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SPACE ORBITS OF COLLABORATION

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16. Abstract The article notes, with considerable satisfaction, the U.S.S.R. cooperative space program with other Socialist countries dating back to 1957. The "Interkosmos" program, which is divided into three series of satellites (solar, ionospheric and magnetospheric), is discussed. Details concerning the "Prognoz", "Kosmos", "Soyuz", and "Mólniya" spacecraft are presented. The article ends with the observation that the U.S.S.R. also has undertaken collaborative efforts in space with capitalist countries, including the U.S.A.

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SPACE ORBITS OF COLLABORATION

B. Petrov** /10*

In the Jubilee year of the 60th Anniversary of the Great October Revolution, our nation can note with satisfaction that its creative endeavor has ensured for it the role of the first entry into outer space, and moreover, it has created the prerequisites for the emergence of a essential new sphere of international division of labor. These achievements are the realization of the aspirations of the best sons of our Motherland, first among whom is the founder of astronautics, K. E. Tsiolkovskiy, who has written; "All my life I have dreamed that with my labors mankind would progress, if only slightly. Before the revolution, my dream could not be realized. Only the October Revolution has brought recognition . . ."

To solve most of the research problems of outer space, a complex of approaches is required, involving the combined efforts of scientists from various countries. Moreover, the industrial and scientific-technical possibilities in many countries do not permit them to undertake this kind of research by their own efforts. The great cost of rocket-propelled space devices and scientific equipment intended for work in outer space, the economic advisability of using the technical and industrial base already in existence, together with the experience accumulated, lead naturally to the necessity for cooperation in the sphere of space activities.

The collaboration of the Socialist countries in the realm of space research and utilization goes back to the year 1957. Immediately following the launch of the first artificial satellite of the earth, Soviet and foreign specialists began to undertake joint optical (visual and

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*Numbers in margin indicate pagination in foreign text.

**President, of the "Interkosmos" Council of the U.S.S.R. Academy of Sciences.

photometric) observations. Naturally, there arose the need for bilateral, and then multilateral agreements, permitting subsequently the devising and achievement of programs for coordinated action based on the development of a network of ground stations equipped with automatic photographic cameras and laser range-finding installations. The totality of these operations became an organic part of the common program "Interkosmos".

In 1965, in Moscow there took place a conference of representatives of Bulgaria, Hungary, the German Democratic Republic, Cuba, the Mongolian People's Republic, Poland, Rumania, the Soviet Union and Czechoslovakia concerning collaboration in the study and exploitation of outer space for peaceful purposes. Concrete subjects for study were determined in the realm of the physics and meteorology of outer space, the physics and technology of remote radio communication and television, space medicine and biology; also the possibilities were evaluated for joint construction and launching of satellites, the development of devices and equipment for these objectives by specialists of the interested countries. In April, 1967, there was formulated and accepted a multinational program of collaboration in outer space among the Socialist countries. It is also agreed that this date be considered as the point of departure for the realization of the "Interkosmos" program, although it received its official designation somewhat later - in 1970.

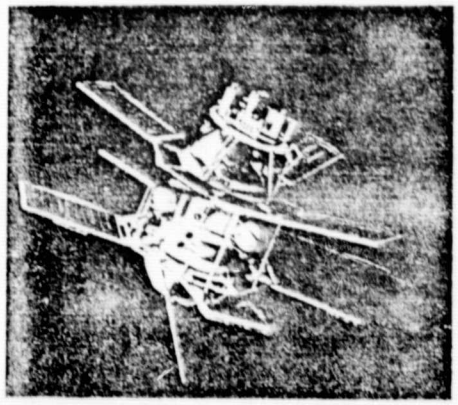

Figure: A satellite of the "Interkosmos" System.

The countries participating in the "Interkosmos" program do not have a common financial fund. The Soviet Union furnishes to its collaborating partners free of charge the equipment of rocket-propelled technology for outer space. In accordance with its financial capabilities, each country finances the development and construction of equipment and the conduct of experiments in which it is interested, makes

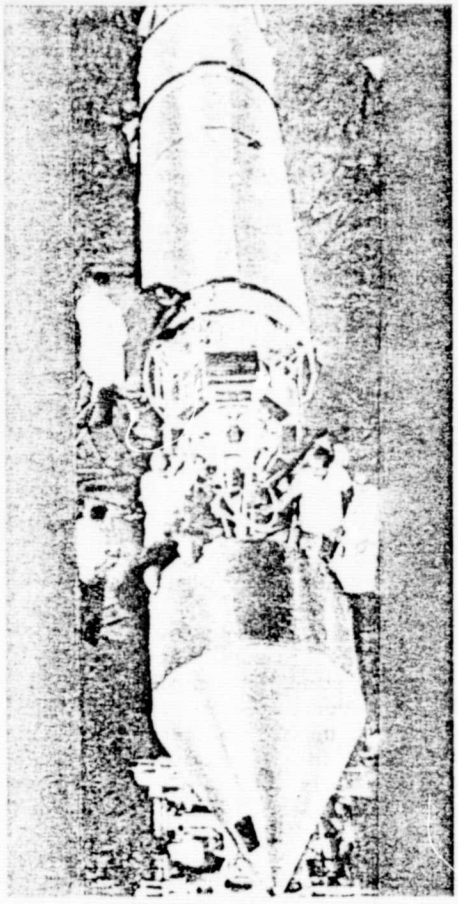

Figure: Assembling the rocket "Vertikal'"

available the appropriate scientific-technical cadres, etc. Herein lies one of the basic distinctions between the collaboration through the program "Interkosmos" and the collaboration, for example, of the ten countries of Western Europe which participate in the European agency for outer space.

For the Soviet Union "Interkosmos" is first of all a program involving every kind of assistance to the fraternal countries in a field which is new to them, and is concerned in actively acquainting them with the investigation of our planet as an outer space object in the solar system and the universe.

The realization of the "Interkosmos" program was a good example of the effective Socialist integration of scientific research. What, say, are the purely external indications of its realization? For the period from the end of 1969 through 1976, 16 satellites of the "Interkosmos" series have been launched, as well as four high-altitude, geophysical research "Vertikal" rockets, and ten meteorological rockets. In addition, instruments constructed by scientists and specialists from

the Socialist countries were installed on a number of space vehicles launched in the U.S.S.R. under a national program.

In terms of their special designations, the "Interkosmos" satellites are divided into three series: solar, ionospheric and magnetospheric. On satellites of the last series instruments were also intalled for the study of the radiation belts, high-energy cosmic particles, electrodynamic processes in interplanetary space, etc.

For centuries, scientists have observed the sun in the optical range with the aid of earth-based telescopes. But solar activity has a most immediate effect on the processes occurring in space near the earth, and also in the biosphere. However, short-wave X-rays and ultraviolet radiation, and also the radiation in the radio range, are practically completely absorbed by the earth's atmosphere.

With the help of the solar series "Interkosmos" satellites and the /11
rockets "Vertikal-1" and "Vertikal-2", the X-rays from the solar corona were investigated under the conditions of both the "quiet" sun and during the period of its increased activity, as was the appearance of a large number of sunspots and flares on its disk. The question concerning the role of directional currents of accelerated electrons in the mechanism of solar "disturbances" is of special interest to scientists. Czechoslovakian scientists and engineers have constructed a special photometer which makes it possible to carry out a patrol service for the detection of solar X-rays.

The discovery that the X-rays from flares are polarized has led to the conclusion that in the initial stage of flares (during the first few minutes), powerful currents of accelerated electrons emerge which are directed radially - from the highest layers of the corona to the lowest layers. This is a fundamental fact of solar science.

Important knowledge about the close connection between various forms of solar radiation - X-rays (hard and soft), the visible spectrum and radio waves - has been obtained. These data are extraordinarily important for the prediction of "disturbances" in solar activity which are fraught with danger to astronauts and undesirable consequences on earth. In the Soviet Union in the years 1972-1976, the automatic stations "Prognoz" were specially launched for protracted observations of the behavior of the "solar wind", (i.e., the plasma current from the sun). They made it possible also to track the zones of the radiation belts, the boundaries of the magnetosphere, the transitional region and the shock wave

front of the "solar wind".

The earth's ionosphere (the second direction of research) exerts a significant influence on the state of the lower-lying atmospheric layers, the biosphere, the physical processes and phenomena which have an effect on the practical activities of people also. The ionosphere consists of charged particles - free electrons and ions with low energies. Its lower boundary lies at an altitude of approximately 50 km, the upper one - at a distance on the order of 20-30,000 km. Knowledge of the laws governing its variations, the ability to predict these changes - these are important scientific problems. Today, as the result of sounding measurements of ionospheric parameters with the help of scientific instruments installed on satellites, and also the investigations by the network of ionosphere stations in Bulgaria, Hungary, Cuba, the German Democratic Republic, Poland, Rumania, the Soviet Union, and Czechoslovakia, a broad idea of the processes occurring here has been obtained, thus establishing the premises for constructing a dynamic model of the ionosphere.

And finally, there is the study of the magnetosphere, the radiation belts, and cosmic rays. The existence of terrestrial magnetism has been known for a long time. At the beginning of the 17th century, it had already become clear to scientists that our planet is its own form of magnet. However, until artificial satellites and space vehicles were launched, all deliberations in this regard had led to the model of a simple dipole which is well-known from high school physics courses. Space research has disclosed a completely unexpected map of space near the earth, and has shed light on the character of previously-unknown processes occurring there.

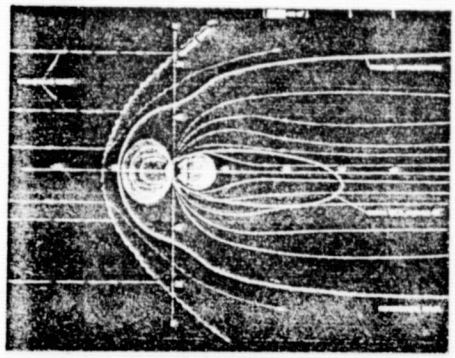

Figure: Diagram of the Earth's Magnetic Field and the Movement of the "Solar Wind".

The launch of even the first space vehicles (in the years 1957 to 1958) made possible the discovery of the earth's radiation belts,

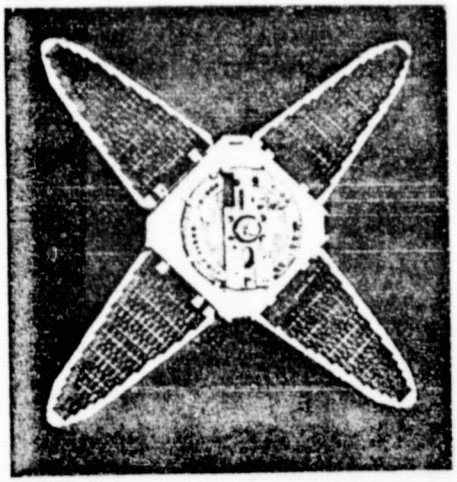

Figure: Artificial Earth Satellite "Prognoz".

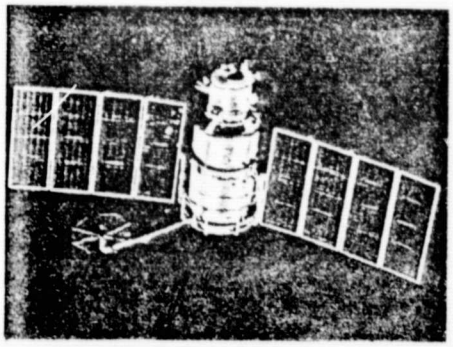

Figure: "Kosmos-122" ("Meteor")

which constitute a zone where charged particles - protons and electrons with a broad range of energies - are steadily captured by the geomagnetic field. The form of these zones is reminiscent of vast rings encircling the planet, and having a thickness equal to several terrestrial radii.

Another important scientific event was the discovery of the "solar wind", already mentioned by us. Its supersonic current, interacting with the geomagnetic field, deforms this field, with the result that a space is formed in which the movement of charged particles is reliably controlled. This region of outer space has also been designated the magnetosphere. The processes which take place in it are complex. One thing is indisputable; they influence many geophysical phenomena, and they in their turn are affected dynamically by the solar activity.

The magnetospheric satellites of the "Interkosmos" series have

made it possible to obtain new data about the radiation conditions at altitudes from 200 to 1300 km, about the dynamic processes in the magnetosphere and the polar ionosphere of the earth. Interesting data were provided by an experiment to determine the relationship between currents of charged particles and the occurrence of very low-frequency radio signals. In 1971, important information was obtained concerning the character of an "eruption" of particles from the radiation belts in the ionosphere. The electromagnetic relationship between the earth's magnitosphere and ionosphere was also studied.

After two decades of intensive study of the space near the earth, science is able to explain in broad outline the morphology of the region. Today, this problem is included in the acquisition of knowledge of cause-and-effect relationships, in obtaining deeper and more detailed information about phenomena in the magnitosphere which should lead to construction of an appropriate physical theory.

Among the important problems under study by scientists from the Socialist countries, a prominent place is occupied by the study of charged particles with enormous energy which move in outer space with a velocity close to that of light. Specialists from Hungary, Mongolia, Poland, Rumania, the Soviet Union, and Czechoslovakia who had already worked on accelerators in the Joint Institute for Nuclear Research in Dubna and in high-altitude cosmic ray stations, expressed the desire to participate in this project. Outer space has now become a distinctive laboratory for their common efforts.

One important experiment was conducted as follows. With the aid of the guidance system of the satellite "Interkosmos-6", an input window for a recording instrument was oriented toward open outer space in order to receive a current of primary cosmic particles, accelerated to enormous velocities. After exposure to outer space in the course of a 24 hour flight, a large photoemulsion unit was returned to earth and subjected to detailed study. It turned out that primary cosmic particles with energies of several billion electron-volts had been recorded. As is well-known, particles with such energies can still not be obtained in not even the most powerful accelerators. After being fixed, the photoemulsion was then distributed among the participants in the experiment and treated by a method developed by Soviet and Polish scientists. The results of this experiment have demonstrated the existence of a unique opportunity to study nuclear reactions in a broad spectrum of

energies through prolonged exposure of large-scale photoemulsions in outer space.

Devices for use in outer space make it possible to understand atmospheric processes better and promote improved precision in weather forecasting. /12 It should be noted that the contemporary meteorological satellite is essentially a flying observatory in terms of its complement of scientific instruments, the variety of its measurements and the volume of its recorded data. In one circuit of its orbit, it can "see" nearly 10% of the earth's surface, and in 24 hours it can obtain information about the weather over the entire planet. In the entire world the number of meteorological stations exceeds 10,000. In the course of a single rotation around the planet, a satellite collects a volume of data which is 100 times greater than the information received by all of these stations, and what is very important, it provides information about weather conditions on that 70% of the global surface which remains as "white spaces" for the weather forecaster (oceans, seas, deserts, polar regions, etc.). Efficiency in the use of meteorological satellites is on the increase.

After obtaining information, received for the most part from the Soviet meteorological satellite "Meteor", and applying the method agreed upon, scientists of the collaborating countries use the necessary data for their own research, which is offered for their immediate practical benefit.

Specialists from the Socialist countries have successfully collaborated in the realm of space biology and medicine. The basic direction of this collaboration are in space physiology, radiation safety in space flights, pharmacochemical protection, and the treatment of radiation injuries incurred during space flights. In the years 1974-1975, two specialized biosatellites, "Kosmos-690" and "Kosmos-782" were launched on which complex biological experiments were conducted.

In September, 1976, under the "Interkosmos" program, a flight of the space vehicle "Soyuz-22" was completed with a crew consisting of astronauts V. Bykovskiy and V. Aksenov. On board the space vehicle, there was installed the multizonal photographic apparatus MKF-6, developed by specialists from the U.S.S.R. and the German Democratic Republic, and manufactured at the national plant, "Karl Zeiss, Jena." The relatively high orbit and the large supply of film, ensured photographs of a significant area of the terrestrial surface. The basic

advantage of the multizonal photographs obtained was their high resolution and the potentiality for machine treatment and interpretation. Without loss of information, it was possible to reduce to a minimum the dimensions of the frame and also the weight and overall characteristics of the photographic apparatus.

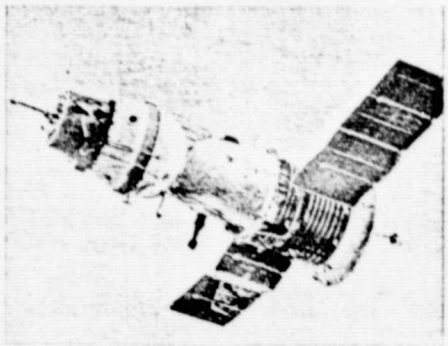

Figure: Space Vehicle "Soyuz-22".

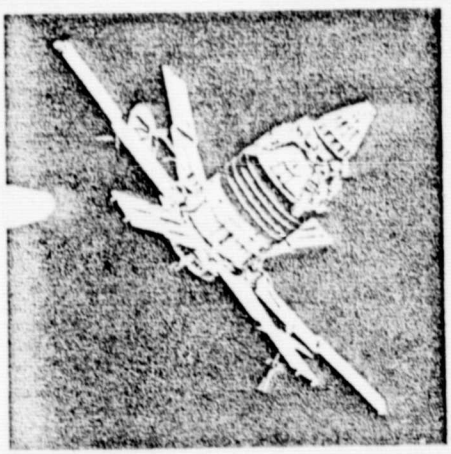

Figure: Artificial Communication Satellite "Molniya-1".

Tests of the new equipment during an 8-day flight under the conditions of outer space have demonstrated its high degree of operating qualities. The astronauts obtained and delivered to earth more than 2000 high-quality photographs of the territory of the U.S.S.R. and the German Democractic Republic in six spectral zones. Each photograph covered a portion of the earth's surface 165 x 115 km in size with a resolution of nearly 20 meters.

The experiment "Raduga" ("Rainbow") was of complex character; simultaneously with space photographs, ground observations were carried out on polygonal areas in Azerbaydzhan, near Krasnoyarsk, in the Far

East, and in the Fergan valley. In individual regions of our country, photographs from on board the "Soyuz-22" were accompanied by synchronous shots from aircraft.

The study of the natural resources of the earth from outer space is a comparatively young, but very promising, applied trend. The collaborative efforts of scientists and specialists of the Socialist countries in this connection are very encouraging, promising large economic results to all countries entering into the SEV [Sovet ekonomicheskoy vzaimopomoshchi = Council for Mutual Economic Aid].

The success of astronauts in the use of radio communication during investigations of outer space and the rapid development of electronics have made possible the creation of a new, high-quality global form of radio communication by means of artificial earth satellites. In 1965, the first communication satellites, "Molniya", were launched in our country, and in October, 1967, on the eve of the 50th anniversary of the October Revolution, the first receiving station of the "Orbit" network was placed in service. At the present time, this network numbers 74 receiving stations, thanks to which, millions of inhabitants of the Far North, Siberia, and the Far East and Central Asia are able to view regularly television transmissions from Moscow and other cities of the Soviet Union, and also from other countries. The operating group of specialists, which includes representatives of the ten Socialist countries, has agreed upon a promising program of scientific research and technical development involving the means of space communication.

Today, the international system of space communication, "Intersatellite", is meeting the needs of the collaborating countries in the area of telephonic and telegraphic communication, and the exchange of radio and television programs.

In accordance with the program of further development of communication systems using artificial earth satellites, the communication satellite "Molniya-3" was successfully launched into a high elliptical orbit in the Soviet Union in April, 1977. This satellite has on-board relay equipment which ensures the operation of a communication system in the centimeter wavelength range; it is designed to provide for the operation of a system of long-distance telephone and telegraphic radio communication in the Soviet Union, and the transmission of programs of the U.S.S.R. Central Television to points of the "Orbit" network and

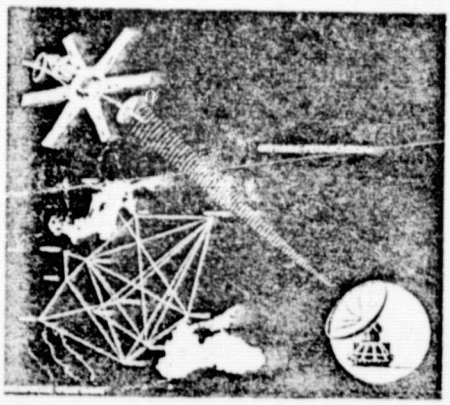

Figure: Diagram of Space Communication by means of the System "Orbit"

the International Cooperative,

1976 was the initial year of the new stage of high-quality satellite and rocket research under the "Interkosmos" program. At that time, the launch of the first automatic universal orbital station (AUOS) was accomplished. In technical facilities of this type, it is possible to accomodate from 3 to 4 times more scientific equipment in comparison with previous satellites, and there is a threefold increase in the active lifetime of the satellite. On board the first AUOS ("Interkosmos-15") experiments of the Unified Telemetric System (ETMS) - intended for direct reception of information from satellites of the "Interkosmos" series on territories of the countries participating in the program - were successfully conducted.

In Moscow in July and September of the same year, during negotiations among participants in the "Interkosmos" programs, a proposal of the Soviet Union concerning participiation by citizens of Bulgaria, Hungary, the German Democratic Republic, Cuba, the Mongolian People's Republic, Poland, Rumania, and Czechoslovakia in manned flights of Soviet space vehicles and stations was received with gratification. The negotiations were completed with the acceptance of the Soviet resolution. The first group of astronaut candidates - citizens of Czechoslovakia, Poland, and the German Democratic Republic - had already begun training at the Yu. A. Gagarin Center for the Preparation of Astronauts.

As is well-known, the U.S.S.R., besides its many-sided collaboration with the Socialist countries within the framework of the "Interkosmos" program, has also undertaken collaborative efforts in the area of research and utilization of outer space with capitalist countries,

among which are France, India, Sweden, and the U.S.A.

The growth of the role of science and technology in society, is closely connected with the conversion of scientific-technological collaboration into a factor for the development of international relations, the relaxation of tension in the world, and the strengthening of the friendly ties between peoples.