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COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE

IMPLEMENTATION OF THE RECOMMENDATIONS OF THE SECOND UNITED NATIONS CONFERENCE ON THE EXPLORATION AND PEACEFUL USES OF OUTER SPACE

International cooperation in the peaceful uses of outer space: activities of Member States

Note by the Secretariat

Addendum

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V.98-50476 (E)

INTRODUCTION

1. In accordance with the recommendation of the Committee on the Peaceful Uses of Outer Space at its fortieth session,[1] Member States have submitted information on the following topics:

(a) Those space activities that were or could be the subject of greater international cooperation, with particular emphasis on the needs of developing countries;

(b) Spin-off benefits of space activities.

2. The information on those topics submitted by Member States as at 31 October 1997 is contained in document A/AC.105/679 and the information submitted as at 15 January 1998 is contained in document A/AC.105/679/Add.1.

3. The present document contains information on those topics submitted by Member States between 15 and 21 January 1998.

Notes

[1]*Official Records of the General Assembly, Fifty-second Session, Supplement No. 20* (A/52/20), para. 163.

REPLIES RECEIVED FROM MEMBER STATES

FRANCE

[Original: French]

The launching of the first Earth satellite on 4 October 1957 heralded the beginning of a new era, that of space. In 1962, the National Centre for Space Studies (CNES) was set up and the foundations of the French space industry were laid. On 26 November 1965, Asterix, the first French satellite, was launched and within several decades space activities gained a place in the world, calling for considerable stakes in the industry, research, culture and defence sectors.

For CNES, the year 1996 was marked by the preparation of a strategic plan representing a basis for the activities to come. CNES adopted a strong dynamic approach enabling its activity to be part of the world evolution within the space context.

A. Strategic plan of the National Centre for Space Studies

The important changes taking place at the end of the century affect in particular the space sector, which, by nature, is located at the intersection of scientific, technological, economic and political stakes. Thus, along with developments corresponding to a new geopolitical order, such as the international space station, or to an awareness of global problems, such as space systems devoted to the study of climatic and environmental changes, there now appears to be a large amount of activity associated with the onset of growing markets for space applications, such as those relating to society's need for information.

This development has already changed, probably on a long-term basis, the behaviour of certain space Powers such as Japan and the United States of America. In addition to their traditional role involving substantial programmes remote from the market, these States now consider it necessary to promote the competitiveness of their space industry, a necessary stage in increasing employment in an advanced and innovative sector.

To enable Europe to remain a space Power of the first order, the countries of Europe must in turn adapt to this development. France, which plans to remain one of the promoters of European space activities, has a major role to play in this undertaking. CNES has adopted a policy of strategic thinking so as to enable France to find its place in the major international programmes in order to retain a higher-calibre scientific community and to have a competitive space industry capable of meeting the growing demands of space users.

This plan should be reflected in the operational sense by the medium-term programming of its relations with industry and with its institutional partners.

B. Main aspects of French space policy in 1996

The Ariane 5 programme is a fundamental unit for European cooperation since it makes it possible for Europe to maintain a strong position on the satellite launching market. The successful launching of the second test flight in October 1997 has made it possible to continue the work for operational testing of the launcher during 1998.

The operation of the Hélios 1A satellite, launched in July 1995, has continued successfully. In parallel, the trials with the Hélios 1B satellite have proceeded in a satisfactory manner and have led to its acceptance, its launching being planned for 1999. Its design is identical to that of Hélios 1A, but it possesses a semiconductor mass memory, which will improve its operational capabilities. The Hélios 2 satellite is at present at the development stage.

The French space industry covers launchers, telecommunications, Earth observation and military space. The companies working in these fields are mainly located in the Midi-Pyrenean area; they employ almost half of the personnel concerned with the space sector.

As part of the research and development plan for 1996, stress has been placed on the technologies going into the design of vehicles and payloads and the improvement of systems and equipment and on methods of managing programmes in order to optimize the partnership between public research and industry.

C. Industrial activity

Since its creation, CNES has been seeking to promote an industrial potential geared towards space activity, its aims being to ensure the continuation of existing competencies, the capacity to meet needs and the possibility of facing international competition and ensuring the profitability of public investments.

1. Aérospatiale

Aérospatiale is the industrial architect of the Ariane 4 and Ariane 5 programmes. In this capacity, it is conducting studies and tests on systems and building the first and third stages of Ariane 4, as well as the principal cryogenic stage and the power acceleration stages of Ariane 5. It performs mission analyses for each launching, provides flight schedules and processes the flight data.

Aérospatiale is developing the atmospheric re-entry demonstrator (ARD), which is an automated capsule that makes it possible to test re-entry materials as well as landing and recovery systems. The company is the contractor for the development of the automatic transport vehicle (ATV) for servicing the international space station and is studying, within the framework of a European economic interest group, the crew transport vehicle (CTV) for the European Space Agency (ESA). It is also the contractor for several telecommunications satellites: ARABSAT 2 (Arab League), Turksat (Turkey), Nahuel (Argentina), ThaVcom 3 (Thailand), Agila (Philippines), Sirius 2 (Sweden), Eutelsat 3 (W 24) and Sinosat (China). It also constructs the Météosat (Eumetsat) meteorological satellites, the Infrared Space Observatory (ISO) infra-red astronomy satellite and the Huygens interplanetary probe, which is due to land on Titan (ESA missions).

Aérospatiale has been selected by CNES for the development in partnership of a small multi-mission platform (Proteus). The first application will involve the Jason satellite, successor to Topex-Poseidon. It is also constructing for CNES the platform for the Stentor experimental satellite and the Vegetation payload for SPOT 4.

Furthermore, Aérospatiale is participating as a major partner in the construction of the Globalstar satellites. It is also collaborating in the Medsat initiative, aimed at promoting satellite services for the countries of the Mediterranean Basin. Finally, in 1997, it set up a subsidiary organization called Aérospatiale Multicom for high-output satellite transmissions.

2. Alcatel Espace

As a subsidiary of Alcatel, Alcatel Espace occupies an important place in the field of satellite tele-communications systems and telecommunications payloads.

Alcatel Espace is the promoter of the SkyBridge system, a network for wide-band access for interactive multimedia services, using a constellation of 64 low-orbit satellites. SkyBridge will have world coverage and will permit services such as the Internet at a very high speed, telecommuting, tele-education, teletherapy and all types of on-line services and free-time activities. This constellation will be put into operation in the year 2001. Loral Space and Communications (United States of America), Toshiba, Mitsubishi and Sharp (Japan), Aérospatiale (France), SPAR (Canada) and the Regional Investment Company of Wallonia are the main partners so far.

Alcatel Espace is the contractor for the World Space system, the first system for digital broadcasting by satellite, built for World Space Inc. (United States). The World Space system will be operational at the beginning of 1999.

Besides the major communications companies, Alcatel Espace is a strategic partner of the Globalstar system, a new world system for mobile telephony to be put into service in 1999. In 1996, Alcatel Espace was selected to make the payloads of the following telecommunications satellites:

M2A, with Loral/Space Systems—high-output digital telecommunications (Indonesia);

Intelsat IX, with Loral/Space Systems—telecommunications (Intelsat International Organization);

Express A, with NPO PM—telecommunications (Russian Federation);

Hispasat 3, with Aérospatiale—telecommunications and television (Spain).

Alcatel Espace will construct the Poseidon II radar altimeter for Jason, a joint mission of CNES and the National Aeronautics and Space Administration (NASA).

3. Arianespace

In accordance with its development plan, this company has continued to adapt its full space transport service to meet the changes in the requirements of its clients. At the end of 1996, the contracts signed covered more than 40 satellites that were to be launched.

As far as Ariane 4 is concerned, the activity in 1996 was continued, with 10 launchings in 11 months; this has made it possible to place 15 satellites in orbit. In order to meet the demand, an additional order for 10 Ariane 4 satellites has been decided on, bringing to 33 the number of launchers of this type in production.

Arianespace has continued its work for the coming operation of the new launcher Ariane 5 and has undertaken studies for its further improvement, especially for increasing its efficiency so as to meet future needs. An initial order for 14 Ariane 5 satellites has been signed.

Furthermore, Arianespace has extended the services offered to clients by setting up the Arianespace Finance Company and has broadened its international presence by opening a commercial enterprise in Singapore that will cater for the south-east Asian market.

4. Matra Marconi Space

In the field of Earth observation, Matra Marconi Space is the contractor for the SPOT satellites (SPOT 4 will be launched in 1998 and SPOT 5 is currently being developed) under the CNES programme for Helios military satellites intended for the General Armaments Office. Matra Marconi Space constructs more than 50 per cent of the radar satellites for the European Space Agency (RES 1 and RES 2 are operational and Envisat will be launched in 1999), including the platform, the synthetic aperture radar and the instruments for measuring atmospheric ozone, and the microwave radiometers.

In the field of meteorology, Matra Marconi Space is constructing the instrumentation for the Meteosat satellites and will be the contractor for the Metop satellite intended for the European Meteorological Organization (Eumetsat), the development of which is being carried out by ESA.

Matra Marconi Space is developing a line in platforms for future low-orbit missions (Leostar), to be used in minisatellites (up to 1 tonne).

In the telecommunications field, Matra Marconi Space is the contractor for the following programmes: Silex (Optical Intersatellite Liaison System—ESA/CNES); Hot Bird (Eutelsat); Skynet D, Skynet E and Skynet F (United Kingdom of Great Britain and Northern Ireland); Nileset (Egypt); ST 1 (Singapore and Taiwan Province of China); Astra 2 (Luxembourg); Intelsat KTV and Nato 4 (North Atlantic Treaty Organization).

In addition, Matra Marconi Space is taking part in the Inmarsat 3 and Koreasat programmes as the payload contractor.

5. Société européenne de propulsion

For the Société européenne de propulsion (SEP), the leading European company in the field of space propulsion, the main civilian activity concerns the Ariane 4 and Ariane 5 launchers. The production of the Ariane 4 engines continued at a steady rate. Moreover, the Vulcan cryogenic engine designed for the second Ariane 5 flight has been delivered, along with the nozzles for the solid propergol engines. The development work on the improved version of Vulcan 2 has continued.

SEP has also delivered to Pratt and Whitney the first carbon-carbon divergent nozzle intended for the RL10 cryogenic engine and the tests in 1997 were highly satisfactory.

SEP has continued to cooperate in the matter of the cryogenic engine with the Russian company CADB, as well as continuing its work on plasma propulsion for satellites. An engine of this type, called PPS 1350, will be used in the CNES Stentor satellite.

Finally, SEP is continuing to introduce into the market drive mechanisms for the solar panels used for geo-stationary satellites. In the case of low-level liquid propulsion for satellites, it has made plans to cooperate with Brazil.

6. SPOT Image

SPOT Image, which has been commercially operating SPOT satellites for more than 10 years, has become a world leader on the market for geographical information stemming from satellite imaging. Because of its knowledge of implementation needs, its means and its resources for this purpose, SPOT Image has succeeded in gaining 60 per cent of this emerging market. The commercial network of SPOT Image and its subsidiaries (Australia, Singapore and United States) is spread over the five continents and reinforces the presence of the company at the world level.

The SPOT system offers a complete operational service: reception, processing and commercial distribution of data. Thanks to the SPOT 4 and SPOT 5 satellites, each of which will contain technological innovations, the continuity of the service for users is guaranteed well beyond the year 2000.

SPOT Image, through its contact with users, has the benefit of the experience gained since the launching of the first satellite, in 1986. The company meets the multiple demands of the market through a broad range of products that are adapted to the emerging applications. The geographical data provided by SPOT images are accurate, up to date and objective; they are of value to many users (public services, managers, decision makers and planners) and have a great variety of applications (cartography, geographical data systems, agriculture, town or country planning). SPOT Image markets standard products, value-added products and turnkey projects, in which it plays the part of designer, product and service integrator and contractor. Access to the imaging still remains one of the company's main concerns: the Dali catalogue accessible by Internet contains references to more than 5 million images and a catalogue of the products will be placed on the Internet at the beginning of 1998.

D. Activities conducted in France

The activities conducted under the national programme and as part of France's participation in the ESA programmes are as follows:

1. Access to space

The launchers

Ariane is a product of the experience acquired through the development of ballistic missile stages of the deterrent force, and then those of the Diamant launcher. Today, Arianespace markets and provides launching services for the Ariane 4 version, which is capable of launching 4.2 tonnes into a geostationary transfer orbit for the most advanced configuration.

The success of the programme and the trends in the market have reinforced the will of the European States to develop Ariane 5, which, when tested, will be a launcher offering a high quality to cost ratio. The first test launching took place on 4 June 1996. The origin of the failure of that launching was an error in the design of the internal software of the inertial reference system. Following the recommendations made by the board of inquiry set up after the failure, action was taken to review all the launcher systems. The second test launching, on 30 October 1997, was successful. The data transmitted by the launcher show that the propulsion, trajectory and timing of the stage separation were nominal. The third and final test launch is scheduled for the middle of 1998.

The further development of this launcher is a necessity for maintaining its competitiveness. The Ariane 5 development programme meets this need. The launcher will be capable of placing 7.4 tonnes into a transfer orbit, as opposed to 6 tonnes in the present version.

International space station

At the last ministerial meeting of the ESA Council, in October 1995, it was decided that Europe would take part in the future international space station. The principal unit to be provided by Europe will be the laboratory known as the Columbus Orbital Facility (COF), which will be put into service in 2003, and not 2002, because of a delay in the construction of the service module.

Balloons

These are space vehicles that represent an original means of observation at altitudes ranging from 15,000 to 45,000 m. They are a necessary addition to the observation programmes for satellites. Two important scientific experiments were successfully carried out in 1996:

Interboa. The campaign was developed in August 1996. Three balloons were launched from the Esrange base in Sweden. The programme was carried out in collaboration with the Radiation Space Studies Centre of the National Centre for Scientific Research (CNRS), the University of Washington at Seattle (United States), and the Polar Geophysical Institute at Apatity (Russian Federation). The scientific objective was the study in the polar region of the ionospheric-magnetospheric coupling by correlation of measurements made in a balloon at an altitude of 35 km by satellite and by ground radar;

Pronaos. This relates to a submillimetric astronomical observatory, weighing 2.9 tonnes, proposed by the CNRS laboratories and developed with CNES as contractor; it consists of a telescope, 2 m in diameter, which was launched by NASA, using a CNES stratospheric balloon (altitude of 35 km) from Fort Sumner in the United States. Several interstellar clouds have been observed and the presence of the condensation of very cold interstellar matter unknown so far has been revealed.

Proteus platform

The Proteus (reconfigurable platform for observation of the Earth, telecommunications and scientific uses) programme will make it possible by the year 2000 to have a platform for satellites weighing 300-500 kg adapted to circular orbits between 400 and 1,500 km, together with its ground component. The platform will offer major advantages, such as reduced costs, shortened deadlines, optimal orbit, continuity of service and the possibility of rapidly testing out new concepts while in orbit.

This programme has involved a partnership with Aérospatiale, and an integrated CNES/Aérospatiale team has been put together.

The first programme that can benefit from Proteus is Jason, an altimetric satellite that will be carried out in cooperation with the United States. This satellite will succeed Topex-Poseidon, launched in 1992, and should be operational by the middle of the year 2000. The second programme is to be the Corot (a mission for astroseismology and extrasolar planetary research around nearby stars).

2. Earth observation

The SPOT observation satellites provide a large quantity of information in such varied fields as climatology, agriculture, natural phenomena, natural resources, cartography and land planning. The importance and diversity of these programmes make France a pioneer in the field. Furthermore, since 1992, the data furnished by Topex-Poseidon have permitted better understanding of oceanic circulation and changes in the climate.

SPOT

Manufactured in collaboration with Belgium and Sweden, the SPOT system has been operational since 1996. The third satellite of the series, placed in orbit in September 1993, suffered a breakdown in the attitude control system that has made it unusable since November 1996. The nominal lifetime of these satellites is three years. In order to continue providing a fully operational service, SPOT 1 and SPOT 2 are used in direct transmission mode. The launch date for SPOT 4 has been advanced to the first quarter of 1998.

SPOT 4 will provide continuity of the system up to the beginning of the year 2000. Its capabilities will be enhanced to a considerable extent as compared with those of its predecessors because of the addition of a new spectral band in the infra-red area, which will be useful for the observation of vegetation. In addition, it will include an instrument (Vegetation) permitting daily observation of the continental biosphere by means of a broad visual field (2,000 km) and a resolution of 1 km. SPOT 4 will have a solid-state memory of 10 gigabits, which will improve the reliability of its recording systems. Vegetation has been co-financed by Belgium, France, Italy and Sweden, together with the European Union. The instrument will bring about definite progress as compared with the other systems.

It will contain three other instruments as well:

Pastec (technological passenger) for studying the orbital environment;

Pastel (passenger SPOT telecommunications laser) for transmitting high-output images through an optical link with the data relay satellite;

Doris, for determining with precision the satellite orbit in order to be able to provide superimposed photographs.

France has decided to undertake the SPOT 5 programme, which will make it possible to ensure the continuation of the system beyond the year 2000. Several improvements have been decided on, the most important one concerning

the resolution on the ground, which will be finer (3 m instead of 10 m in the panchromatic mode, and 10 m instead of 20 m in the multispectral mode).

Topex-Poseidon

The aims of this Franco-American mission have been broadly fulfilled and remarkable scientific results have been obtained in several areas: the mean oceanic circulation has been quantified, seasonal effects and interannual anomalies of the El Niño type have been observed, ocean waves moving from east to west have been traced and described, and the tide models have been, to a large extent, improved. The data obtained have been a major contribution, in conjunction with those provided by ERS, to improving the marine geoid.

Bearing in mind these results, the need to follow up this programme was clear and, in December 1996, an agreement between CNES and NASA was signed. Jason will be the name of this new mission. CNES will provide the altimeter and the Doris system, while NASA will supply the radiometer, the laser reflector and the positioning system. The payload will be installed on the Proteus platform (see above).

Scarab

This programme, undertaken in collaboration with Germany and the Russian Federation, is aimed at monitoring the terrestrial radiation balance. The first instrument, mounted on the Russian satellite Meteor 3 and launched in January 1994, functioned for 13 months. The data obtained were distributed to scientists for their use. The second flight model should have been launched with the Russian satellite Resurs in June 1997, but the launching has been put off until the first half of 1998.

Polder

The Polder imaging polarization reflectance radiometer, intended to collect information on the visible radiation reflected by clouds, aerosols and marine and continental surfaces, was the first joint effort between Japan and France in the area of Earth observation. It was part of the payload of the Adeos satellite of the National Space Development Agency (NASDA) of Japan, which was launched successfully in August 1996. This satellite stopped functioning in June 1997. The data acquired over eight months have been processed at the Toulouse Space Centre and are now being distributed.

IASI (infra-red atmospheric sounder instrument)

This new instrument for meteorology is the most important part of the payload in the meteorological satellites of the Metop series. This satellite, the first model of which is to be launched in 2002 or 2003, will be inserted into a polar orbit.

The probe is necessary for progress in the digital prediction of time and the study of the climate. Its spectral and radiometric performance will permit the observation of temperature and humidity profiles in the troposphere with an accuracy and vertical resolution unobtainable with the present operational probes, and access to measurements of the integral gas contents, such as ozone, methane and carbon monoxide, that play a key role in the additional greenhouse effect.

Development up to the definition phase has been carried out by CNES. The development phase has been the subject of a cooperation agreement with Eumetsat to provide the first flight model and two additional models for Metop 2 and Metop 3.

3. Telecommunications

As the most important area in the commercial applications of space, space telecommunications represent high economic, political, cultural, strategic and industrial stakes. This sector, especially that of the satellites in geostationary orbit, represents for the moment the essential segment of the market for the Ariane launcher.

In the future, satellites will be called on to play a major role, whether in the matter of television broadcasting or mobile telephony, with personal satellite communication systems having world coverage.

The liberalization of telecommunications in Europe with effect from 1 January 1998 has led traditional operators to refocus on their activities. In the case of France, the France Télécom Research Centre (CNET) is responsible for research into future telecommunications programmes, while CNES prepares and supports the research and development activities in the field of space telecommunications, with the aim of cooperation and partnership with industry.

In August 1996, the telecommunications satellite Telecom 2D was successfully put into orbit by Ariane. This satellite, the fourth in the series, was constructed by Matra Marconi Space and Alcatel Espace was a co-contractor. CNES, which placed it in position, is in charge of keeping it in position and controlling it in orbit.

In the field of telecommunications satellites, French industry is having to face up to rapid progress in technologies and the needs of the market within a highly competitive environment. Aware of the extent of the stakes involved, the French Armaments Office (DGA), France Télécom, CNES and the industrial contractors (Matra Marconi Space, Aérospatiale and Alcatel Espace) have pooled their efforts to propose a technological programme able to enhance the competitiveness of the French industrial firms. This programme, which was agreed to in October 1994, covers research and development activities, ground developments, a satellite (Stentor) and the incorporation of new technologies validated by the programme into industrial product lines.

Stentor will have a mass of 2,000 kg, with an electrical output of 2,400 W and a lifetime of nine years.

4. Location

COSPAS-SARSAT

This programme is intended to aid research and rescue all over the world. An agreement was signed in 1988 between the four founding countries (Canada, France, Russian Federation and the United States) to provide the space equipment. By the end of 1996, 24 countries had undertaken to provide the ground component. In France, CNES, aided by user administrations, is operating the reception station and the mission control centre, located at Toulouse.

So far, the service has been provided from five International Search and Rescue Satellite System (COSPAS-SARSAT) satellites: three satellites using a United States National Oceanic and Atmospheric Administration (NOAA) platform and Canadian and French payloads and two satellites supplied by the Russian Federation.

Argos

Intended mainly for study and the protection of the environment, the Argos system contains a space component made up of data-collection instruments and locating devices provided by France and incorporated into the American polar satellites (NOAA) for meteorology. In 1996, the number of beacons using this system was more than 5,000 and it is growing steadily.

The NOAA-K satellite, the launching of which was scheduled for August 1997, will now be launched in 1998. It will carry the first Argos payload (Argos 2) of the second generation, which will offer a greater capacity and enhanced sensitivity. Three other NOAA satellites equipped with the same instrumentation will be launched later on.

CNES and NASDA are collaborating to equip the Adeos 2 satellite with an Argos instrument that has new functions making it possible for users to conduct a dialogue with their beacons. The identification model was successfully tested in November 1996. This instrument (Argos 3) could also be used for Metop satellites. Discussions are under way with Eumetsat on this point.

5. Navigation

The satellite navigation systems will make it possible to provide the services needed for the navigation of civil aircraft. It will then be possible to do without a complex and costly ground infrastructure that does not guarantee the sufficient coverage of needs. Designed to supplement the American Global Positioning System (GPS), the European programme known as the Global Navigation Satellite System (GNSS-1) will enable aeronautical needs to be met. This programme has been coordinated by the tripartite group made up of the European Union, ESA and Eurocontrol.

The Council of the European Union adopted a resolution on 19 December 1994 on the European contribution to the establishment of a global satellite navigation system. An initial European draft plan of action on the subject of satellite navigation was submitted in May to member States. For its part, in line with the project proposed within ESA, the Eurocontrol Management Committee adopted a strategy for using satellite navigation systems with, as the final aim, the installation of a single navigation system for all the phases of the flight.

ESA has included a navigation programme within the framework of the advanced research and telecommunications systems (ARTES) programme. It includes chiefly the development of the European pre-operational system (GNSS-1) in Europe. This programme was unanimously adopted by member States in December 1994. CNES has been taking part in the ARTES programmes since February 1995.

Set up in Toulouse at the site of CNES, the joint team for the ESA project includes personnel from several participating countries with staff from CNES and the Civil Aviation Office (DGAC).

At the industrial level, the European team built up around Thomson-Csf, the system contractor, has made progress in defining architecture systems for the pre-operational and operational phases.

The system will make it possible for aircraft to navigate along oceanic and continental routes and to improve the conditions for the approach and landing stages. It will be possible to reduce the spacing in the aerial corridors and trajectories will be optimized.

6. Exploration of the universe

Scientific space programmes traditionally involve a balance between three lines of research—astronomy and astrophysics, exploration of the solar system and the physics of space plasmas. Besides this, new areas have emerged, such as basic physics and exobiology.

A large part of the French activity is conducted through the ESA scientific programmes.

At the national level, a programme has been prepared for scientific missions using light satellites. The first such mission will be Corot, which is an experiment in astroseismology aimed at measuring the frequencies, amplitudes and widths of natural oscillation modes of stars. It will make use of the Proteus platform.

Half-way between the satellite and the balloon (see section D, above), Pronaos is a submillimetric astronomy project, the last area not yet covered by the observations. This area is located between the distant infra-red already observed by the satellites and the millimetric area, the study of which is possible using ground telescopes. The programme relates to the study of cold objects such as planets, comets or cold clouds, the physics of interstellar

space, the physiochemistry of interstellar dust, the formation of stars, the variation from one galaxy to another and the study of the primitive evolution of the galaxies.

Cooperation

France is making a contribution to the Odin scientific satellite developed by Sweden and intended for the observation of the as yet unstudied electromagnetic spectral bands situated in the neighbourhood of wavelengths between 0.5 and 3 mm.

France has taken part in the Russian programme Mars-96. The planet Mars is a major objective for the exploration of the solar system. It manifests certain resemblances to Earth, as well as marked differences.

The Mars-96 mission, for which the Russian Federation is responsible, was carried out in collaboration with some 20 countries. The launching of the Mars-96 mission was scheduled for November, with an orbiter equipped for about 20 scientific experiments and with two ground stations and two penetrators. The nominal lifetime of the satellite was one terrestrial year. France, along with Germany, was the first partner of the Russian Federation, being the contractor for eight experiments and contributing to the performance of eight others. France provided the system installed aboard the orbiter, which relayed the data obtained from smaller stations placed on the surface of Mars, together with a second relay placed on the American satellite Mars Global Surveyor launched at the beginning of November.

The main scientific objectives of the mission were the global study of the physical parameters of the planet Mars (atmosphere, surface and interior) so as to trace the complex history of its evolution since it was first formed.

The launching in November 1996 was not successful because of a defect in the thrust of the fourth stage of the Russian launcher Proton.

France has also taken part in the INTERBALL programme intended to study the behaviour of plasma in the auroral regions and in Earth's magnetospheric tail. This programme has been carried out in cooperation with numerous countries. The mission includes two satellite couples: one, which is eccentric, placed in a high-apogee orbit (200,000 km), and the other, auroral, launched in August 1996 by the Russian launcher Molnya into an orbit with a lower apogee (20 000 km). The inclination of each couple of satellites is 62.88 degrees. Each of the couples consists of a main Russian satellite and a Czech subsatellite. A complete account of the functioning of the satellites and their payloads shows satisfactory performance as a whole. Conversely, the auroral subsatellite is not functioning properly because of a defect in the solar panels.

7. Life and weightlessness

Scientific and technical missions are continuing within the framework of cooperation with the Russian Federation and the United States.

Life and Microgravity Science mission

Jean-Jacques Favier of the French Atomic Energy Centre was selected as a payload expert to fly aboard the NASA Life and Microgravity Science (LMS) Spacelab Mission in June 1996. The mission programme covered experiments in the life sciences, the physical sciences, basic physics and a series of photographs intended for the study of climates and the environment. Jean-Jacques Favier carried out an experimental programme that included, in particular, several French experiments on solidification in the Advanced Gradient Heating Facility of ESA. He was also both the subject and the experimenter for tests in human physiology aimed at better evaluation of the way in which weightlessness alters the basic physiological functions of humans. He also performed experiments intended

to bring better understanding of climate and the environment. In France, the flight was monitored in its entirety from the Toulouse Space Centre, which received visits by scientific teams from Europe.

The LMS mission began on 20 June 1996 and ended on 7 July 1996 (a record time for the length of a shuttle flight). The crew of the Columbia space shuttle consisted of seven persons, one of whom was Canadian.

The human physiology programme, which deals with overall physiological functions under conditions of microgravity, was carried out in an identical fashion by four of the Columbia astronauts. On the ground, the four experimenters immediately simulated the same programme for purposes of comparison over an identical period.

The Cassiopée mission

This mission took place between 17 August and 2 September 1996, with 14 days aboard the Mir space station. The Franco-Russian crew of the Cassiopée mission included Claudie André-Deshays, the first French woman astronaut.

The scientific and technological programme for the mission was carried out in full; it included three life sciences experiments: Physiolab to study the cardiovascular system, Cognilab to study perception mechanisms under microgravity and Fertile to study the development of embryos in vertebrates under conditions of microgravity, an experiment in physical sciences; Alice 2 to study fluids at the critical points and two technological experiments; Dynalab to measure the level of microvibrations at different places in Mir and Treillis for an analysis of the dynamic behaviour of a mechanical trellis floating in the Mir space station.

The experiments are now being processed and a symposium for the initial examination of the scientific results was held on 19 December 1996. On the technical plane, the Castor experiment has permitted the study and validation in orbit of the dynamic characterization of the structures and principles governing the active damping of vibrations. These techniques will be indispensable for future space missions based on interferometry.

POLAND

[Original: English]

Space activity in Poland is conducted mainly in the following fields:

Space physics;

Remote sensing;

Planetary geodesy;

International cooperation;

Teaching in space sciences.

The main institutions involved in this activity are as follows:

Space Research Center of the Polish Academy of Sciences;

Institute of Geodesy and Cartography;

Astronomical Copernicus Center of the Polish Academy of Sciences;

Warsaw University;

Warsaw University of Technology.

The whole activity in space research in Poland is coordinated by the Committee on Space Research (COSPAR), which is a scientific body that also plays the role of the National Committee of COSPAR.

A. Activities in space physics

This year, Polish activities in space physics have been concentrated in the following fields:

(a) Participation in space missions;

(b) Design and construction of scientific equipment for future experiments in space physics;

(c) Processing of data obtained from previous and current space experiments;

(d) Theoretical investigations and interpretation of observational results in the field of space physics.

1. Space missions

The main space project, in which Polish physicists have been involved this year, is INTERBALL, an international multi-satellite mission, devoted to study the terrestrial magnetosphere and the transfer of energy from solar wind into Earth's magnetosphere. All the satellites of this project, the tail probe (INTERBALL-1), launched on 3 August 1995, its subsatellite Magion-4 and the auroral probe (INTERBALL-2), launched on 29 August 1996, operated by the Institute of Space Research in Moscow, are successfully continuing their mission.

Polish scientists have been participating in four experiments of the mission:

Two on the tail probe: ASPI—to measure the plasma waves and electromagnetic fields along the spacecraft orbit; and the solar X-ray thomograph—photometer RF15-I (the last one was constructed in cooperation with the Czech Republic);

One on the Czech subsatellite Magion-4 of the tail probe: SAS—the plasma wave spectrum analyser;

One on the auroral probe: POLRAD—the radio-spectro-polarimeter to measure electromagnetic auroral kilometric radiation.

All of these instruments continue to deliver a good deal of observational data, which are the subject of cooperative analysis in Polish laboratories. Polish engineers have contributed to the development of instrumentation for all of them.

2. Hardware and software for future experiments

Development of instrumentation for several international space projects is being continued in Poland. Listed below are projects to which Poland contributes:

(a) In the CORONAS-F project (coordinated by the Russian Federation): finished construction and tests (in cooperation with the Rutherford-Appleton Laboratory in the United Kingdom of Great Britain and Northern Ireland) of the solar X-ray photometer RESIK;

(b) In the RELICT-2 project (coordinated by the Russian Federation): flight models for GAS-E and GAZ-E ground support equipment have been built;

(c) In the NASA/ESA mission CASSINI/HUYGENS (launched on 15 October 1997): the thermal properties metre (THP) sensor, built in Poland, which is a part of a United Kingdom surface science package (SAP) experiment, has been installed on the HUYGENS lander to Titan, to measure temperature and thermal conductivity of gases and liquids in Titan's atmosphere and ocean;

(d) In the central European satellite for advanced research (CESAR) project: contribution to the construction of the satellite and development of instrumentation for the experiments designed to measure:

(i) Electric and magnetic fields in plasma (wave diagnostics) (PWP);
(ii) Profiles of the spectral lines of the components of Earth's atmosphere (Fourier spectrometer);
(iii) The monitoring of thunderstorms;

(e) In the International Gamma Ray Astrophysics Laboratory (INTEGRAL) project devoted to measuring the X-ray and gamma ray deep space sources:

(i) Contribution to the gamma imager IBIS (construction of the veto electronics system);
(ii) Contribution to the tests and integration of the main detector of the SPI spectrometer;
(iii) Contribution to the X-ray monitor JEM-X (construction of the ground support electronics);
(iv) Contribution to the software in the INTEGRAL Science Data Center;

(f) In the ROSETTA project—a mission to the comet P/Wirtanen: a contribution to the MUPUS experiment in the penetrator PEN/MUPUS, intended to measure the density, temperature, thermal conductivity and mechanical properties of the cometary nucleus: a pre-laboratory model has been produced; and to the experiment VIRTIS, which will measure the spectra of dust-gas emission, the modelling of infra-red spectra of the dust-gas mixture is being conducted;

(g) In the COMPAS project (Russian Federation)—a satellite to investigate electromagnetic disturbances and the ionospheric plasma: construction of the wave spectrometer operating in the frequency range of 0.1-15 MHz.

3. Data processing and interpretation

Listed below are the Polish contributions to the processing and analysis of space data. Most of them have resulted in publications in international journals:

(a) Analysis of data obtained from ASPI (INTERBALL-1) and SAS (subsatellite of INTERBALL-1);

(b) Analysis of data from the solar X-ray spectrometer on board INTERBALL-1;

(c) Analysis of data on auroral kilometric radiation from POLRAD (INTERBALL-2);

(d) Continued data analysis from the SORS-D experiment on electromagnetic wide-band disturbances (CORONAS satellite);

(e) Cooperation in the analysis of solar X-ray Yohkoh data, for investigations of flare heating, plasma motions in flares and the chemical composition of flare plasma;

(f) Data processing and interpretation of the ULYSSES-GAS experiment on the distribution of interstellar helium.

B. Remote sensing activities

The Polish contribution in the field of remote sensing includes the following activities:

(a) Application of NOAA AVHRR satellite images for the development of an early warning system for drought detection (Curie-Sklodowska Foundation);

(b) Investigations on the use of satellite and meteorological data for determination of soil and vegetation indices used in field simulation models (European Community);

(c) The use of airborne and satellite remote sensing to stratification of agricultural production areas for determination of agricultural land structure using the method of area frame sampling;

(d) The use of the digital terrain model in geometrical and radiometric correction of microwave satellite images with varying relief (European Community and local);

(e) Application of radar data (ERS/SAR) for soil moisture assessment (in cooperation with the European Space Agency; ESA pilot project).

In the area of Earth observation, the present activity at the Space Research Center is focused on the preparation of an experiment with the IR Fourier spectrometer (FTIR) for the CESAR space mission to be launched in the year 2000. CESAR will be a Sun-pointing satellite with the following orbital parameters: perigee—400 km, apogee—1,000 km, inclination—70 degrees and period—98.8 minutes. The FTIR spectrometer is devoted to the investigation of the concentration and spatial distribution of atmospheric trace gases (e.g. CH_4, SO_2, NH_3, NO_2, NO_x and HCl) and natural O_3 in the wavelength band 2-16 µm with spectral resolution 0.1 cm^{-1}.

In connection with space missions, a proposal of combined space and ground-based spectrometric observations of the vertical distributions and column densities of nitric acid and nitric oxide has been advanced. Aspects related in particular to the idea of correlative measurements: geometrical details, simulation of the solar absorption spectra corresponding to different observational geometries and associated retrieval methods have been discussed.

The research has been carried out in collaboration with the Belgian Institute for Space Aeronomy.

C. Activities in satellite geodesy

Poland has undertaken investigations of artificial satellite movement for the purpose of geodesy and geodynamics. Major programmes for orbital calculations are being developed and used as tools. The geodynamic processes of regional and local areas are being investigated within the framework of international scientific programmes such as WEGENER, DOSE and CERGOP. Activities in which Poland has been involved include the following:

(a) Investigations of short periodic oscillations of the ocean level using the data from satellite altimetry;

(b) Analysis of the fundamental coordinate systems and their reciprocal transformation;

(c) Investigation in the area of integration of a satellite (GPS) and inertial navigation systems;

(d) Application of satellite methods for precise navigation at the surface of Earth and in the air;

(e) Construction and investigation of models of the ionosphere and the troposphere for geodetic purposes;

(f) Organization of permanent stations with GPS and laser equipment for geodynamic investigation.

D. International cooperation

Cooperation has continued in the following areas:

(a) COST—agreement on PRIME 1—construction of models of the ionosphere over Europe;

(b) French-Polish cooperation on space research;

(c) Russian-Polish cooperation in ionospheric and magnetospheric studies; participation in the Russian INTERBALL project;

(d) Participation in ESA/NASA projects: INTEGRAL, ROSETTA, CASSINI/HUYGENS;

(e) Progress reports and scientific publications for the international scientific community.

E. Education in space sciences

The following activities in education in space sciences are continuing:

(a) Popular science programmes on Polish radio and television;

(b) Popular science lectures for schoolchildren, amateurs in astronomy, physics and astronautics;

(c) Course lectures for university students;

(d) Presentations and lectures for scientific communities;

(e) Popular science articles in the Polish press (daily, weekly and monthly);

(f) Articles in Polish popular science journals (*Postepy Astronomii*, *Urania*, *Delta*).

There is inter-faculty education at Warsaw University in the field of protection of the environment using remote sensing techniques. Recently, inter-faculty education in the field of space science and technology was introduced at Warsaw University of Technology. Lectures at the master of science level will be conducted in the following areas of specialization: remote sensing, satellite telecommunication, space instrumentation, space physics and its applications, satellite geodesy and navigation. Poland also takes part in the initiative organized under the auspices of the United Nations to educate high-level experts in the field of space science and technology applications.

RUSSIAN FEDERATION

[Original: Russian]

The space activities of the Russian Federation in 1997 were conducted under the Federal Space Programme and also as part of international scientific-technical cooperation and commercial agreements.

The Federal Space Programme in 1997 was directed towards priority tasks relating to the most important areas of the exploration and utilization of outer space for the purposes of developing science and technology and intensifying international cooperation.

These priority tasks include the following:

(a) The implementation of international agreements relating to space projects, including the establishment of the International Space Station (ISS);

(b) The maintenance of a global communications system and the relaying of television programmes throughout the Russian Federation;

(c) The undertaking of basic scientific research in astrophysics, planetology, solar physics and solar-terrestrial interaction;

(d) The performing of experiments on the Mir manned orbital station and research on technologies for the production in space of new materials and high-purity substances;

(e) Monitoring of the natural environment, disaster monitoring and management, and exploration of natural resources;

(f) Provision to various users in the Russian Federation and elsewhere of global high-precision coordinate and time references at any time of day and in all locations;

(g) The development of scientific-technical and technological process stock for future space technology.

In 1997, a total of 45 space objects of various kinds were injected into geostationary orbit, including:

(a) Two manned spacecraft from the Soyuz TM series (Soyuz TM-25 and Soyuz TM-26);

(b) Four unmanned cargo spacecraft from the Progress series (Progress M-34 to Progress M-37);

(c) Twelve satellites from the Cosmos series (Cosmos-2337 to Cosmos-2348);

(d) Six telecommunications satellites (three Gonets-D1 satellites, one Molniya-1 satellite, one KUPON satellite and one Zeya satellite);

(e) One Foton spacecraft for research in the field of space technology and biotechnology and one Resurs-F1M spacecraft for investigation of Earth's natural resources;

(f) Nineteen commercially launched spacecraft: TELSTAR-5, PANAMSAT-5, Iridium (14 spacecraft), Astra-1Zh, FAISAT-2v and Early Bird.

On 25 December 1997, the commercial television and radio-relaying satellite ASIASAT was launched into an unplanned orbit.

The above-mentioned space objects were injected into orbit by 28 launches by Proton, Soyuz, Molniya, Tsiklon, Cosmos and Start-1 carrier-rockets.

MAIN RESULTS

A. Manned space flight programme

The fortieth anniversary of the first launch of an artificial Earth satellite was celebrated on 4 October 1997.

The achievements of Russian cosmonautics have found a fitting symbol in the development of the manned Mir space station, which has been operating in the geostationary orbit for more than 10 years as a permanently functioning scientific research laboratory for experimental investigations in real space conditions.

A series of experiments are currently being performed in the Mir station in the following fields: space technology, geophysics, medicine and biology, Earth's natural resources, environmental science, biotechnology, astronomy, space power engineering and engine design.

In 1997, work connected with the Mir manned scientific research station continued under the programme for the 22nd, 23rd and 24th principal expeditions (EO-22, EO-23 and EO-24), and also under international cooperation programmes conducted jointly with the National Aeronautics and Space Administration (NASA) of the United States of America and the German Space Agency (DARA).

The 22nd principal expedition with a crew of two Russian cosmonauts—Valery Korzun (commander) and Aleksandr Kaleri (flight engineer)—continued its work on board the Mir station from August 1996 and was joined by the United States citizen John Blaha as flight engineer 2 in September 1996.

Atlantis STS-81 returned John Blaha to Earth on 22 January 1997 after a flight under the Mir-NASA-4 Programme which lasted from 15 January to 20 January 1997. He was replaced on board the station by NASA-4 astronaut Jerry Linenger.

The launch of the Soyuz TM-25 craft with the crew of the 23rd principal expedition, consisting of the two Russian cosmonauts Vasily Tsibliev (commander) and Aleksandr Lazutkin (flight engineer) and the German astronaut and research scientist Reinhold Ewald, took place on 10 February 1997.

The crew of the 22nd principal expedition (EO-22), consisting of cosmonauts Valery Korzun and Aleksandr Kaleri and German astronaut and research scientist Reinhold Ewald, was returned to Earth on 2 March 1997 by the Soyuz TM-24 craft.

The 22nd principal expedition lasted 192 days.

The United States astronaut Jerry Linenger continued working on board the Mir station as a member of the crew of the 23rd principal expedition.

In accordance with the scheduled programme, Atlantis STS-84 was launched on 15 May 1997 at 1208 hours and docked with the Mir station on 17 May 1997 at 0639 hours.

The duration of the joint flight by the Atlantis craft and the Mir station was five days, during which the following main operations were performed:

(a) Delivery to the station of the United States astronaut Michael Foale for continuation of the NASA-5 long-duration mission;

(b) Delivery to the station of American scientific instrumentation for the purposes of research, components for the life-support system, Russian instrumentation, including an Elektron oxygen generator unit for the crew, and consumables;

(c) Completion of a joint programme of experiments and research;

(d) The return to Earth of the scientific research results, Russian equipment, including the malfunctioning Elektron unit, and American apparatus and equipment.

On 22 May at 0503 hours Atlantis STS-84 undocked from the Mir station and on 24 May at 1728 hours landed on the landing strip of the Kennedy Space Center in Florida.

The NASA-4 astronaut Jerry Linenger was returned to Earth by Atlantis STS-84. The duration of his flight on board the Mir station had been 134 days.

Michael Foale remained on board the Mir station as a member of the 22nd principal expedition, and as its fifth American astronaut, in order to conduct scientific experiments in the course of a long-duration orbital flight. Thus, NASA astronauts have been working on the Mir station continuously since March 1996.

During the work phase of the 23rd principal expedition, on 25 June, when the Progress M-34 transport craft was approaching the Mir station, a collision occurred between the two craft. As a result, the Spektr module was depressurized and the module's electric power system was cut off from the Mir station's power supply bus, which caused a power shortage on the station and cut off the supply to the Kristall module and the docking module used for docking with the Shuttle orbital craft.

Despite the fairly critical emergency situation on board the station during the first moments after collision with the transport craft, the crew of the 23rd expedition (commander V. Tsibliev, flight engineer A. Lazutkin and flight engineer 2 M. Foale) managed to disconnect the power cables and seal off the air ducts running through the hatch of the Spektr module and prevent loss of pressure using the reserve pressurization system in accordance with the instructions from flight control and to close the hermetic cover of the hatch from within the transfer chamber of the station's base block.

It was determined from the results of the analysis performed that in the collision with the transport craft one of the four solar arrays of the Spektr module and the external radiator of the heat regulation system had been damaged. The precise place in the module's structure where a pressure leak had occurred could not be established and has yet to be ascertained.

Owing to the disconnection of the Spektr module flight systems, the most unfortunate consequence of the accident was the considerable reduction in electric current supply to the station's power supply system, which made it necessary to cut off the power supply to the Kristall and Priroda modules and caused a power shortage on the Kvant-2 module.

Thanks to further power conservation measures on the Kvant-2 module, it was possible by 14 July 1997 to restore a positive power-supply balance.

Structural load evaluations after the collision between the Mir station and the Progress M-34 craft showed that the load-carrying capacity of the docking nodes of the orbital station's modules had not been affected. These evaluations were confirmed by successful docking operations of the Progress M-35 and Soyuz T-26 transport craft with the orbital station.

Repair equipment and instrumentation were delivered by the Progress M-35 transport craft to the station for the purpose of connecting the power supply system of the Spektr module to the station's general power supply system.

In the interests of carrying out a more detailed analysis of the technical conditions of the station's flight systems and on the basis of an objective assessment of the psychological and physical state of the EO-23 crew, decisions were taken to proceed with a "spacewalk" by the crew with the 24th principal expedition into the depressurized Spektr module, with the aim of connecting its solar arrays to the general power-supply system of the station, and to defer the visit of a French astronaut under the Pegasus programme to the mission of the 25th principal expedition, by which time conditions allowing the implementation of special programmes would be restored.

On 14 August 1997, the crew of the 23rd expedition, consisting of cosmonauts V. Tsibliev and A. Lazutkin, was returned to Earth after a flight lasting 185 days.

The 24th principal expedition (EO-24) began its work on board the Mir station with a crew consisting of two Russian cosmonauts, Anatoly Solovev (commander) and Pavel Vinogradov (flight engineer 1), who were delivered on board the Soyuz TM-26 craft on 7 August 1997, and the NASA-5 astronaut and United States citizen Michael Foale (flight engineer 2), who had been a member of the 23rd expedition.

Unlike previous expeditions, whose purpose was to carry out a large volume of research and experimental work, the scheduled programme of work for the 24th expedition includes as a special feature repair and maintenance operations on structural components of the Spektr module.

In 1997 the crew of the 24th principal expedition performed five space walks, in the course of which operations were carried out to repair the power-supply circuit of the Mir station, evaluate the structural condition of the Spektr module at the site of the pressure leak, replace a solar array on the Kvant module and perform various scientific experiments.

These operations resulted in restoration of the normal operation of the Mir station and full working order of all critical life-support systems. In addition, they permitted the delivery on board and installation of the Vozdukh and Elektron supplementary systems.

In accordance with the scheduled programme, on 26 September 1997 at 0634 hours the launch of the Atlantis STS-86 spacecraft took place; it docked with the Mir station on 27 September 1997 at 2357 hours.

The crew of Atlantis STS-86 consisted of seven astronauts, including the Russian cosmonaut V. Titov, the French astronaut Jean-Louis Chrétien and the NASA-6 astronaut David Wolf, who replaced the NASA-5 astronaut Michael Foale on board the Mir station.

The joint flight of the Atlantis craft and the Mir station lasted six days, during which the following main operations were performed:

(a) Approach and docking of the Atlantis craft and the Mir station;

(b) Delivery to the station of an American astronaut for the purpose of carrying out the NASA-6 long-duration mission;

(c) Delivery to the station of cargo, including a Salyut 5 B flight computer and repair equipment (cone) for repairing the pressure leak on the Spektr module;

(d) A joint programme of research and experiments;

(e) The performance of a “spacewalk” by the astronauts from the Atlantis craft for the purpose of removing from the station’s docking module American apparatus mounted during the STS-76 flight;

(f) A circling of the station for the purpose of inspecting and documenting any damage and possible pressure-leak sites on the Spektr module using photographic and video equipment;

(g) The return to Earth of the American astronaut from the NASA-5 mission;

(h) The return to Earth of the research findings and the malfunctioning equipment for research under factory conditions.

On 3 October at 2116 hours, Atlantis STS-86 undocked from the Mir station and landed on 7 October at 0155 hours on the landing strip of the Kennedy Space Center in Florida.

The NASA-5 astronaut Michael Foale, who was delivered to the Mir station on board Atlantis STS-84 on 18 May 1997, was returned to Earth on board Atlantis STS-86. His flight on board the Mir station had lasted 144 days.

David Wolf remained on board the Mir station as a member of the 24th principal expedition (EO-24); he is the sixth American astronaut to embark upon a wide-ranging programme of work to be performed during a long-duration orbital flight. There has thus been an unbroken succession of NASA astronauts working on the Mir station since March 1996.

The return of David Wolf is planned to take place on board Endeavour STS-89 at the end of January 1998.

During the mission of the 24th expedition the Mir station docked with the transport craft Progress M-36 (launched on 5 October 1997) and Progress M-37 (launched on 20 December 1997); plans have also been made for docking with the manned transport craft Soyuz TM-27 (launch date 29 January 1998), carrying the three-member crew of the 25th expedition (EO-25), one of the crew members being an astronaut from the Centre national d’études spatiales (CNES) of France.

Various scientific and practical results obtained on the Mir station have had a considerable impact on the development of new technologies with industrial and social applications for the twenty-first century. These include the development of basic technologies for obtaining perfect monocrystals for use in the design of ultra-high-speed radiation-resistant integrated microcircuits, super-high-frequency and laser technology and nuclear radiation detectors; the development of experimental diagnostic antisera for use as standards in the production of flu vaccines; refinement of the technique of growing crystals of various proteins and viruses necessary for the development, by means of genetic engineering, of new medicines to combat oncological diseases, acquired immunodeficiency syndrome (AIDS) and other diseases.

A whole array of practical results obtained during missions on board the Mir station are already being used today in various branches of industry, science and medicine. On the basis of materials produced by space photographic surveys, methods have been developed for soil inventory and for predicting and prospecting for deposits of useful minerals, and a photographic album entitled “Space environmental evaluation methods” has been compiled. Weighted spacesuits with electrostimulators are being used to good effect for medical purposes in clinics. A mobile medical complex has been established for the purpose of providing emergency medical care for disaster victims and is currently being used in relief operations after earthquakes and other catastrophes. Astrophysicists have made a number of important discoveries in their observations of the Supernova. A total of 10 new X-ray sources have been discovered, a map of X-ray objects at the centre of the Galaxy and the Large Magellanic Cloud has been drawn, and various other scientific data have been obtained.

The continued operation of the Mir complex until the years 1999 and 2000 is worth while because of the presence on board the station of a considerable assembly of fully operational research apparatus of both Russian and foreign manufacture and also because of the necessity that the Russian Federation fulfil its obligations regarding the completion of joint research programmes with foreign partners and the possibility of amassing invaluable experience in the operation of the station and refinement of principles, design-related solutions and technologies for restoring the full working order of long-duration manned stations capable of making an effective contribution to future Russian and international space programmes, including the ISS programme.

B. Applied space technology programmes, communications, television transmission and navigation

1. Space communications, television transmission and navigation

In 1997 the operation of the long-range telephone and telegraph communications system was maintained, as was the relaying of radio and television programmes and the transmission of data on behalf of various official authorities and industrial sectors of the Russian Federation and international communications by means of the Gorizont, Ekspress, Gals and Ekran-M spacecraft.

Under the programme to establish a space data transmission system, three further Gonets-D1 space objects were launched to supplement the three already in orbit.

The year 1997 saw the continued operation of the Global Orbiting Navigation Satellite System (GLONASS), used for navigation by civil aircraft and naval vessels and also by other sectors of industry. There are currently 13 spacecraft from the Cosmos series in orbit as part of GLONASS.

The Nadezhda satellites continued operating within the International Search and Rescue Satellite System (COSPAS-SARSAT), an international system for tracking and rescuing sea vessels and aircraft in distress.

2. Remote Earth sensing, meteorological observation and environmental monitoring

Issues relating to the environment, the rational utilization of natural resources and the establishment of a natural disaster and catastrophe warning system have acquired enormous importance in the world today. Work is being done in this area with a view to the establishment or modernization of satellites designed for high-resolution operational observation of Earth, all-weather observation of the Pacific Ocean and environmental monitoring.

In 1997 there was continued operation of meteorological satellites (Meteor-3 and Elektro), an oceanographic satellite (Okean-01) and a natural-resource monitoring satellite (Resurs-01), together with continued use of data received from foreign satellites (NOAA and Meteosat) and information from the Priroda module, belonging to the Mir orbital station.

In November 1997 the launch took place of the Resurs-F1M satellite, from which photographic observation of Earth has been carried out.

Space data received on a regular basis from the satellites Meteor-3, Elektro, NOAA and Meteosat are used in weather analysis and forecasting. On the basis of data received from the satellites Okean-01, Meteor-3 and NOAA it has been possible to monitor the ice situation in the Arctic (along the North Sea route) and the Antarctic (during the delivery of goods and new expedition members to Russian Antarctic stations).

In the interests of achieving more accurate forecasts of hazards over areas of inland and landlocked water in the European part of the Russian Federation, regular use has been made of data on the velocity of sea-surface winds and areas of particularly high precipitation on the basis of radiophysical data received from the Okean-01 satellite.

In satellite hydrology, work is currently being focused on environmental research aimed at determining the extent of chronically polluted areas of river basins and at mapping submerged areas along the flood plains of rivers. This work has been based on complex analysis of photographic satellite images, collated with the findings of operational ground-based observations, and mapping and statistical data.

Work continued in 1997 with a view to establishing future space technology for different purposes, namely hydrometeorological observation (the Meteor-3M satellite) and operational land and ocean observation (the Okean-0 satellite), both of which are scheduled to be launched in 1998.

3. Space technologies

Studies in the sphere of space technology and the physics of weightlessness were directed towards the production under microgravity conditions of new organic and inorganic materials and the refinement of the technologies and equipment required for their production, including commercial production. The use for these purposes of both manned and unmanned spacecraft has made it possible to grow crystals with properties which are unobtainable on Earth, thus providing the requisite scientific and technical process stock for the transition to the experimental industrial production of materials in space. The main purpose of establishing the planned space assembly is to complete the development of basic technologies for producing test parts for semiconductors, “gradans” and other preparations with practical industrial applications.

The space technology programme is being conducted by means of the Foton spacecraft (launched on 9 October 1997) with the participation of European Space Agency (ESA) member States. Semiconductor materials produced under microgravity conditions (cadmium telluride, gallium arsenide, zinc oxide, silicon etc.) have properties representing an improvement on their Earth counterparts by a factor of 50-70. The biological preparations obtained are 5-10 times purer than their Earth counterparts.

Work is under way to design a new generation of spacecraft in order to continue research under microgravity conditions. The new spacecraft are being designed to have an active life 10 times longer than that of the Foton. Plans are being made to use these craft to refine the basic technologies for the production of semiconductors, “gradans” and biological preparations with practical industrial applications.

C. Space research programmes

Fundamental research on celestial bodies and outer space contributes to humankind’s knowledge of the Universe, the processes at work in it and their impact on Earth. Such research will assist future human endeavours in space and on the celestial bodies and will provide a basis for manned flights to Mars in the new millennium.

The Russian Academy of Sciences plans to use space technology in conducting more detailed study of high-energy space particles and of solar-terrestrial interaction, the development of a heliogeophysical monitoring system being planned for the future. It intends to carry out complex research of Earth’s magnetosphere and to study the interaction of processes on the Sun and in the circumterrestrial plasma with life on Earth.

A programme of flight experiments has been successfully conducted at the Granat orbital observatory. During its eight years of operation, a detailed study has been made of several dozen galactic and extra-galactic sources, representing possible black holes, neutron stars (X-ray bursters and X-ray pulsars), X-ray novae and accumulations of galaxies and quasars; a number of interesting and hitherto unknown objects have been discovered. For the first time, sources emitting radiation in the annihilation gamma line of positronium have been localized. The observatory is currently operating in the scanning regime and is continuing to transmit valuable information.

Solar research is of exceptional scientific importance. The Sun is the principal source of energy and the "generator" of all the main natural processes on Earth and in cirumterrestrial space. Furthermore, it is the star most accessible to study, being observable from Earth as an extended object.

The Sun and its corona provide, essentially, a vast natural laboratory for the study of fundamental properties of substances in the plasma state. Research conducted on spacecraft from the Automated Universal Orbital Station (AUOS) series using new configurations of scientific instrumentation are substantially improving the understanding of the mechanisms of solar flare activity and are making it possible to locate the active parts on the Sun's surface and to identify phenomena reliably heralding flares.

All of this provides a basis for reliable forecasting of solar activity. A different area of research is the processing of the valuable information yielded with a view to identifying meaningful patterns.

Under the INTERBALL programme (two satellites from the Prognoz-M2 series), a system has been set up in space for conducting long-term fundamental research on processes taking place under the influence of solar radiation in Earth's magnetosphere. This research forms an integral part of the international programme for investigating the nature and mechanisms of solar-terrestrial interaction by means of spacecraft and ground-based observatories in various countries.

The Prognoz-M2 satellite has been fitted with scientific instruments designed by scientists and specialists from the Russian Federation, from Austria, Bulgaria, Canada, Cuba, Czech Republic, Finland, Germany, Greece, Hungary, Italy, Kyrgyzstan, Poland, Romania, Slovakia, Sweden, Ukraine, United Kingdom of Great Britain and Northern Ireland and Uzbekistan, and also from ESA.

The results of the research are extremely promising, since the investigation and identification of patterns and mechanisms of interaction in the behaviour of the Sun and circumterrestrial plasma will provide a key to a closer understanding of the "secret" of life on Earth.

Work is currently under way in the field of astrophysics in connection with the Spektr-RG project (high-energy research) and the Spektr-R project (development of a fundamentally new area of research on astrophysical objects by means of very long base radiointerferometry (i.e. using a base greater than Earth's diameter).

D. International cooperation

One of the most important components of the Russian space programme today is international cooperation.

The international cooperation efforts of the Russian Federation are being deployed in virtually all areas of its national space programme, including:

(a) Implementation of a programme of manned flights; participation in the large-scale joint scientific and technical project to establish ISS;

(b) Use of Russian carrier rockets for launching foreign satellites;

(c) Study of Mars, including, in particular, participation in the United States project Mars-98 (installation on board the craft of two Russian instruments);

(d) Use of the global navigation satellite system (the Russian system GLONASS and the American Global Positioning System (GPS));

(e) In the area of microgravity, implementation of the Foton project with the participation of ESA, CNES and the German Aerospace Research Establishment (DLR);

(f) Development of COSPAS-SARSAT, the international tracking and rescue system;

(g) Photography and exchange of remote Earth sensing data, in particular those data received from the Russian Resurs satellites and the French Système pour l'observation de la Terre (SPOT) satellite;

(h) Contractual assignments in the sphere of research and development, fundamental research, experimental and ground-based trials to ensure the future development of space and rocket technology;

(i) Cooperation with member States of the Commonwealth of Independent States (CIS) under an inter-State programme for the exploration and use of outer space.

The Spektr programme of astrophysical space research is the international and national space programme assigned top priority in the field of fundamental research. In addition to institutes of the Russian Academy of Sciences and Russian companies and organizations in the rocket and space sector, organizations and companies from 20 other countries are involved in the execution of this project.

New and even more favourable conditions for the implementation of international space agreements are being created in the Russian Federation with a view to developing international cooperation, including cooperation within the context of the world commercial space market. Inter-State and intergovernmental agreements on cooperation in the sphere of space activities have been concluded with a large number of countries. The Russian Space Agency has also signed agreements with the space agencies of 13 countries, ESA and the International Space University.

A number of joint ventures with foreign firms have been established by enterprises in the rocket and space sectors of industry.