EUROMIR
ЕВРОМИР

Missions to Space with Russia

Russian Space Agency

RKA

The Russian Space Agency (RKA), created in 1992 by a presidential decree and located in Moscow, is the main civilian governmental entity responsible for the elaboration of the national space policy and the coordination of the related research, development and operational activities in Russia.
Staff: about 200
Director General: Yuri N. Koptyev.

НПО
«ЭНЕРГИЯ»

NPO Energia

NPO Energia (full name: Rocket Space Corporation 'Energia') is located in Kaliningrad, north of Moscow. It is the leading Russian industrial company in the field of space systems and technology. It bears the name of academician S. P. Korolev who founded it in 1946. The famous R-7 rocket that later evolved into the Soyuz-TM launcher which still today forms the backbone of the Russian manned space programme, the first artificial Earth satellite 'Sputnik', the first interplanetary probe 'Venera-1', the first manned spacecraft 'Vostok', the present Soyuz-TM and Progress-M space transportation vehicles, as well as the space stations 'Salyut' and 'Mir', together with the heavy 'Energia' launcher and the spaceplane 'Buran' were developed here.
NPO Energia is also responsible for the final assembly of the launch vehicles at the Baikonur cosmodrome.
Staff: about 30 000.
Director General: Juri P. Semyonov.

ЦПК

TsPK

The Yuri Gagarin Cosmonaut Training Centre (TsPK), commonly named 'Star City', is located in Shchelkovsky Rayon, 35 km north-west of Moscow. It was created in 1960 – one year before cosmonaut Gagarin's first flight on board Vostok. The TsPK is placed under the authority of the Russian Ministry of Defense. It is responsible for the selection and training of the flight crews. Cosmonauts are trained here on all theoretical and practical aspects related to cosmonautics as well as to all spacecraft systems on board Soyuz and Mir. Training is performed on simulators for Soyuz-TM flight and for Soyuz-TM and Mir system management. Familiarisation and operational practice for the work under weightlessness conditions are performed in specially equipped '0-*g* aircraft' (called 'flying laboratory' in the Russian terminology) which are able to fly parabolic flight manoeuvers, and under water in a neutral buoyancy facility (called 'hydrolaboratory' in the Russian terminology).
Director: General Pyotr I. Klimuk

ЦУП

TsUP

The Russian Mission Control Centre (TsUP), also located in Kaliningrad (Moscow region), is a department of the Central Scientific Research Institute for Machine Building (TsNIIMash) – the principal scientific research centre in Russia for space programmes. Founded in 1946, TsUP has a long-standing experience in mission control of interplanetary probes of the Venera and Mars type and the manned Salyut and Mir space stations. Today TsUP not only controls the missions of the cosmonauts onboard Mir, but is also responsible for the coordination with communication and tracking ground stations, the relay satellites, the launch control centre at Baikonur, and with the search-and-rescue service during return and landing of the cosmonauts.
The Mir control team at TsUP is composed of specialists from NPO Energia, TsNIIMash and other cooperating organisations.
Director: Vladimir I. Lobachev

ВОЕННО-КОСМИЧЕСКИЕ СИЛЫ

Baikonur

The Baikonur cosmodrome, situated east of the Aral Sea near the ancient village of Tyuratam in Kazakhstan (45.6° latitude North), is in fact 300 km away from the town of Baikonur. The staff working at the cosmodrome and their families are living in the nearby city of Leninsk (founded in 1954) which has gradually grown around the Tyuratam railway station. The cosmodrome and the city of Leninsk form together the 'Baikonur Space Complex'. The complex belongs now to the Republic of Kazachstan which has leased it in March 1994 to Russia for a duration of 20 years. Beginning with the historic flight of Gagarin on 12 April 1961, all Soviet and Russian manned spaceflights took off from Baikonur. Upon completion of training at the 'Star City' the crews leave for Baikonur for direct prelaunch training. Final operations on the spacecraft and launch vehicle processing are conducted according to the NPO Energia documentation under the supervision of the Military Space Forces of Russia and NPO Energia. The Baikonur launch base performs and controls all assembly, pre-launch and launch operations until the separation of the Soyuz and Progress vehicles from the last stage of the launcher. Once Soyuz and Progress have reached their orbit, the Launch Control Centre in Baikonur hands the flight control over to the Mission Control Centre (TsUP) near Moscow. On the return flight to Earth, landing takes place about 500 km north-east of the Baikonur cosmodrome.

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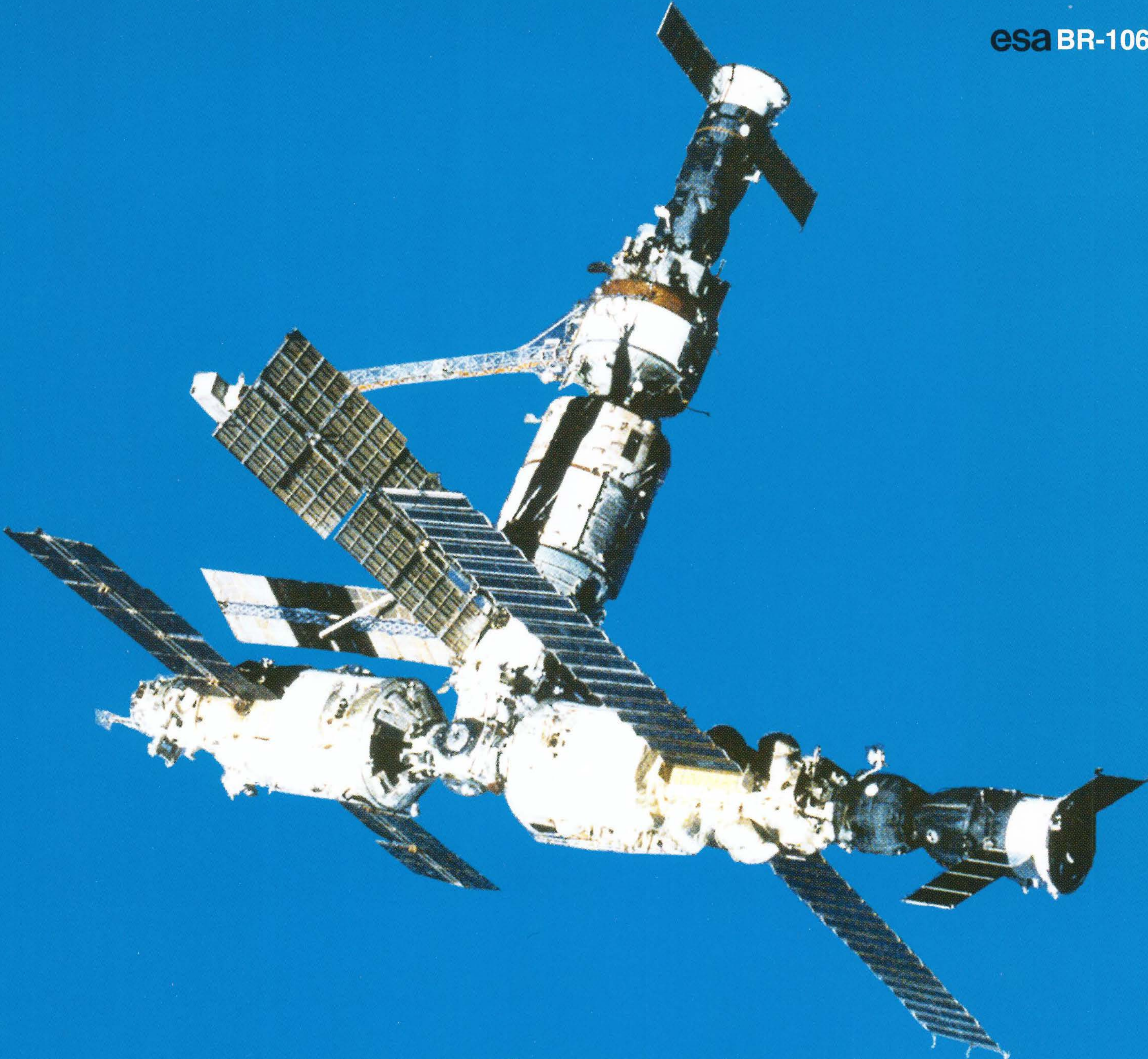

Missions to Space with Russia

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printed in the Netherlands

Peaceful Space
ESA and a New Partnership

The European Space Agency (ESA) is today's realisation of a vision from the 1960s that Europe should have a space organisation to *"provide for and promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications."*

Through its 13 (soon to be 14) Member States ESA has developed international cooperation to a degree not exceeded anywhere in the world. It has learned to combine the political will of governments, the technical competence and skills of European engineers, the outstanding ability of the continent's space science communities, and the ambitions of high-technology industry into a world-class space endeavour.

It is not surprising therefore to find that when the opportunity came for a freer cooperation with Russia, ESA should have been amongst the first to reach out towards a new partnership in space research.

Such a partnership has much to offer to both ESA and the Russian space entities. ESA has proven technological and scientific successes and Russia likewise. The combination of both potentials could add up to a whole 'greater than the parts', and give the concept of 'European cooperation' a fuller meaning.

These ideas were approved in the resolution that the Ministers of ESA Member States endorsed at their meeting in Granada (Spain) in November 1992.

"The (ESA) Council meeting at Ministerial level ... wishing to increase the existing cooperation between the Agency and Russia and extend it ... also in the areas of manned in-orbit infrastructure, crew transport and the associated communication facilities ... endorses the Director General's proposals ... to widen and strengthen such active cooperation with the space institutes of the Russian Federation during the period 1993—1995 ..."

EUROMIR
a pan-European idea in the making

In the Russian language *Mir* means, among other things, 'Peace' and 'Universe' — thus embodying in one word the fundamental idea behind the Granada resolution.

Immediately planners from ESA, the Russian Space Agency (RKA) and the main Russian entities in charge of the exploitation of the Russian Mir station began intensive meetings to discuss potential missions of ESA astronauts to the Russian space station Mir that would save the interests of both communities.

For some years ESA had been considering how best to prepare itself and a user community (all disciplines and all categories) for the advent of the International Space Station, by means of **Precursor Flights,** both manned and unmanned. These flights were foreseen as part of the **Columbus** programme — ESA's contribution to the International Space Station.

The major objectives of the Columbus Precursor Flights are to:

- prepare the European space user community for the Space Station era;
- provide the user community with continuing flight opportunities as a transition to the utilisation of Columbus

ESA Director General Jean-Marie Luton and RKA Director General Yuri Koptyev signing the Joint Declaration on Space Cooperation in Paris on 12 October 1992.

elements and other Space Station facilities;

- provide in--flight validation of design concepts for Columbus payloads (e.g. serviceability, telescience) and to introduce, as far as feasible, the operational concepts foreseen as part of the support to experimentation on board Columbus;
- develop and maintain a core of ESA astronauts, and to provide them with flight opportunities in order to improve European experience in crew-operated space systems.

The decision to carry out two joint European-Russian missions **(EUROMIR),** one in 1994 and one in 1995, is fully in line with these objectives . In particular, following recent evolution in the Space Station programme which will include in its configuration a significant contribution of Russian elements. EUROMIR flights will familiarise ESA crew with Russian systems.

Mir offers ESA an excellent opportunity for long-term experience in microgravity conditions; ESA astronauts will work in a space station environment, and experimenters will be able to try out their research projects in ways not otherwise available to them. EUROMIR 94 will last 30 days, and EUROMIR 95 135 days.

NPO Energia Director General Yuri Semyonov, and ESA EUROMIR Programme Manager Wolfgang Nellessen signing the EUROMIR contract in Kaliningrad (Moscow Region) on 7 July 1993.

The Rus
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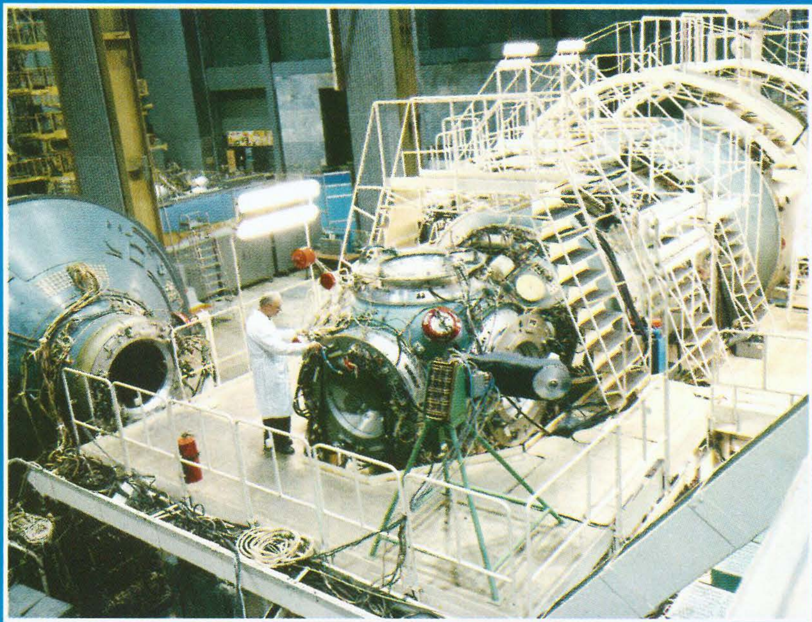
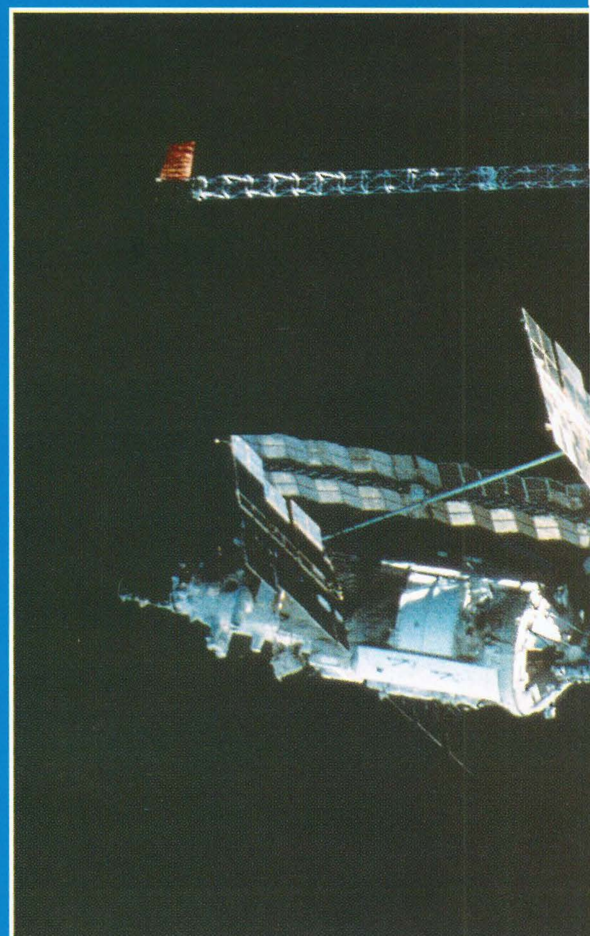
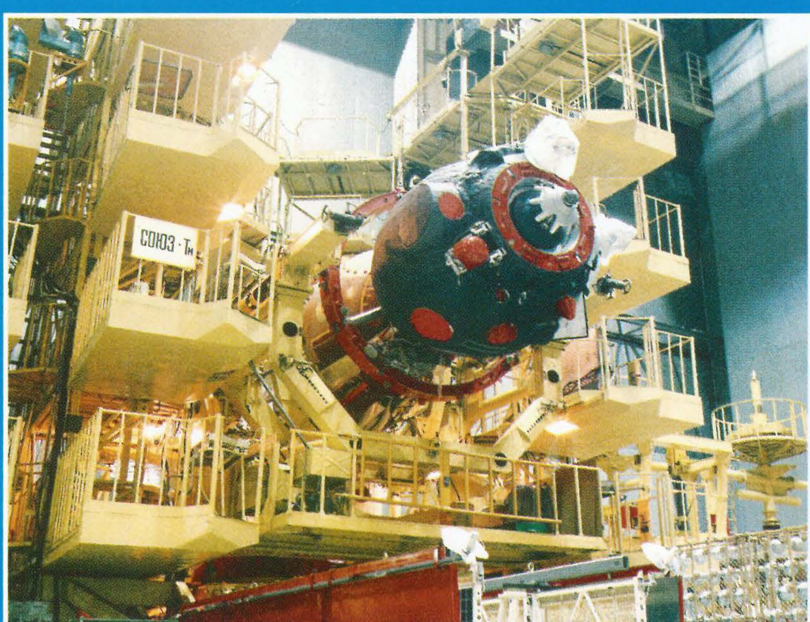




The space station Mir has a modular structure. Three s
(above), Kvant-2 (below left) and Kristall (below right). Tw
remaining docking ports.



Soyuz-TM crew transportation vehicle

an Space
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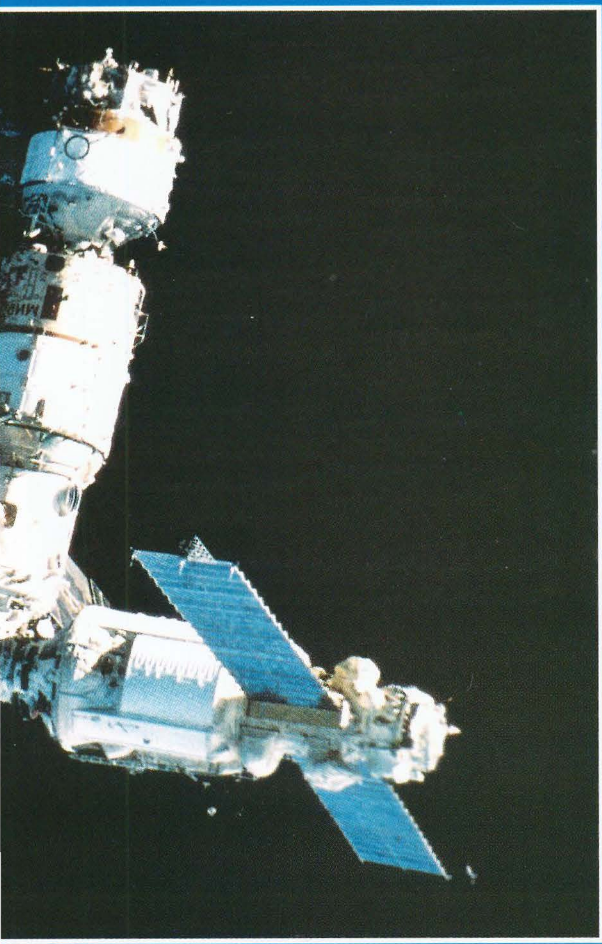


fic modules are already docked to the core module: Kvant
her modules (Priroda, Spektr) are planned to be attached to

The Space Station Mir

The Russian manned space programme followed a very individual line from the early days. After the first man in space (Yuri Gagarin on Vostok-1 in 1961), the first woman in space (Valentina Tereshkova on Vostok-6 in 1963) and the first extravehicular activity in space (Alexei Leonov on Voskhod-2 in 1965), the then-USSR turned its attention towards long-term occupation of space.

The first Earth-orbiting space station Salyut-1 was launched in 1971, followed by several other stations during the next ten years. As from Salyut-6, the station became permanently occupied. Today the Mir orbital complex, a permanently-staffed operational base, represents the third generation of Soviet and Russian space stations. The complex has a modular construction, each module having a structure and purpose of its own.

The habitation module (the core of the station) was placed in orbit early in 1986. Since then the complex has grown as the Kvant astrophysics module, the Kvant-2 re-equipment module, and Kristall materials study module, were added. Future plans include two scientific modules, Spektr and Priroda.

The Mir complex orbits at 350-450 km altitude with an inclination of 51.6°; its mass, fully assembled, is some 130 tonnes and it can accommodate a crew of up to six cosmonauts.

The Soyuz launcher on its way to the launch pad at the Baikonur cosmodrome

Launch of the manned S
launcher

To and from the Station

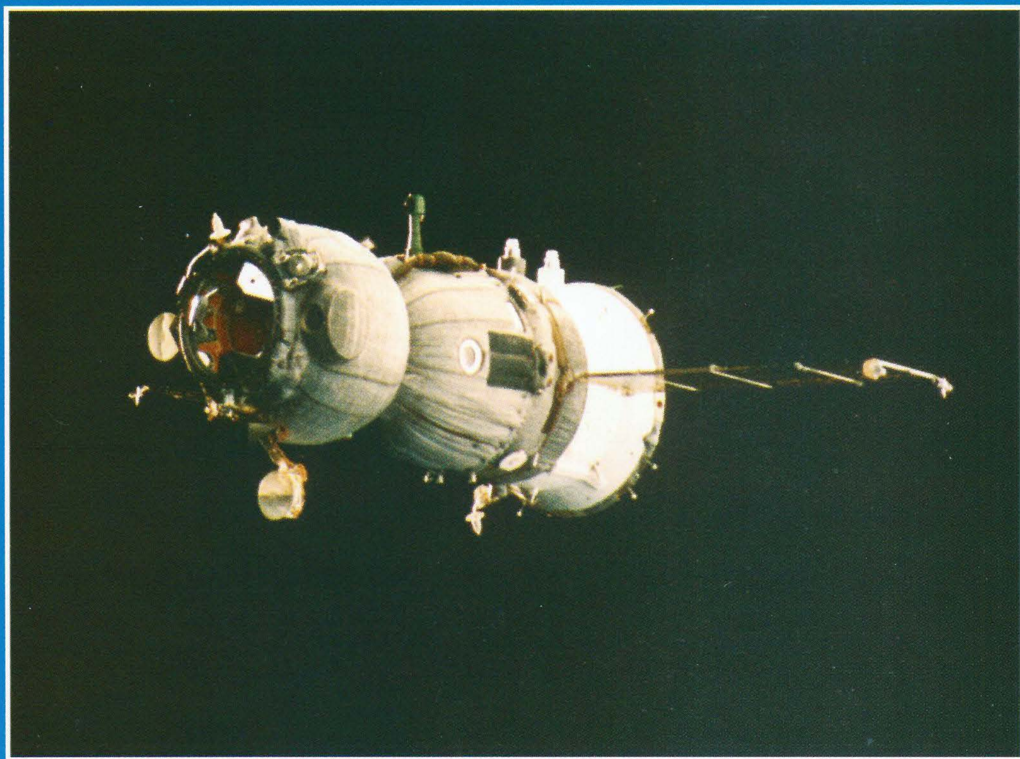
The Soyuz-TM vehicle is a compact, cost-effective and reliable crew transport vehicle used to ferry cosmonauts from Earth to the Mir station and back to Earth. It offers place for three crew members and is capable of carrying, in addition to the crew, up to 200 kg of payload.

The Progress-M cargo spacecraft carries replacement scientific equipment, food for the cosmonauts, propellants for the station and other consumables and commodities needed by the crew. It is normally launched at two-to-three month intervals. It docks automatically to Mir. It is not recovered on Earth, but charged with no longer used consumables and equipment and destructed in the atmosphere.

The rocket which carries both the manned Soyuz-TM crew transport vehicle and the un-manned Progress-M cargo transport vehicle into space is called the Soyuz launcher. Its development goes back to the famous R-7 (Semyorka) rocket of the 1950s. It is 51 m in height, and together with Soyuz-TM weighs 310 tonnes.

The sequence of events after launch is the following: once Soyuz-TM is separated from the launcher, three orbits are spent checking the on-board systems; orbits four and five are used for orbit-raising manoeuvres, and the crew then sleeps for five orbits. The station-approach manoeuvres are performed during orbits 17 and 18, and the final manoeuvres are completed on the 33rd orbit, leading to rendezvous and docking to Mir on the next orbit (i.e. about two days after launch).

TM spacecraft by a Soyuz



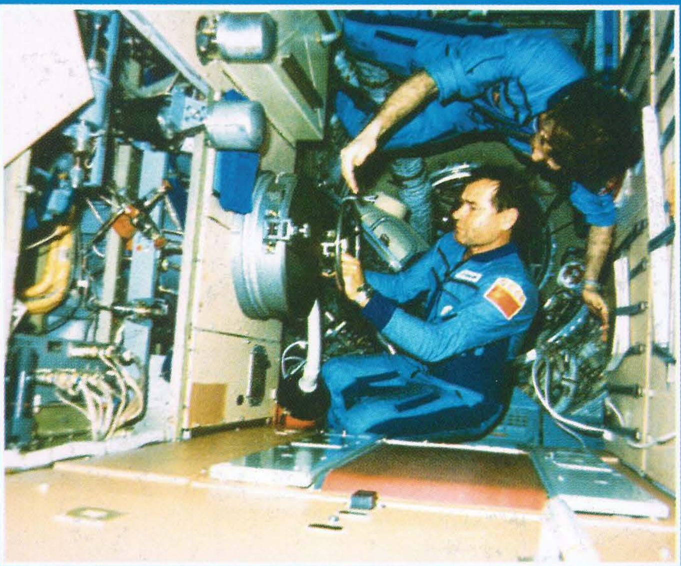
Soyuz-TM spacecraft, consisting of three parts: the orbital module (in front) equipped with the androgynous docking system for docking to the Mir station, the manned return module (centre) and the service module (rear).

Parachute portion of the descent of the manned return module of the Soyuz-TM spacecraft.

Why Science in Space

When the traditional space scientists first had satellites orbiting above the Earth's atmosphere, a new universe, almost literally, opened up for them.

Now, thanks to human presence in space, other sciences, particularly the life sciences and material sciences, are developing new avenues of research.



Life inside space station Mir. Mir has been in space for more than 8 years since February 1986.

Onboard the Mir complex the gravitational pull of the Earth is compensated by the centrifugal forces resulting from the circumterrestrial flight path, and this equilibrium of forces leads to weightlessness. These conditions are described as 'microgravity'. As a result, basic research in the life sciences can focus on the way gravity affects the development and functioning of living organisms, and also on the effects that microgravity exerts on the human cardio-vascular, muscle and bone structures and nerve systems.

Gravity seriously impedes a number of operations associated with the material sciences. Under microgravity conditions, however, scientists can learn more about solidification and crystal growth from the melt, crystal growth in solutions, the behaviour of fluids near their critical point, and the purification and crystallisation of biological micromolecules. Such research holds out hopes for future aplications both for long-term missions in space and improved processes on the ground.

ESA participation in EUROMIR 94

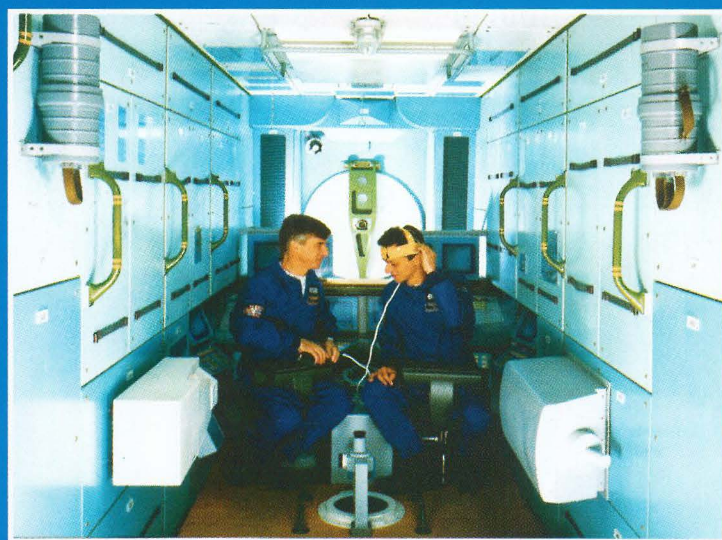
Although the ESA astronaut will perform experiments in materials sciences, life sciences, basic physics and technology, by far the bulk of the experiments will be in human physiology. Some 22 experiments will be performed (eight of them on the ground) aimed at establishing greater knowledge of the effects of a microgravity environment on astronauts. This will improve the fundamental knowledge of the human body which will help in the support of manned space flight through provision of the necessary countermeasures, and may be applied downstream on patients suffering from heart disease or with neurological, muscular, circulatory or bone disorder.

As a result the astronaut will not only play a scientific role, but he will also be a key element in the experiments . Examples of the subjects to be covered include fluid balance during weightlessness, radiation during prolonged space flight, spatial orientation and space sickness, basic vestibulo-oculomotor mechanisms in an altered gravitational environment, and central venous pressure.

The four material science experiments include specific undercooled melts, liquid-liquid phase separation in glasses, metallic glass research, reaction and solidification behaviour of in-situ metal matrix composite materials. It is hoped that the knowledge acquired about these materials and their processing in space may later be applied during their manufacturing on Earth. This should lead to improved techniques and materials.

In addition there will be three technology experiments. All the experiments form clearly a very full manifest for the astronaut both as scientist and as 'sample'.

The datasheets in this folder give a more detailed description of the scientific experiments embarked on EUROMIR 94.



Training of ESA astronauts Ulf Merbold and Pedro Duque in a mock-up compartment of the Mir station.

Astronaut training

It will be clear from the previous pages that astronauts have two prime functions in space: firstly to provide a 'hands-on' ability not possible in automatic spacecraft, and secondly they are themselves 'test subjects' for many experiments. The way in which they operate experiments has a further advantage, for they can interpret new requests from the scientists on the ground, and use their initiative to correct or take advantage of unexpected situations.

The ESA astronauts — preparing for a 'first'

In August 1993, four ESA astronauts began training at the Yuri Gagarin Cosmonaut Training Centre near Moscow, known as 'Star City'.

For each of the two EUROMIR missions, there is one ESA designated astronaut and one back-up, both of whom have been following the same training programme. The mixed teams (2 Russian cosmonauts + 1 ESA astronaut) train as two separate units, and final decisions are made on the team rather than on individual criteria.

Before beginning their Mir training, the European astronauts followed basic training, and intensive Russian language courses at the ESA European Astronauts Centre (EAC) in Cologne, Germany, to prepare themselves both for the training sessions at Star City and the subsequent on-board mission operations, which are all conducted in Russian. A one-month stay at Star City in November 1992 allowed them to familiarise themselves with the facilities and the environment of the training centre.

ESA astronaut Ulf Merbold (Crew 1) training at Star City for a 30-day mission on Mir (EUROMIR 94).

ESA astronaut Ulf Merbold training on a Russian IL-76 aircraft during a parabolic flight in preparation for the EUROMIR 94 mission.

The second element, taking the astronauts through to the flights, has been concentrated on the specific missions that they will fly. This includes crew training in the Soyuz-TM and Mir simulators, Mir systems, and technical and biomedical subjects. The major part of this training sequence has been an in-depth knowledge of the ESA experimental programme during the mission. Using dedicated procedures, the ESA astronauts and, for supporting activities, the Russian cosmonauts were fully trained for nominal and off-nominal experiments flown. This training part, under control of EAC, was largely executed in Europe or in the Star City by the European Principal Investigators.

After the training phase, key activities during the mission in which the ESA astronauts will take part (except for the experimental programme) include:

- launch of an unmanned Progress-M cargo vehicle, accommodating most of the ESA payload to the Mir station, approximately one to two months prior to the launch of the ESA astronaut;
- launch of the European astronaut and two Russian cosmonauts, together with the remainder of the ESA payload, on board a Soyuz-TM;
- rendezvous and docking of the Soyuz-TM with Mir about two days after launch;
- station hand-over activities from the out-going crew to the newly arrived crew, including the ESA astronaut, and start of the experimental programme;
- return to Earth of the outgoing crew (for EUROMIR 94, the ESA astronaut and the ESA experiment results will be returning at the same time) on board the Soyuz-TM; some payload will also come down with the Shuttle in 1995;
- post-flight activities such as measurements of various physiological parameters, compared with pre-flight data.

ESA astronaut Pedro Duque (Crew 2) training at Star City for EUROMIR 94.

Centrifuge for cosmonaut selection and training at the Gagarin Cosmonaut Training Centre (TsPK), Star City

ESA astronauts Pedro Duque, Thomas Reiter, Christer Fuglesang and Ulf Merbold at Star City.

EUROMIR
Mission control and support

All space ventures, and particularly those in which astronauts take part, call for immaculate planning and execution of the operational phase.

TsUP

The Russian Mission Control Centre (TsUP, located in Kaliningrad, near Moscow) is responsible for the overall operations of the Mir station. TsUP therefore is the top operational echelon of the EUROMIR missions. It is through TsUP that SCOPE receives processed data from Mir. A Euromir mission operations support team will be located at TsUP, providing a direct interface and also a support unit for the ESA astronaut.

SCOPE

The 'System for Control of Operations of Payloads for EUROMIR 94' (SCOPE) has a special significance. It is from SCOPE, located within the French national space agency (CNES) establishment in Toulouse, that the EUROMIR mission will be managed. SCOPE will make use of the existing infrastructure created to provide support to the French Mir missions.

The EUROMIR mission management team (prior to taking up duty at SCOPE, it operates as the EUROMIR project team in ESA/ESTEC) will be responsible for activity coordination with TsUP, ESA/EAC and USOCs, mission assurance and safety matters, flight operations and contingency operations affecting the payload experts of the mission, management of the ground network and coordination of scientific support.

The Mission Control Centre (TsUP): Main control room.

USOC

The Principal Investigators (PIs) whose experiments are being flown will spend much of their time during the operational phase in the User Support and Operations Centres (USOC). The USOCs will have continuous contact with SCOPE. In addition to SCOPE, the USOCs are MUCS at DLR in Germany, and ESA/ESTEC in The Netherlands.

Back-up crew members

Although not acting in the prime function for which he was trained, the ESA back-up crew member will act as a crew interface coordinator (CIC) for his colleague who is on board Mir. He will work in the Russian Mission Control Centre (TsUP), and will carry out some ground control experiments as well as acting as a focal point and communications link between the PIs and the astronauts.

ESOC

ESA's European Space Operations Centre (ESOC) in Darmstadt, Germany, has special communications facilities operating between Europe and Russia. These will be at the service of EUROMIR, as will be the infrastructure which was put in place for the IML-2 (International Microgravity Laboratory) mission, which will provide a back-up data archiving channel.

EAC

ESA's European Astronauts Centre (EAC) is located in Cologne, Germany. Although most of EAC's work for EUROMIR takes place before the operational phase, it will provide support for the ESA astronauts during flight.

The Soyuz launch vehicle on its launch pad at Baikonur cosmodrome.

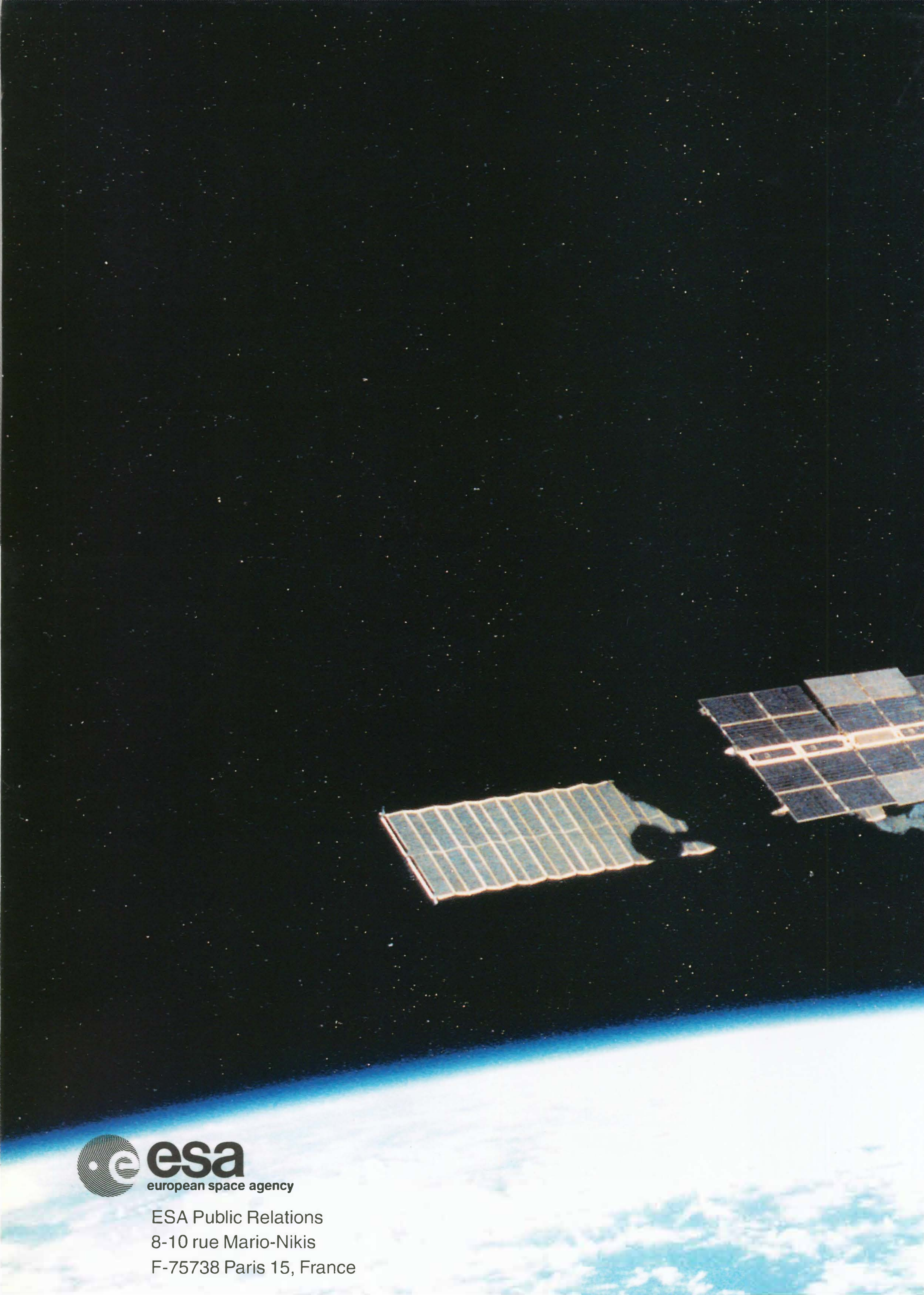
The ***European Space Agency (ESA)*** was formed, in 1974, out of the two earlier space organisations: the *European Space Research Organisation (ESRO)* and the *European Organisation for the Development and Construction of Space Vehicle Launchers (ELDO)*. Today ESA's Member States are: Austria, Belgium, Denmark, France, Germany, Ireland, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom. Finland will enjoy full membership in 1995, while Canada is a Cooperating State.

The ESA Convention stipulates: *"The purpose of the Agency shall be to provide for and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications with a view to their being used for scientific purposes and for operational space applications systems..."*

The Agency is directed by a Council composed of representatives of Member States. Its Management is in the hands of the Director General – who is ESA's chief executive and its legal representative – , the Inspector General, the Director of Science, the Director of Observation of the Earth and its Environment, the Director of Telecommunications, the Director of Launchers, the Director of Manned Spaceflight and Microgravity, the Director of ESTEC, the Director of Operations and the Director of Administration.

The ESA **Head Office** is in Paris. The major establishments are:
- the European Space Research and Technology Centre (**ESTEC**), Noordwijk, The Netherlands;
- the European Space Operations Centre (**ESOC**), Darmstadt, Germany;
- the European Space Research Institute (**ESRIN**), Frascati, near Rome, Italy.
- the European Astronauts Centre (**EAC**), near Cologne, Germany.

Staff: about 2000
Chairman of the Council: Pieter Gaele Winters
Director General: Jean-Marie Luton



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