 μm. The scientific objectives concern both astronomy and aeronomy. It is scheduled to fly on Spacelab in 1986-1987.

SIRTF, the one meter class, cryogenically cooled, infrared astronomy observatory, which will fly on Spacelab or on a Space Platform, is still in preliminary design phase at this time. It will be a natural follow on to the IRAS sky survey, and will provide the capability for detailed observations of specific infrared sources. Detailed design of the SIRTF is planned currently to start in 1984, and the first launch will occur in 1988-89, contingent on the availability of funds.

Undergoing a phase A study at ESA, the Infrared Space Observatory (ISO) is a 60 cm cryogenically cooled telescope, to be launched by Ariane in the late 1980's. The operational lifetime would be around 1.5 years. The instruments presently envisaged are spectrometers and photometers covering a wide range of wavelengths of the highest sensitivity. The scientific programme will build on the results of the IRAS survey. In addition, emphasis will be made on extragalactic measurements.

The study of an infrared telescope in Japan (IRTS) has been in progress. The zero gravity experiment of superfluid helium, and the porous plug phase separator thereof, were successfully performed with a sounding rocket.

3. High Energy Astrophysics

Analysis of the HEAO-2 (Einstein) and HEAO-3 results continues to provide new insight into a variety of astrophysical problems at this time. Among the important recent results reported from the HEAO-2 (Einstein) mission are:

-quasars contribute a significant fraction to the X-ray background.

-the X-ray luminosity of quasars is related to their optical luminosity and the X-ray luminosity function may not evolve cosmologically as fast as the optical luminosity function.

-two new pulsars were discovered in supernova remnants through the X-ray analysis, bringing the total to four.

-six radio pulsars were observed to be surrounded by small X-ray nebula thought to be synchrotron sources.

-numerous stellar X-ray sources were found in the Hyades and Pleiades star clusters.

-the majority of clusters of galaxies appear to be in early stages of their dynamical evolution.

-the jets in M87 and 3C273 were found to emit X-rays, and a strong X-ray jet was discovered in Centaurus A. The X-ray jet found in Cen A was observed also to be a radio jet.

The guest observer program has been very active and more than one hundred guests carried out scientific analysis at the Center for Astrophysics (Harvard College Observatory). The Einstein Observations are being placed in a data bank open to all qualified users.

Among the recent HEAO-3 results are:

-measurements of a 0.511 MeV positron annihilation line from the galactic center, which varies significantly in six months.

-measurements of the gamma ray continuum from the galactic centre, which also varies in correlation with the positron annihilation line.

The isotopic composition of cosmic rays is now understood much better. Abundances and propagation parameters have been derived.

The successful gamma ray burst SIGNE programme has continued, with observations from the Soviet satellites, Prognoz 7, Venera 11, 12, 13, and 14. An international network, with ISEE-3, Pioneer Venus Orbiter, and the Solar Maximum Mission, allows to obtain the position of these peculiar objects.

The European gamma-ray obseratory, COS-B, ended its scientific mission, as planned, in the early hours of 26 April 1982, after more than six and a half years of operations. During that time, it successfully observed over 30 discrete sources, including pulsars, and was also used to study the cosmic background. The target for the 64th and last COS-B observation was the Anticenter region, including both the Crab and Gemini (CG195+4) gamma-ray sources. This target was selected as a result of earlier COS-B discoveries of time variability in the gamma-ray light curve of the Crab. Earlier in the year, the spacecraft was used to conduct a long duration search for time variability of gamma-ray sources in the Cygnus region.

The UK has continued its very active programme in X-ray astronomy with the Ariel VI spacecraft, which observed many galactic and extragalactic sources, and within the framework of a cooperative venture with Italy, with the launch of a balloon-borne low energy gamma-ray telescope.

The Japanese satellite, Hakucho, has established nine new burst sources. A number of phenomena have been found inconsistent with the nuclear flash model. Burst profiles from a source are variable without correlation with persistent emission. Several pairs of bursts occurred with intervals as short as, or shorter than, 10 min.

Several binary pulsars have been observed. In particular, the rate of pulse period change of Vela X-1 has become positive since 1980, and the short-term rate fluctuates in several days with absolute values often much greater than the long-term rate.

The Japanese X-ray astronomy satellite, ASTRO-B, will be launched in February 1983.

Development of the European Exosat is still proceeding according to plans and the mission currently is scheduled for launch, on an Ariane rocket, in early 1983. The mission, which carries two small X-ray telescopes, will be operated from Villafranca. To date, over 500 proposals have been received from scientists in ESA member states for observations to be conducted during the first nine months of operations. Subsequent to this period, which is reserved exclusively for ESA member states, the research opportunity will be expanded to include USA scientists.

USSR and France are proceeding with the preparation of the Gamma-1 spacecraft, to operate between 2 keV and 5 GeV.

The primary scientific objective of the FRG ROSAT mission is to perform the first all-sky survey with an imaging X-ray telescope leading to an improvement in sensitivity by several orders of magnitude, compared with the previous surveys, and offering the possibility of discovering and locating over 10^5 new sources. The main ROSAT telescope will consist of a five-fold nested mirror system with an 83 cm aperture and three focal plane instruments, one of which is supplied by the USA. A complementary, parallel looking Wide Field camera, supplied by the UK, will be used to extend the spectral coverage into the XUV region. The ROSAT is currently nearing the end of its detailed design phase and a "verification model" of the mirror system and engineering model of the focal plane assembly are approaching completion. It is anticipated that the hardware phase will start in 1983, leading to a Shuttle launch of the spacecraft, into a 430 km orbit, in 1987. The mission will have a 1.5 year operational lifetime.

The USA Gamma-Ray Observatory (GRO) mission is also just reaching the end of its detailed design phase at this time, and is preparing to enter the hardware development phase in 1983. The primary objective of this mission is to study the full range of gamma-ray phenomena, spanning the entire gamma-ray band of the electromagnetic spectrum, from about 50 keV to approximately 50 GeV. The GRO will be able to see sources at least ten times fainter than previously observed, and will improve our knowledge of gamma-ray source positions in the sky by a factor of 50 to 100, allowing searches to be made for optical, X-ray or radio counterparts. GRO will also explore previously unobserved portions of the gamma-ray spectrum and will be able to study the entire gamma-ray sky. The mission is currently planned to be launched by the Shuttle in 1988.

A new X-ray observatory, the Advanced X-ray Astrophysics Facility, AXAF, is presently under study in the USA. It should provide a factor of 100 or more increase in sensitivity over the Einstein Observatory. At this time, AXAF is still in its preliminary design phase. The technical feasibility of the approach is being determined through technical mirror demonstrations. As currently planned, hardware development for AXAF will start in 1986, and the observatory will be lanched no earlier than 1991.

Under phase A study at ESA is the X-80 mission, to undergo competitive selection in February 1983. This mission would combine spectroscopic timing and transient observations. It is designed to perform an integrated, systematic, and comprehensive study of X-ray sources from a single satellite.

Another mission, the X-ray Timing Explorer (XTE) is a relatively newly planned USA Explorer class mission, which will study the variabilities of X-ray sources on time scales ranging from milliseconds to years. It is currently intended that the XTE will follow the EUVE in the USA Explorer development line-up. This points to a 1985 hardware start, and a late 1980's launch.

4. Solar Physics

The major space observatories for studies in solar physics were the NASA Solar Maximum Mission (SMM - launched in February 1980) and the Japanese Hinotori (launched in February 1981). These missions coincided with the maximum of activity in the 11-year solar cycle and have provided particularly interesting data on the phenomena associated with solar flares. These include the intense high-energy (X-ray and gamma-ray) emissions that characterize these giant eruptions; both satellites carry novel imaging instruments for hard X-ray emission. Among the highlights of the new observations can be noted:

-the discovery that gamma-ray line emission commonly occurs in flares and that the necessary particle acceleration occurs in the flare proper, rather than in the corona;

-the identification of hard X-ray bursts with the chromospheric foot-points of magnetic loops;

-the observation of chromospheric evaporation during flares;

-the first detection of high-energy neutrons from flares; and

-the discovery of flare-like phenomena that appear to occur mainly in the corona, with little coupling to the lower solar atmosphere.

A technical problem brought some SMM observations to a temporary halt in late 1980, but NASA now plans to use the Space Shuttle to carry out repairs in orbit in early 1984, restoring virtually the full capability of the spacecraft. In the meanwhile, substantial observa-tions continue to be contributed by ISEE-3 and other spacecraft, as well as several sounding-rocket and balloon programmes, in particular, in the USA, Europe, and USSR.

In addition to the comprehensive flare observations from these satellites, the SMM also carries a radiometer for the measurement of variations in the "solar constant", the total energy flux from the Sun. Variations, on time scales of days, with amplitudes of as much as 0.2%, were observed during 1980.

The first solar experiments with instruments on board the Space Shuttle have already been carried out. These will lead up to SOT, the Solar Optical Telescope, which is now an approved programme. SOT will take advantage (as will the Space Telescope) of the perfect observing conditions in space to obtain high-resolution optical and UV images. The more distant future may bring an Advanced Solar Observatory (ASO), incorporating SOT and other observing facilities (such as XUV, soft X-ray, or hard X-ray instruments), to make a coordinated attack on the complex and heterogeneous structures in the solar atmosphere. The first observations of ASO should take place at the end of the decade to be able to take advantage of the next solar maximum and to build upon results from SMM and Hinotori.

ESA is presently undertaking a phase A study of the DISCO project, a satellite placed at the Lagrangian point, L_1, aimed at investigating the interior of the Sun through helioseismology from the continuous measurement of velocity and intensity oscillations. DISCO will also serve as a reference located in the ecliptic plane for the ISPM spacecraft.

Chapter VI

LIFE SCIENCES AND SPACE RESEARCH

In 1981-1982, space life science research was concerned with the following topics: radiation effects on biological systems (Radiation Biology) effects of space flight on living organisms (Gravitational Biology), as well as studies of chemical evolution and the origin of life.

Also, studies on global ecology as perceived from orbiting spacecraft and autonomous life support systems were continued, and discussions took place on reassessment of planetary quarantine requirements in the light of present knowledge of the planets within the solar system and their satellites.

1. Radiation Biology

In this field, the following topics were studied:

i. Ground Research: Heavy Ions

Substantial investigative work has been achieved in heavy ion accelerators, now available in the USA, the USSR, Japan and the FRG, with respect to biomedical space-related research. Using bacterial spores as a radiobiological model system, a better insight into the mechanism of interaction has been obtained. Inactivation cross sections exceed the size of individual cells. With increasing LET of the ion, the reparability by cellular enzyme systems of the induced damage was drastically decreased, as was the frequency of induced mutations. Other physico-chemical primary effects, in addition to the effects of delta-electrons, are suggested to be responsible for such specific effects of heavy ions.

In corneal tissue of living rats, membrane lesions have been traced back to the passage of individual heavy ions. Rabbits and monkeys showed late skin degeneration after heavy ion irradiation. In vitro cultivation of the irradiated tissue indicated a degeneration of skin stem cells.

ii. Ground Research: Influence of the Environment

Internal, as well as external, factors influence the radiation sensitivity of a biological system. The results, obtained in the laboratory, on radioprotection and radiosensitization by chemical and physical agents, on the role of water and oxygen in radiation response, and on the combined effects of high- and low-LET radiation, represent basic information for assessing potential radiation risk in manned space flight, but also for estimating the chance of survival of resistant life forms in space.

iii. Radiation Safety Standards for Manned Space Missions

Considering the recent results on heavy ion effets, which suggest a qualitatively different mechanism of radiation damage and severe late injuries, considering the late radiation responses in man from evaluations from Hiroshima and Nagasaki, the radiobiologists were concerned about the inadequacy of the radiation standards for manned space flight, presently used in space travel circumstances. Therefore, a reassessment of the radiation safety standards and the radiation protection guidelines for manned spaceflight has been recommended, especially in view of the Shuttle era, with an increasing number of men in space, including scientists and technicians.

iv. Spaceflight: Radiation Effects on Plant Seeds

The orbital station, Salyut 6, was used for extended exposure to space flight conditions, up to 827 days, of plant seeds. A global postflight analysis of the effects of cosmic radiation on subsequent development showed reduced viability and higher sterility of the plants, effects which indicated an accelerated aging process.

A similar experiment is being carried out on board the orbital station, Salyut 7. The main objective of this experiment is the study of the biological effects of cosmic rays and, particularly, of HZE particles. Biological objects investigated are Artemia cysts, tobacco and rice seeds, and embryos. A first container was recovered by the French spationaut, Jean-Loup Chrétien; the second and third containers will be recovered next year after having spent about six and ten months, respectively, in orbit.

The first analysis showed a decrease in the breeding ability and changes in the repair of preflight radio-induced damage. Investigation of rice and tobacco seeds are being continued.

2. Gravitational Biology

Gravitational biology is a research effort of importance in two contexts. First, that of human safety and functionability: Are human beings able to cope with long-term exposures to very low gravitational fields or are normal functions, e.g., circulation and hemodynamics, vestibular activity, bone structure, etc., affected so profoundly as to serve as a temporary or permanent health hazard, or as to affect the ability of the individual to function (work) satisfactorily during space flight? Gravitational biology is thus central to manned space flight. The second area of importance has to do with the use of the lowered (near-zero) gravitational environment as a research tool to study cellular and sub-cellular mechanisms. Terrestrial life has evolved in a "1 G" environment. During the course of that evolution, inter-relationships and inter-dependencies have evolved between gravity and certain biological functions - e.g., plant stems react negatively to gravity, while roots react positively. Certain basic embryonic processes are gravity influenced. The inter-relationships of life and gravity at the fundamental level are not well understood or defined. Thus, a new research tool is at hand.

With this in mind, numerous space flight opportunities - using the Soviet Cosmos, Soyuz, Salyut spacecraft, and now the USA/European Spacelab - are being, or will be, used as platforms for a variety of experimental systems, from plants to bacteria to man. Scientists from many nations have been involved, e.g., France, the FRG, the USA, the USSR, and others. In addition, sophisticated ground-based research facilities have been developed in many nations to do the ancillary research, using centrifuge and clinostat, so necessary for the interpretation of the in-flight experiments.

Reports on this work, at the COSPAR Meeting in Ottawa (May 1982), provide fascinating testimony to the productivity and directions of this research. Peculiarities of plant growth in "0 G" are now being studied in depth, in space and in the laboratory on Earth. Gravitational effects on living organisms, plant and animal, at the cellular and molecular levels, are now well documented. International teams of scientists are well established in the design and flight of follow-up experiments now that spacecraft with appropriate environmental conditions are available. Gravitational effects on mammals, including humans, have also now been defined to the point where specific problem areas, e.g., bone demineralization, have been identified for in-depth study, both in flight and in the laboratory on Earth, in many countries.

The field of gravitational biology has now become an integral part of the annual meetings of such highly regarded scientific societies as the American Physiological Society, and is appearing in the agenda of international scientific organizations in addition to COSPAR. The biological community is looking forward to continued productive research in this area, of great importance to man in his space flight activities and to basic biological science.

As examples of research carried out recently in this field, a few experiments conducted during the flight of the French spacionaut, Jean-Loup Chrétien, on board the space station, Salyut 7, are briefly described below.

i. Experiment Cytos II

Effects of space flight were investigated on two bacteria, Escherichia coli and Staphylococcus aureus, isolated from the future spationaut, before the flight. Cultures were prepared in the Space Center at Toulouse, France: each culture included a culture medium, an antibiotic (in different concentrations), a pH indicator, and a glass ampulla containing the bacteria. Inoculation was performed in orbit and the cell growth in space was evaluated from changes in the colour of the pH indicator. Results suggest that resistance to different antibiotics investigated was increased in space flight conditions.

ii. Experiment on the Cardiovascular System

The echography experiment was proposed by the Laboratory of Biophysics of the Medical School in Tours, France. It is now well known that exposure to microgravity leads to a shift of blood and interstitial fluid from the inferior part of the body to the chest and head, causing perturbations of the cardiovascular system and, particularly, of the veinous return and the right heart. After a few days in space, a new hydrodynamic balance is found, where intricate neuro-hormonal regulation systems are involved.

The experiment consisted of an non-invasive exploration of the cardiovascular system, as complete as possible, and using ultrasounds. Several modes have been gathered together: real time imaging (3.5 MHz) for heart and abdominal vessels; real time imaging (5 MHz), coupled with a Doppler mode, for quantitative blood debimetry; time motion modes for heart exploration and continuous-wave Doppler mode for peripheral vessels. An ECG was recorded in synchronism with all the above, for pulse/velocity measurement.

A large amount of data have been recorded and are still under investigation. Variations, before, during, and after the flight, of cardiac indices, blood flow peripherial resistence, vessel compliance, etc., will be published soon.

iii. Experiment Posture

The aim of this experiment was to study the adaptation of the sensory-motor system, involved in posture control, in the weightless environment. The experimental procedure was to analyze posture modification induced by a voluntary elevation movement of the arm, due to passive displacement of the platform on which the subject stood upright. Furthermore, the role of vision (essentially peripheral vision) during the compensatory movement following the perturbation created by the arm movement was evaluated.

Parameters studied included electromyographic (EMG) activity of the leg muscles (biceps, quadriceps, soleus, tibialis anterior), angulation of the ankle, the anterior-posterior direction, acceleration of the arm during elevation, displacement of the platform supporting the subject, and chronophotography of the entire subject during the experimental session.

Subjects were tested pre-flight (one month and three days), in-flight (second, third, and seventh day for one subject; only the fifth day for the other subject), and post-flight (20 hours and three days after landing).

Pre-flight tests showed typical variations of the EMG activity of the leg muscles preceding (anticipatory adjustment) and following (reactional adjustment) the movement of the arm. These variations represent, particularly, anticipatory posture adjustment of the whole body to prevent destabilization due to arm elevation.

Furthermore, in some subjects, vision is strongly effective during this adjustment, since occultation of the peripheral vision gives rise to modifications of these motor programmes.

Preliminary results of the in-flight experiment show unimportant changes of EMG activity, of the recorded muscles, when subjects are in a relaxed upright position.

The change in angle of the ankle with the movement of the arm is not very different from that observed on Earth. In weightlessness, occultation of peripheral vision, when moving the arm, induces modifications of the motor programmes which are stronger than on Earth. Gain of reflex activity in leg muscles after stretching is largely decreased in flight.

3. Chemical Evolution and the Origin of Life

The field of chemical evolution and the origin of life included studies of organic cosmochemistry, prebiotic synthesis of biologically important molecules, formation of polymers and membranes, archaean microfossils, early biological evolution, and theorizing about life beyond the solar system.

Chapter VII

MATERIALS SCIENCES IN SPACE

1. The European Space Agency Programme

During the past few years, the interest in microgravity investigations has continued to grow and spread to an ever wider scientifc community, in an increasing number of countries.

In Europe, the European Space Agency was able to develop its activities from an initial nucleus of 37 experiments, provided by nine different European countries, to be flown on the first Spacelab mission in 1983. This preliminary work has succeeded in opening the way to the recent ESA Microgravity Research Programme, which formally began on 15 January 1982, and which is, initially, concentrating on two main activities, described below.

The Sounding Rocket Programme element got off to a flying start with the successful launch of two sounding rockets carrying 12 experiments, either precursory experiments for later, longer duration experiments, or experiments to obtain self-consistent scientific results in specific areas of materials science research.

The Fluid Physics Module follow-on activities are oriented towards the definition of improvements to be introduced after the first Spacelab mission. This improved version would be flown on the second Spacelab mission, D1.

Parallel to the Microgravity Research Programme, a Spacelab follow-on programme was started on 15 April 1982. The most important element of this new programme is the development of a fully automated platform, the European Retrievable Carrier (EURECA), which will have, as a core payload for its first mission in 1987, a cluster of six materials science instruments with about 80 experiments.

In summary, one of the prime functions of the Agency is to provide opportunities that could not be conceived within single-nation efforts, and to encourage European scientific cooperation on specific topics of essential interest. About 150 European laboratories, in 12 countries, are in permanent contact with ESA.

2. National Programmes

In the frame of their national space activities, many Western European countries are developing their own materials sciences programmes and scientific activities, either on a purely national basis (the FRG and Sweden) or in bilateral cooperation with other European or non-European nations.

The Federal Republic of Germany has developed its own sounding rocket programme, TEXUS, in which more than 30 experiments have been performed successfully. The FRG has also reserved an FRG Spacelab flight, D1, now scheduled to fly on STS in 1985, involving both previous equipment of the FSLP and new equipment. In parallel, automated experiments, with limited accommodation requirements and microgravity exposure times of some hours, will be performed in the MAUS programme, using the STS carrier capabilities. Preparation of eight to fourteen MAUS payloads is underway.

Sweden flew many experiments in the frame of its national activities (project S.R. PIRAT), and some others in close cooperation with the FRG and the USA.

France was able to fly, successfully, 15 scientific experiments, using the equipment and capabilities of the FRG TEXUS programme, the USA SPAR programme, and the USSR Salyut 6 and 7 space platforms. More than 30 new experiments are under preparation to be flown in the frame of the ESA FSLP, US STS, FRG D1, and USSR ELMA 2 missions. Close cooperation exists between the French space agency, CNES, and some scientific laboratories to develop new concepts, well adapted to microgravity facilities.

Denmark has developed an original FSLP equipment for solution growth, and is planning to follow it through in cooperation with the FRG and the USA.

Italy has shown great activity concerning specialized equipment for fluid physics science in microgravity.

In the USA, most of the active materials science research groups, universities, or industrial laboratories, are participating in these activities, with special emphasis on fundamental science. Since the end of the ASTP project, the flight opportunities for researchers have been limited to ballistic flights providing approximately six minutes of weightlessness, allowing about 50 experiments to be completed. The new availability of the Space Shuttle appears as the opening of a new era, allowing other long duration experiments to be performed by several means: the Autonomous Materials Experiment Assembly (up to five days), manned Spacelab experiments (up to 10 days), and Automated Materials Experiment Carrier experiments (up to three months). In addition to these activities, research is continuing for the development of more precise, straight-forward, experimental facilities, connected with the particular features of the microgravity environment, and to test fundamental concepts by using very short duration low-gravity facilities, such as drop tubes and parabolic aircraft flights.

In the USSR, three facilities (furnaces SPLAV, CRYSTAL, and MAGMA) on board the space stations, Salyut 6 and 7, are available for use by Soviet and foreign experimenters almost on a routine basis. Significant participation of scientists from Poland, Czechoslovakia, the GDR, Cuba, and Vietnam has taken place, both in scientific cooperation and in the development of facilities. A very large number of experiments, either purely scientific or more technology-oriented, have already been realized.

Interest has spread also to India, Japan, Canada, and Argentina. In particular, Japan has initiated a strong programme, using both Japanese sounding rockets (two launches effectuated up to now) and the capabilities of the US STS, with more than 30 experiments under preparation.

However impressive the amount of space experiments already flown and the increasing importance of activities currently under development, this discipline, when compared to other space disciplines, remains a very new one. And, as in any new field, a considerable amount of basic research is necessary before the potential applications are known and become available. It is hoped, however, that this research will lead to improvements which have a direct influence on man's life on Earth. One of the main benefits achieved in microgravity is that it could lead to new interdisciplinary relations. Amongst the future expected benefits, it is worth mentioning the growth of more perfect crystals for electronic components, improved metallurgical processes leading to better quality of new alloys, and a deeper understanding of the related physical and chemical processes. These are but a few of the avenues which will be explored in the coming years and, as always in similar situations, any complete appreciation of what will actually be achieved would be superficial.

LIST OF ACRONYMS AND ABBREVIATIONS
(including satellite and space probe names)

ADOS - African Doppler Survey
ALGEDOP - Alpine Geoid by Doppler
AMPTE - Active Magnetospheric Particle Tracer Explorer
Ariane - (European lauch vehicle)
Ariel VI - UK payload, launched by USA, for measuring cosmic radiation
ASO - Advanced Solar Observatory (USA)
ASTP - Apollo Soyuz Test Project
ASTRO-B - Japanese X-ray astronomy satellite
AU - Astronomical Unit
AXAF - Advanced X-ray Astrophysics Facility
CAMP - Cold Arctic Mesopause Project
CCCO - Committee for Climate Changes and the Oceans (of SCOR-IOC)
CCIR - International Radio Consultative Committee (of ITU)
CDAW-6 - Coordinated Data Analysis Workshop
CIRA - COSPAR International Reference Atmosphere
CNES - Centre National d'Etudes Spatiales (France)
COBE - Cosmic Background Explorer (USA)
COS-B - (ESA gamma-ray satellite)
COSPAR - Committee on Space Research
COSPAR ISC - COSPAR Interdisciplinary Scientific Commission
Cosmos - series of Soviet satellites with varying payloads
COTES - conventional terrestrial reference system
D1 - FRG Spacelab experiment (2nd Spacelab flight)
DE-1, DE-2 - Dynamic Explorers 1 and 2
DISCO - (Structure of the Sun and the Heliosphere)
ECG - electrocardiograph
EISCAT - European Incoherent Scatter radar
ELMA - Materials Elaboration project (USSR)
EMG - electromyograph
ERIDOC - European Interferometry and Doppler Campaign
ERS 1 - ESA Remote Sensing satellite
ESA - European Space Agency
EURECA - European Retrievable Carrier
EUV - extreme ultraviolet
EUVE - Extreme Ultraviolet Explorer
Exosat - European X-ray Observatory Satellite
FORTRAN - computer language
FSLP - First Spacelab Payload
FUSE - Far-Ultraviolet Spectroscopic Explorer
Galileo - planned USA mission to study Jupiter
Gamma-1 - Franco-Soviet spacecraft for gamma-ray observations
GARP - Global Atmospheric Research Programme
GEOS-2 - Geostationary Earth Orbiting Satellite-2 (ESA)
GIOTTO - (ESA mission to Halley's Comet)
GIRL - German Infrared Laboratory (for Spacelab)
GMS-1 and GMS-2 (Himiwari-2) - Geostationary Meteorological Satellites (Japan)
GOES-West - Geosynchronous Operational Environmental Satellite (West)
GRO - Gamma-Ray Observatory (USA)
GS-1 - geodetic satellite project (Japan)

Hakucho - Japanese satellite for studies of gamma ray burst phenomena
HEAO-2 (Einstein), HEAO-3 - High Energy Astronomical Observatories 2 and 3 (USA)
Helios 1 - space probe for solar and magnetospheric studies
Hinotori - Japanese satellite for solar observations
Hipparcos - European High Precision Parallax Collecting Satellite
HZE - very heavy ion particles of cosmic radiation
IAMAP - International Association of Meteorology and Atmospheric Physics (of IUGG)
ICSU - International Council of Scientific Unions
IG DOC - Italy-Greece Doppler Campaign
IKI - Space Research Institute (Moscow, USSR)
Intercosmos Bulgaria 1300 - first Bulgarian satellite launched by USSR
IOC - Intergovernmental Oceanographic Commission
IRAS - USA/Netherlands Infrared Astronomy Satellite
IRI - International Reference Ionosphere (joint URSI/COSPAR continuing project)
IRTS - Infrared Telescope in Space (Japan)
ISEE-1, ISEE-2, ISEE-3 - International Sun-Earth Explorers 1, 2, and 3 (USA/ESA)
ISL-SCP - International Satellite Land-Surface Climatology Project
ISO - Infrared Space Observatory (ESA)
ISO - International Standardization Organization
(ISO/TC 20/SC8, SC6) - ISO Technical Committees and Sub-Committees
ISPM - International Solar Polar Mission (ESA/USA)
IUE - International Ultraviolet Explorer
IUGG - International Union of Geodesy and Geophysics
JSC - Joint Scientific Committee (of WMO and ICSU for WCRP)
LAGEOS - USA Laser Geodynamic Satellite
Landsat - series of USA satellites for Earth resources studies
LASSO - Laser Synchronosation from Stationary Orbit
LDEF - Long Duration Exposure Facility
LET - linear energy transfer (radiation biology)
MAP - Middle Atmosphere Programme
MAUS - Autonomous Materials Research Facility (in Microgravity) (FRG program)
MERIT - Monitoring the Earth Rotation and Intercomparison of Techniques
METEOSAT - European Meteorological Satellite
MHD - magnetohydrodynamic
MPI - Max-Planck-Institut (FRG)
NASA - National Aeronautics and Space Administration (USA)
Pioneer 10, 11 - deep space probes (USA)
Pioneer Venus - probe of Pioneer series for studies of Venus (USA)
Planet A - (Japanese mission to Halley's Comet)
Prognoz - Soviet spacecraft for solar and magnetosphere studies
ROSAT - Roentgen Observatory Satellite (FRG)
S 3 - ionospheric probes (USA)
Salyut 6, 7 - Soviet space platforms
SCATHA - Spacecraft charging at high altitudes
SCOR - Scientific Committee on Oceanic Research
SCOSTEP - Scientific Committee on Solar-Terrestrial Physics
Seasat - ocean dynamics satellite (USA)
SIGNE - gamma ray burst observation programme (international network)
SIRIO II - Italian communications satellite
SIRTF - Shuttle Infrared Telescope Facility
SKR - Saturnian kilometric radiation

SME - Solar Mesosphere Explorer (USA)
SMM - Solar Maximum Mission (USA)
SOT - Solar Optical Telescope (USA)
Spacelab - European space laboratory facility to be flown on STS (first flight 1983)
SPAR - Space Processing Applications Rocket
SPARRSO - Space Research and Remote Sensing Organization (Bangladesh)
S.R. PIRAT - Swedish sounding rocket launchings for materials sciences studies
ST - Space Telescope
STARLAB - cooperative (Australia/Canada/USA) ultraviolet observation facility
STARLETTE - French satellite for geodetic, geodynamic, and earth-moon systems studies
STS - Space Transportation System (Space Shuttle)
TEXUS - (Technological Experiments in Microgravity payloads, FRG program)
UAG - Upper Atmospheric Geophysics (publications series)
UCLA - University of California at Los Angeles (USA)
ULF - ultra low frequency
UNEP - United Nations Environment Programme
UV - ultraviolet
VAS - VISSR Atmospheric Sounder
VEGA - USSR Venera-Halley Project (to study Venus and Comet Halley)
Venera 9, 10, 11, 12, 13, 14 - series of USSR space probes for studies of Venus
VIKING - Swedish satellite for ionospheric/magnetospheric phenomena studies
Viking 1 - USA mission to Mars
VISSR - visible-infrared spin-scan radiometer
VLBI - very long baseline interferometry
VLF - very low frequency
Voyager 1 and 2 - deep space probes (USA)
WCRP - World Climate Research Programme
WINE - Winter in Northern Europe
WMO - World Meteorological Organization
World Data Center A (STP) - World Data Center A for Solar-Terrestrial Physics
X-80 - (Spectroscopy/Timing Transient Mission in X-ray Astronomy)
XTE - X-ray Timing Explorer (USA)