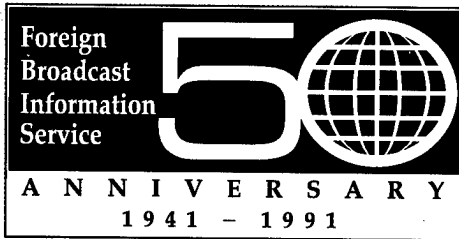


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7 FEBRUARY 1991



# *JPRS Report*

# Science & Technology

*USSR: Space*

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# Science & Technology

## USSR: Space

JPRS-USP-91-001

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**Cosmonauts Prepare for 2 Dec Soviet-Japanese Space Launch**

*LD1211185890 Moscow Domestic Service in Russian  
1513 GMT 12 Nov 90*

[Report by correspondent Vladimir Belyayev from the Zvezdny Gorodok studio on preparations for the 2 December joint Soviet-Japanese space launch—live]

[Excerpts] [passage omitted] The crew has finally been named, so on 2 December, at 1130 [0830 GMT], the crew will be launched from Baykonur cosmodrome and will include Flight Commander Viktor Mikhaylovich Afanasyev; Flight Engineer Musaki Romanovich Manarov [Musa Manarov], who is hero of the Soviet Union and holds the record for the longest stay in space, one year; and the Japanese cosmonaut, our journalist colleague, Toyohiro Akiyama.

The crew has been formed, and I gave you the launch date.

The Japanese crew member will return on 10 December, but Viktor Afanasyev and Musa Manarov will return to Earth on 10 May. [passage omitted]

The management of the Japanese TBS [Tokyo Broadcasting System] company, which is organizing the flight, thinks the flight will be a big contribution to the coming visit of President Mikhail Gorbachev to the Land of the Rising Sun. It was announced here that the company would do a great deal even during the flight to make the meeting as friendly as possible and to benefit our two countries as much as possible. [passage omitted]

[Valeriy Vladimirovich Polyakov, the cosmonaut who will monitor the flight] [passage omitted] It will be a very interesting flight.

The flight will start with a representative of Japan, and then the men will stay on for 169 days.

The work will be not only interesting but also difficult because there will be three to five spacewalks: the number will be determined during the work itself. Overhaul work will have to be done on the hatch, which the previous crew did not manage to do.

The main thing is that this flight is really regarded as a profit-making flight in the interests of our economy. There will be both technological experiments and biotechnical ones, including very interesting ones on ecological monitoring of Earth, and much more. [passage omitted]

The interdepartmental commission declared today the technical readiness of the crew, and our representatives also said that the cosmonauts are healthy and that they are ready for flight. [passage omitted]

**Cosmonauts Manakov, Strekalov Complete Three and a Half Months on 'Mir'**

*LD161111590 Moscow TASS in English 1000 GMT  
16 Nov 90*

[Text] Moscow November 16 TASS—Soviet Cosmonauts Gennadiy Manakov and Gennadiy Strekalov have been working in orbit for three and a half months.

This week's research program for the Mir station crew included astrophysical and technical experiments and medico-biological examinations.

A series of experiments to define the potential strength and spectrum of space radiation were carried out with the help of the Buket telescope and the Mariya spectrometer.

Another round of research was completed to evaluate the influence of open space factors on construction materials. Samples of each are fastened to the Kvant-2 module surface.

In accordance with the schedule for medical examinations, both cosmonauts were subjected to cardiovascular tests, including under physical load.

Protracted melting operations were completed, using the Gallar and Krater-B installations to obtain high-quality gallium arsenide monocrystals.

The Gallar installation will again be used to grow a sample of semi-conducting zinc oxide. The 140-hour procedure will begin later today.

Work proceeds according to schedule, both cosmonauts are feeling fine and healthy.

**Cosmonauts Continue Materials, Biological Research**

*LD2011162590 Moscow TASS in English 1229 GMT  
20 Nov 90*

[Text] Moscow November 20 TASS—This week's flight schedule on board the Mir space station includes space material studies, medical and biological research and servicing of scientific equipment.

Soviet cosmonauts Gennadiy Manakov and Gennadiy Strekalov began smelting in the Zona-03 installation to obtain semiconductor germanium.

They continue experiments to work out the technology to grow vegetables in space flights, using the Svet greenhouse designed by Soviet and Bulgarian specialists. The crew are controlling microclimatic parameters in the greenhouse, take photographs and study plants' development.

Under the schedule of works with the Progress M-5 cargo spaceship, on Tuesday, cosmonauts are expected to fill up station fuel tanks with fuel and oxidisers.

Cosmonauts are expected to undergo medical examination to determine the reaction of cardiovascular systems to a limited physical load. The research will be carried out with the help of the multifunctional GAMMA recording equipment.

### **Soviet-Japanese Space Crews Prepare for Flight**

*LD1911104790 Moscow TASS in English 1019 GMT  
19 Nov 90*

[By TASS correspondent Rena Kuznetsova]

[Text] Moscow November 19 TASS—Two international Soviet-Japanese crews leave for the Baykonur space center today, from where one of them will fly to the Mir soviet space station on December 2.

The main crew consists of Colonel Viktor Afanasyev, Musa Manarov and Toyehiro Akiyama, a reporter working for the TBS [Tokyo Broadcasting System] Japanese TV and radio broadcasting company.

The stand-by crew includes Anatoliy Artsebarskiy, Sergey Krikalev and Ms. Ryoko Kikuchi, who also works for TBS.

A state commission will choose which of the two crews will go on the mission shortly before the launching.

Soviet cosmonauts, accompanying one of the Japanese telejournalists, will replace Gennadiy Strekalov and Gennadiy Manakov aboard Mir and will stay there until May 1991.

The crew are expected to make four space walks, including repair of a faulty hatch.

A Japanese journalist will spend eight days in space and will then return to earth with Manakov and Strekalov, who have been staying in space since August 1.

The Japanese cosmonaut will hold 10-minute TV broadcasts and 20-minute radio sessions from space daily.

This will require much efforts, experts say, and the journalist will be helped by the flight engineer of the international crew.

Cosmonauts will also sound [as received] the Earth's surface and conduct medical and biological tests.

### **Pre-Launch Activities at Baykonur**

*PM2711142090 Moscow Television Service  
in Russian 1800 GMT 25 Nov 90*

[Report by A. Gerasimov and G. Vishneva; from the "Vremya" newscast]

[Text] [Announcer] At the Baykonur Cosmodrome, pre-flight preparations continue for the Soviet-Japanese crew.

[Reporter] Baykonur is currently buzzing with unusual activity. More than 100 Japanese from the TBS [Tokyo

Broadcasting System] television company, together with their Soviet colleagues, are completing prelaunch preparations at the cosmodrome. All this is being done to aid the television screening of the space flight by the first representative of Japan, journalist Toyehiro Akiyama. On 2 December, together with crew commander Viktor Afanasyev and flight engineer Musa Manarov, he is to set off for the Mir orbital complex, on which Gennadiy Manakov and Gennadiy Strekalov are now working. The five men will be on the space station for only a few days, but specialists say that with this crew, output from the orbital complex will increase considerably. Given the existing volume of scientific and technological apparatus on board the station, the permanent crew of two is physically incapable of processing the entire flow of information and ensuring maximum productivity of the complex.

In the next few years it is planned to increase the manning of space expeditions to three or four people. Products created in space—this means new biological preparations for medicine, semiconductor materials, and hundreds of geophysical survey cine-films and video films—require regular deliveries to earth. In a few months' time this problem will apparently be resolved. With the help of this cargo ship in the Progress series, now being produced, capsules containing the results of space production work will be delivered to earth. A kind of conveyor belt is being set up.

In the last few days both crews have undergone medical and physiological examinations. Doctors found all the cosmonauts fully prepared for the flight. An unusual feature of the new crew, from the medical point of view, is that for the first time a nonprofessional cosmonaut is to fly. But nonetheless Toyehiro Akiyama is optimistic.

[Akiyama] I think, well, everything is ready.

[Reporter] There have been no problems?

[Akiyama] No, no problems.

[Reporter] The progress of flight preparations gives us reason to hope that there will be no problems in orbit either.

### **'Progress M-5' Capsule Returned to Earth 28 Nov**

*LD2811125290 Moscow TASS in English 1245 GMT  
28 Nov 90*

[By TASS correspondent at Mission Control Center]

[Text] Moscow November 28 TASS—The experimental return capsule, which was part of the Progress M-5 unmanned spacecraft, parachuted safely to earth today, bringing back a container with the results of studies by two Soviet cosmonauts on board the orbiting platform Mir.

When the cargo spacecraft jettisoned from the platform at 9:15 and slowed down by its own propulsion engine,



started the descent, the ballistic capsule was detached from it at a pre-set altitude.

Progress M-5 burnt up after plunging into the dense layers of the atmosphere, while the capsule continued the descent with the help of a parachute system. It made a soft touchdown at 14:04 in the area where Soviet manned spaceships usually land.

Meanwhile, the two cosmonauts, Gennadiy Manakov and Gennadiy Strekalov, continue their work in space, including geophysical and technical experiments.

Today they are to produce a television report on their biological studies and continue preparing to receive the Soviet-Japanese mission.

The flight of the Mir platform is continuing normally.

#### **'Soyuz TM-11' on Launch Pad, Value of Space Program Emphasized**

*PM0312133190 Moscow Television Service  
in Russian 1530 GMT 30 Nov 90*

[Report by A. Gerasimov at Baykonur Cosmodrome; from the "Vremya" newscast]

[Excerpt] [Announcer] The Soyuz TM-11 spaceship, which will carry the joint Soviet-Japanese crew into orbit, was placed on the launch pad at the Baykonur Cosmodrome today.

[Gerasimov] The day before, cosmodrome specialists had assembled the launcher and the TM-11 orbital craft into a single unit.

Meanwhile the search and rescue service personnel were rehearsing crew rescue operations. God forbid that anything should go wrong, but anything can happen during a launch. Equipment is only equipment. In the event of an "unscheduled" situation arising—this is the term they use here—an abort system is designed to uncouple the orbital craft from the rocket and jettison it at a safe distance. The rest is up to the rescue team.

The launcher was wheeled onto the launch pad today in the early morning, as is the custom, at 0500 Moscow time. This operation, no matter how many times you have watched it, is spell-binding. If I had my way, I would organize excursions against payment for those wishing to enjoy this fantastic spectacle. There would be no shortage of them, and the revenue would be substantial.

Our reports on manned launches furnish, apart from anything else, an additional opportunity to talk about the problems of developing our space program. The crisis in which the Soviet Union finds itself has caused many people to say: There is nothing to eat, and you are pushing your rockets. Even at the highest level, calls are heard more and more frequently to cut appropriations for the space sector. It is true, of course, that returns from space must become much more effective than they

are now, and our science must address these issues. But imagine that all the existing space systems were switched off, just for an hour. Suffice it to say that, if that happened, the screens would go blank for most of you sitting in front of your television sets, not to mention nonfunctioning telephones, no weather forecast for tomorrow, and a multitude of other highly unpleasant surprises.

#### **Revenue From Japanese Cosmonaut Mission Lauded**

*PM2711155390 Moscow Television Service  
in Russian 1530 GMT 22 Nov 90*

[Report by A. Gerasimov, G. Vishneva, from the "Vremya" newscast]

[Text] [Announcer] At the Baykonur Cosmodrome preparations have started for the launch of a Soviet-Japanese space crew.

[Gerasimov] Soviet spaceflights, which always enjoyed priority funding in the past but have lately incurred the disfavor of public opinion, are taking the first step toward commercial viability in the conditions of transition to the market.

The joint part of the upcoming spaceflight is being funded entirely by the private Japanese TBS [Tokyo Broadcasting System] television network.

Journalist Toyohiro Akiyama will spend eight days in orbit with Viktor Afanasyev and Musa Manarov and the cosmonauts currently aboard the "Mir" station, Gennadiy Manakov and Gennadiy Strekalov. His brief duty tour in space will provide our country with the sizeable revenue of several million dollars. The final figure of the TBS company's expenditure is yet to be finalized, but it appears that it will considerably exceed the original figure mentioned in the contract. Specialists attribute this to our lack of experience in space business know-how.

Our space science has also encountered unexpected difficulties in the sphere of applications of space technologies. Unique biological preparations are currently being produced aboard the "Mir" station which can help Chernobyl victims. Cancer treatment drugs are being developed. The successes of space material science have also won general recognition, but the following situation prevails:

[A.A. Leonov, director of cosmonaut training, identified by caption] Very interesting samples of semiconductors, of various kinds of crystals, have been returned to earth by the seventh expedition. They are available, but there are no consumers. Everyone is aware that this is a great achievement, but consumers are afraid to take it up.

[Gerasimov] All these and many other problems connected with our general disorganization in the economy demand urgent solution. The Japanese, who are very

experienced in currency investment, have nonetheless decided to make use of the services of Soviet space science.

Japanese cosmonaut Toyohiro Akiyama underwent a preflight super-crash course in a matter of months. The methodology of space training developed by our specialists nonetheless provides grounds for optimistic forecasts.

[Leonov] We are hoping that the standard which he has attained during training to date will enable him to make the television reportages from orbit which are expected of him, well thought-out reportages, very well thought-out reportages indeed, once again with the help of our crew.

### Japanese Backup Cosmonaut Sick, Akiyama Ready for Flight

*PM2911113390 Moscow Television Service in Russian 1530 GMT 27 Nov 90*

[Report by A. Gerasimov; from the "Vremya" newscast]

[Text] [Announcer] At the Baykonur Cosmodrome, preflight preparations continue for the Soviet-Japanese crew. I recall today the history of the signing and conclusion of this contract, I would remind you that the Japanese have offered \$12 million for this eight-day flight. U.S. specialists were asking \$15-17 million for a similar operation. However, we do not, unfortunately, have last year's latest figures since they are a commercial secret today.

[Gerasimov] The Soyuz-TM11 ship that will put the new crew into orbit is virtually ready for work. The cosmodrome's specialists are putting the finishing touches to the final technical operations. While the group preparing the cosmonauts is completing the training plan. But there is also an unexpected factor. For the first time in the history of manned flight, a few days before the launch the standby crew is incomplete. Yesterday Riyoko Kikuchi had her appendix removed in hospital in Leninsk City.

[I.K. Tarasov, head of cosmonauts' medical preparation] The operation was successful. Our surgeons, including our own surgeon, Doctor Stroy, performed the hour-long operation yesterday. We visited Riyoko today. Her condition can be said to be satisfactory. If everything goes OK, we will naturally try to ensure that she is with the crew by the launch.

[Gerasimov] Toyehiro Akiyama, whose condition is up to scratch, is preparing for work in orbit. He is to carry out several experiments at the station over a period of just under six days. One of which involves studying the behavior in conditions of weightlessness of these fascinating Japanese rain frogs. Two other experiments to study the effect of weightlessness on man's health and state of mind should help medicine on earth in the fight

against some illnesses. The rest of the Japanese cosmonaut's work will be connected with his profession—journalism. It is proposed to conduct daily 10-minute television reports and two 20-minute radio hookups. In that time Toyehiro Akiyama—if of course he adapts rapidly to the absence of the earth's gravity—will describe the sensations of weightlessness and the Soviet cosmonauts' work on the "Mir" station. Incidentally, our onboard engineer Musa Manarov will be the television cameraman during these reports. During the days preceding the launch the TBS company is organizing virtually around-the-clock direct television broadcasts from Baykonur. An impressive band of Japanese specialists has come to the cosmodrome for the purpose. With the help of Moscow television center personnel they are installing a direct space hookup with Tokyo. It must be noted that the capabilities of the Japanese television equipment arouse respect even against the backdrop of our space rocket technology. We also have things to learn from the Japanese in connection with the organization of such major wide-ranging events. Last, both the Japanese cosmonaut's space flight and all the steps taken to implement it are being carried out by the TBS television company above all to boost the firm's prestige—as happens all over the world, isn't that so? The rich do indeed have their whims. Pray god our country quickly reaches the point where it can allow itself to spend millions just on establishing a good name for itself.

### Extensive Press Coverage for Mission

*LD3011145390 Moscow TASS in English 1429 GMT 30 Nov 90*

[By TASS special correspondent Vladimir Khrustov]

[Text] Baykonur Cosmodrome November 30 TASS—More than 150 Soviet and foreign reporters gathered at a press centre, which opened here today, to cover a space mission that, for the first time ever, will include a member of their own profession.

Toyehiro Akiyama from the Japanese TBS television network will take a ride in a Soyuz TM-11 spaceship with two Soviet cosmonauts on Sunday to the space station Mir.

Eight days later, he will return with the latter's host team of Gennady Manakov and Gennady Strekalov to earth in their Soyuz TM-10 capsule.

Their two Soviet replacements, who will accompany Akiyama, will be formally named by a government commission on Saturday.

The press corps descending on Baykonur in anticipation of the mission is dominated by Japanese correspondents. The others are newsmen from Austria, Britain, Hungary, Germany, Italy, the United States, France, Czechoslovakia and the USSR.

All leading Soviet news organisations, as well as Russian, Ukrainian, Kazakh and Estonian newspapers and television, also dispatched reporters to the scene.

The journalists' working day today began in the small hours as they watched the delivery of the booster and Soyuz TM-11 spaceship to the launch pad.

Akiyama's TBS colleague Rioko Kikuchi, was training for the mission along with him, saw all her hopes to take part in next month's flight dashed when she underwent an appendicitis operation on Monday.

The surgery was performed at a local military hospital by Vyacheslav Romanovsky, a colonel in the medical service.

"We consulted physician Eshihiko Hayashi, who escorts the TBS journalists, before the operation, and he confirmed our diagnosis—acute appendicitis," Romanovsky told TASS today.

"Everything went as usual. The patient is feeling well," he added.

Rioko indeed looked well, resting in her room with a television set and books.

"I am feeling well, thank you," she told TASS. "The meals are delicious, the staff most attentive, and doctors knowledgeable and considerate. I am very grateful to them all and hope that they will permit me to attend the government commission's meeting tomorrow, which will decide who's going to blast off with Toyehiro."

The two Soviet cosmonauts, which will be named on Saturday, will be the eighth permanent crew to man Mir since it was launched in early 1986.

### Space Officials Comment on Upcoming Commercial Flights, Buran Plans

*LD0112111890 Moscow Domestic Service in Russian 0612 GMT 1 Dec 90*

[Editorial Report] Moscow Domestic Service in Russian at 0612 GMT on 1 December broadcasts a six-minute report by correspondent Vladimir Bezayev from Baykonur on the impending space mission. He says there are just over 24 hours to go before the launch, which is planned for 1113 Moscow time tomorrow (0813 GMT on 2 Dec). He describes how diligently the Japanese are working at Baykonur.

Bezayev goes on to say that "very late yesterday evening, a news conference took place attended by very many interesting people: Vladimuir Aleksandrovich Shatalov; Yuriy Pavlovich Semenov, chief designer of rocket and space systems; the chairman of the state commission; the minister of health; and high-ranking representatives from the Japanese side. So there were a lot of questions—and what is most interesting is that there were many interesting replies." Bezayev says that this space flight is important for the Soviet Union because it is the

first wholly commercial flight. He then goes on to interview Semenov, who is the creator of the Buran rocket, asking him if this is the only commercial flight or if a program of commercial flights exists, and when the Buran will be launched again.

Semenov replies: "Yes, we do have such a program. At present we are reshaping the contract for the flight of the English cosmonaut, making it somewhat more precise. That will be in May of next year. The flight of an Austrian cosmonaut is planned. That will be next year. We also have plans for 1992. We have signed contracts with the FRG and with France, and there are a number of contracts in the process of being drawn up."

Semenov goes on to say that "as far as the spaceship Buran is concerned, it is at present undergoing tests. It is planned to launch it at the end of next year, as long as no circumstances prevent it. The program is a very complicated one. It should be launched automatically, and dock automatically with the Mir station. The crew of the Mir station will move into the Buran spaceship and do manual operations with the handling arm (manipulator), and dock the module with the Mir station. Then the crew will return to the Mir station, at which point it will undock. We are also planning, after the undocking, to dock the spaceship with the manned Soyuz, as the Buran has capabilities for rescue method simulation and working out international rescue methods. But it will return to Earth automatically, unmanned."

Bezayev concludes his report by noting that the flights will pay for themselves if they learn how to use what is gained from them. Today at 1140, the state commission will finally determine the crew that is to take off. The Japanese woman cosmonaut is not in the running, as she had to have her appendix removed. At 1230 (0930 GMT) there will be a news conference with the cosmonauts, which will be broadcast live to Japan. Bezayev says that he will be able to tell listeners about it at around 1640, and tomorrow at this time the report will already be coming directly from the launching pad.

### Flight Plans for Japanese Cosmonaut, Soviet Main Crew

*LD0212105890 Moscow TASS in English 1041 GMT 2 Dec 90*

[by TASS special correspondent Vladimir Khrustov]

[Text] Baykonur Cosmodrome December 2 TASS—Japanese professional journalist Toyehiro Akiyama—the world's first journalist who has just set out on a space flight among a Soviet-Japanese crew—will soon begin broadcasting from space.

For eight days he will work in orbit with Soviet cosmonauts Viktor Afanasyev, Musa Manarov, Gennady Manakov and Gennady Strekalov. The Soyuz TM-11 spaceship was launched, according to schedule at 11:13, Moscow time, today and is heading for the orbital station Mir.

The flight program is intended for 169 days.

During the first phase—six days—Akiyama will make a series live broadcasts and perform medico-biological experiments.

The ability of the human organism to adapt to zero gravity during the first 24 hours of space flight will be analysed during the experiment "Sleep".

During another experiment—with frogs—the Japanese cosmonaut will watch their reaction to weightlessness.

All cosmonauts will have a busy schedule which will include, as usual, various astrophysical, technological, medical, biological and biotechnology experiments and the photography of the earth for the benefit of various branches of the economy.

The program also envisages repair and restoration work, including that outside the station. Several space walks are planned. There will be probably four or five of them: It is necessary to repair the notorious hatch on the Kvant-2 module. All spare parts to repair it have already been brought to the station.

In addition, by means of a special jib Afanasyev and Manarov will transfer solar-cell batteries to the Kvant module.

Mission commander Viktor Afanasyev, 41, (he will be 42 on December 31) is colonel of the air force. He is an experienced pilot, although this is his first space flight.

Afanasyev graduated from the famous Kachinskoye Air School and then from the Moscow Aviation Institute. He mastered over 40 types of aircraft, mainly fighter planes, and logged more than 2,000 hours of flying time. He has the qualification of test pilot, first class.

Flight engineer Musa Manarov is now one of the most experienced cosmonauts: In December 1988 he returned home after a record-long space flight which continued for exactly one year. He is pilot-cosmonaut of the USSR, hero of the Soviet Union and a people's deputy of the Russian Federation.

Toyehiro Akiyama, 48, is a high-class professional. He is sociologist by education. He headed the TBS bureau in Washington and is now deputy head of the international information department of the TBS.

The TBS is Japan's oldest private-owned television corporation. It will mark its 40th jubilee in May 1991.

#### **Soviet-Japanese Crew Launched in Soyuz TM-11 on 2 Dec**

*LD0212083490 Moscow TASS in English 0829 GMT  
2 Dec 90*

[Text] Moscow December 2 TASS—The Soviet Soyuz TM-11 spaceship with a Soviet-Japanese space crew on board has just been launched from Baykonur Cosmodrome.

The crew consists of Soviet cosmonauts Viktor Afanasyev and Musa Manarov and Japanese journalist Toyehiro Akiyama.

After they dock with the orbital complex Mir, the new arrivals will for six days work together with the members of the seventh main space expedition—Gennadiy Manakov and Gennadiy Strekalov.

After that, Akiyama will return to earth together with them while Afanasyev and Manarov will supersede their predecessors who have worked in space for four months.

#### **Japanese Commentary on Launch**

*OW0212115190 Tokyo KYODO in English 1107 GMT  
2 Dec 90*

[Text] Baykonur, Soviet Union, Dec. 2 KYODO—Japan's first man in space is orbiting the earth with two Soviet cosmonauts in a Soyuz space capsule after their launch from this space center in Soviet central Asia on Sunday.

The seven-ton spacecraft, powered by a three-stage rocket, blasted off at 11:13 A.M. from the Baykonur Space Center in the Kazakh Republic.

Toyehiro Akiyama, 48, a reporter for Tokyo Broadcasting System (TBS), is not only the first Japanese but also the first journalist from any nation to go to space.

On Tuesday, the rocket will link up with the Soviet Mir Space Station, where Akiyama will spend six days before returning to earth on December 10.

His Soviet partners, Commander Viktor Afanasyev and Engineer Musa Manarov, will replace two Soviet cosmonauts who have been in the space station for the past four months. Afanasyev and Manarov are expected to stay in space for six months.

During his stay in the Mir Space Station, Akiyama will describe his journey during live radio and television reports and conduct experiments on six Japanese tree frogs.

The space venture is the Soviet Union's biggest effort yet to commercialize space travel. TBS, Japan's largest private broadcast network, hopes to improve its image through the flight.

TBS reportedly paid Moscow about 1.3 billion yen to be the first broadcasting company to send a journalist into space.

Akiyama, a former TBS Washington correspondent chosen from among 162 candidates for the flight, underwent 14 months of intense physical training in the Soviet Union.

Meanwhile, scientist Mamoru Mori, 42, will be the first Japanese astronaut to participate in a U.S. space voyage, joining an experimental flight aboard the U.S. space shuttle Atlantis next June.

### Second Day of Mission

*LD0312132390 Moscow TASS in English 1309 GMT  
3 Dec 90*

[Text] Moscow December 3 TASS—The Soviet-Japanese crew consisting of Viktor Afanasyev, Musa Manarov and Toyehiro Akiyama began their second day in space at 05:00 this morning and will end it at 16:00 Moscow time.

Under the flight program, the cosmonauts checked the seals on the Soyuz TM-11 spaceship and the operation of its onboard systems. They carried out two maneuvers to bring it closer to the Mir space station.

After adjustments, the ship's orbital parameters are as follows: apogee—326 kilometers, perigee—283 kilometers, revolution period—90.3 minutes, orbital inclination—51.6 degrees.

Gennady Manakov and Gennadiy Strekalov today plan to make visual observations and snapshots of the earth's surface, experiments to measure space radiation and a training session in the Chibis pneumovacuum suit. There will also be time for physical exercises and rest.

Systems aboard the Soyuz TM-11 ship and the Mir complex are operating smoothly.

### 'Soyuz TM-11' Docks With 'Mir' Station

*LD0412101390 Moscow TASS in English 1009 GMT  
4 Dec 90*

[Text] Moscow December 4 TASS—The spacecraft Soyuz TM-11 docked with the manned orbital complex Mir today at 12 hours 57 minutes Moscow time. The spacecraft carries an international Soviet-Japanese crew, comprising Soviet cosmonauts Viktor Afanasyev and Musa Manarov and Japanese journalist Toyohiro Akiyama, which was launched from the Baykonur launch pad on December 2.

The complex Mir has been manned for five months now by the seventh main expedition of Gennadiy Manakov and Gennadiy Strekalov. The Soviet-Japanese team will stay on board until December 10. After that Manakov and Strekalov will return to earth together with the Japanese cosmonaut, while Afanasyev and Manarov will stay on as the eighth main expedition.

### Crew Transfers to 'Mir' Station

*LD0412110390 Moscow TASS in English 0925 GMT  
4 Dec 90*

[By TASS correspondent Rena Kuznetsova]

[Text] Moscow December 4 TASS—Five cosmonauts—four Soviet crew members and their Japanese counterpart—are now aboard the Mir space station. The docking of the Soyuz TM-11 spaceship with the station has just been accomplished.

The Soviet-Japanese crew consisting of Soviet cosmonauts Viktor Afanasyev, Musa Manarov and Japanese journalist Toyohiro Akiyama blasted off from the Baykonur Cosmodrome on December 2.

Gennadiy Manakov and Gennadiy Strekalov, members of the seventh main expedition, are in their fifth month of work on board the Mir space station. After the docking, the mixed crew will work until December 10.

Then Manakov, Strekalov and Akiyama will return to earth. Afanasyev and Manarov will continue work in space as the eighth main expedition. They will be in orbit until May 1991. The cosmonauts plan to make four space walk-outs.

The flight with the participation of the Japanese reporter will last eight days. In this period, Akiyama, aided by Soviet colleagues, will have to implement an extensive programme.

It is planned to carry out several link-ups and reports from flash points in the world, where the ecological situation is critical.

The Japanese cosmonaut will conduct ten-minute telecasts and 20-minute radio broadcasts every day.

The crew also plan to carry out the "Sleep" medicobiological experiment, during which they will study the influence of zero gravity on sleep during cosmonauts' adaptation to space conditions.

The Japanese side suggested an interesting experiment with frogs. This is a special population of rain frogs in Japan. They have suckers helping them to fix their position. Scientists are interested in whether these frogs will be able to use suckers in space.

### Gorbachev Sends Message To Joint Space Crew

*OW0612041990 Moscow in Japanese to Japan  
1000 GMT 5 Dec 90*

["Full text" of Soviet President Mikhail Gorbachev's 4 December message of congratulations to the Soviet-Japanese crew of the Mir space station—first two paragraphs are introduction]

[Text] President Gorbachev and Prime Minister Kaifu have sent messages of greetings to the joint Soviet-Japanese crew, which began survey activities aboard the space station Mir. In their messages, they expressed hopes that the latest joint flight will be a shining page in Soviet-Japanese history and will contribute to further developing cooperation.

We now give the full text of President Gorbachev's message of congratulations addressed to the five members of the international crew aboard the space station Mir—Manakov, Strekalov, Afanasyev, Manarov, and Akiyama. The message of congratulations reads:

I extend my heartfelt greetings to you, the international crew of the Mir space station. The flight of the first joint Soviet-Japanese space crew is a remarkable event marking a new stage in bilateral cooperation and making a major contribution to the cause of strengthening mutual understanding, friendship, and confidence between the peoples of the Soviet Union and Japan.

Your successful work on board the Mir station attests to the great potentialities for joint efforts by the peoples of our two countries both in space and on earth for the prosperity of future generations.

I wish you success in implementing the joint flight program and a safe return to earth.

[Signed] Gorbachev, president of the USSR.

#### Japanese Cosmonaut Begins Work Schedule

*LD0512110790 Moscow TASS in English 0954 GMT  
5 Dec 90*

[By TASS correspondent from the Mission Control Center]

[Text] Moscow December 5 TASS—Gennadiy Manakov, Gennadiy Strekalov, Viktor Afanasyev, Musa Manarov and Toyohiro Akiyama continue to implement the program of the Soviet-Japanese space flight.

Today's schedule envisages that the crew of the eighth main expedition will become acquainted with the peculiarities of running the equipment of the orbital complex Mir and conduct medico-biological research.

The Japanese journalist will make radio and television broadcasts and photograph the earth's surface.

At the end of the day he will also carry out the first of a series of experiments to study the behaviour of tree frogs in orbital flight conditions.

Under the space biotechnology program, the Soviet cosmonauts are proceeding with the experiment Vita, which was started on December 4 and is aimed at obtaining animal cells that produce protein medicinal preparations in zero gravity.

The cosmonauts regularly sample the preparations for subsequent laboratory research.

Akiyama will return to earth on board the Soyuz TM-10 spaceship with Manakov and Strekalov. With this end in view, the cosmonauts, during the day, are to dismantle the support assembly of the Japanese journalist's chair on board the Soyuz TM-11 spaceship and install it in the descent vehicle of the Soyuz TM-10.

According to reports from orbit and telemetry data, the onboard systems of the manned orbital complex Mir are functioning normally and all five cosmonauts are in good health.

#### Experiments Continue Aboard 'Mir'

*LD0712115290 Moscow TASS in English 1132 GMT  
7 Dec 90*

[Text] Moscow December 7 TASS—The new permanent crew of the Soviet Mir space station, Viktor Afanasyev and Musa Manarov, are today acquainting themselves with the station's flight control system. They are also to familiarise themselves with spacewalk procedures.

The outgoing crew, Gennadiy Manakov and Gennadiy Strekalov, began an experiment in space biotechnology. The experiment, codenamed Rekomb, is aimed at studying the cultivation of hybrid cells in zero gravity, which later will be used on earth to obtain biologically active substances.

Japanese journalist Toyohiro Akiyama, who has arrived at the station with Afanasyev and Manarov, apart from his broadcasts, will conduct an experiment to assess the state of the human vestibular apparatus during adaptation to zero gravity.

The flight of the Soviet-Japanese crew is proceeding according to schedule. The cosmonauts are feeling well and working with mutual understanding.

#### Soviet-Japanese Crew's Third Day Aboard 'Mir'

*LD0612123190 Moscow TASS in English 1201 GMT  
6 Dec 90*

[By TASS correspondent from the Mission Control Center]

[Text] The Soviet-Japanese crew have begun their third day of work aboard the orbital complex Mir.

In accordance with the plan for the transfer of duties, Gennadiy Manakov and Gennady Strekalov today share experience with Viktor Afanasyev and Musa Manarov today in operating equipment and scientific apparatus of the Kvant-2 and Kristall modules.

Japanese journalist Toyohiro Akiyama continues his journalistic activities. While the orbital complex was above Japan he beamed a regular telecast from orbit for home audiences.

Today's schedule also envisages a news conference at the Mission Control Centre for Soviet and foreign correspondents.

The cosmonauts continue experiments with biological forms delivered to orbit by the Soyuz TM-11 spaceship: wheat and barley seeds and ginseng tissue culture.

Under the geophysical research program, Manakov and Strekalov on Wednesday photographed individual areas of the territory of Central Europe to identify areas promising for prospecting for economic minerals.

According to the cosmonauts' reports and telemetric data, the flight of the orbital complex Mir is proceeding normally.

#### **Cosmonauts Prepare for Return**

*LD0812123590 Moscow TASS in English 1203 GMT  
8 Dec 90*

[Text] Moscow December 8 TASS—Four Soviet cosmonauts and one Japanese journalist today have begun the fifth day of their joint flight on board the Mir space station.

Gennadiy Manakov and Gennady Strekalov, preparing to return to Earth, today checked the functioning of onboard systems of the Soyuz TM-10 spaceship, in which they will descend.

They began to put capsules with monocrystals of semi-conducting materials, cassettes with films and other equipment planned to be returned, into the spaceship.

Also today, the cosmonauts will undergo training in the Chibis pneumatic-vacuum suit and on a jogging treadmill.

Their replacements, Viktor Afanasyev and Musa Manarov, continue to familiarise themselves with the station. They also help Japanese journalist Toyohiro Akiyama with his medical and biological experiments and broadcasts from orbit.

According to the cosmonauts' reports and telemetry data, the flight is proceeding normally.

#### **Manakov, Strekalov Return to Earth With Japanese Cosmonaut**

*LD1012065190 Moscow TASS International Service  
in Russian 0623 GMT 10 Dec 90*

[Text] Moscow, 10 Dec (TASS) - Today at 0908 Moscow time [0608 GMT], Soviet cosmonauts Gennadiy Manakov and Gennadiy Strekalov and Japanese journalist Toyohiro Akiyama returned to earth.

The descent module from the spaceship Soyuz TM-10 made a soft landing with the crew on board in the area of Arkalyk, Kazakhstan.

The crew of the seventh main expedition on the Soviet long-term "Mir" orbital complex has returned after more than four months in weightlessness. Japanese journalist Toyohiro Akiyama, who—as part of the Soviet-Japanese crew—worked with Viktor Afanasyev and Musa Manarov in space, has completed his eight-day journey. Afanasyev and Manarov are continuing the work in the complex as the eighth main expedition.

#### **Joint Statement Marks Space Mission End**

*LD1112174890 Moscow TASS in English 1644 GMT  
11 Dec 90*

[Text] Moscow December 11 TASS—On the occasion of the completion of the joint Soviet-Japanese space mission, participants in this project passed a joint statement. On December 10, 1990, says the statement released here today, the eight-day mission by a reporter of the Japanese TBS Company aboard the Soviet space station Mir has been successfully completed.

This remarkable event, devoted to the 40th anniversary of the Tokyo Broadcasting System (TBS), was preceded by intensive work by the Japanese company and Soviet organisations that ensured technical implementation of the project.

These are primarily the "Energiya" scientific and production association, the government space agency Glavkosmos, the foreign trade association Licenzintorg, the Yuriy Gagarin Cosmonaut Training Center, the Mission Control Center, the Institute of Medical and Biological Problems, the Baykonur Cosmodrome and other organizations, connected with the implementation of the project.

Intensive work has been completed and the sides note with satisfaction the successful cooperation of the entire multithousand Soviet-Japanese team which worked on that project during 21 months.

All participants in the project express hope that such joint effort will help strengthen and extend friendship between Soviet and Japanese peoples.

#### **Cosmonauts to Return to Star City**

*LD1012222890 Moscow TASS in English 2101 GMT  
10 Dec 90*

[By TASS correspondent Rena Kuznetsova]

[Text] Moscow December 10 TASS—The Soviet-Japanese space mission is over. Soviet cosmonauts Gennadiy Manakov, Gennadiy Strekalov and Japanese journalist Toyohiro Akiyama are today expected to return to Zvezdnyy Gorodok (Star City), the place where their path to orbit originated.

Medical specialists point out that the cosmonauts are feeling well following their landing and therefore such a journey will not be of detriment to their health in any way.

Akiyama together with Viktor Afanasyev and Musa Manarov was blasted into orbit on December 2 and returned to earth with Manakov and Strekalov today.

For six days the five cosmonauts worked together concertedly and then a station crew change-over took place.

Akiyama aired a large number of television and radio broadcasts and performed a number of scientific experiments. He photographed the territory of Japan with particular interest. "Every time I watched my native earth I was filled with an extraordinary feeling of joy. I was gratified to know that people down there were waiting for me to return," he said during an orbit-earth hook-up news conference.

Manakov and Strekalov, following their more than four-month-long stay in orbit, handed over their duties to the crew of the eighth main expedition—Afanasyev and Manarov.

Speaking about results of the seventh main expedition, experts point out that a large amount of scientific and technical research and experiments has been carried out for the benefit of various branches of the national economy.

A regular batch of monocrystals of semi-conductor materials with improved characteristics, necessary for the radio-electronic industry, was obtained on the technological installation Kristall which is referred to as "micro-factory" for the production of crystals in orbit.

Important biotechnology research has been carried out in particular with a view to studying the effectiveness of cultivating protein compounds in zero gravity for their subsequent application in medicine and pharmacology.

Part of the materials obtained was for the first time brought to earth by means of a ballistic capsule that had been part of the Progress M-5 cargo spacecraft.

#### **Post-Flight Press Conference With Cosmonauts**

*LD1112175690 Moscow TASS in English 1559 GMT  
11 Dec 90*

[By TASS correspondent Rena Kuznetsova]

[Text] Star Town outside Moscow December 11 TASS—A room at the Mission Control Center outside Moscow glittered with Christmas decorations and sported Soviet and Japanese national flags in a festive spirit when staff members and journalists assembled there to greet Soviet cosmonauts Gennadiy Manakov and Gennadiy Strekalov and Japanese journalist Toyohiro Akiyama who had returned to earth on Monday.

There was a wall of glass between the cosmonauts and the others to make sure that no earthly infection could affect the former's health.

The three cosmonauts returned to Earth together on Monday and were directly flown to the star town near Moscow, where the Mission Control Center and pre-flight training center are located.

In his opening address the center's chief doctor Ilya Tarasov said that the cosmonauts felt fine after the

mission, although they looked tired and understandably so: They looked as people look who have worked hard to do their duty.

Toyohiro Akiyama had complained of some pain in the back: He said that directly after the touch-down he had twisted his body inadvertently, ignoring the fact that he was back in the world of gravity, weight and flesh.

Upon the arrival at the star town, he was massaged to relieve the pain, which stopped troubling him completely after he took a warm shower on Tuesday morning.

The two Gennadiys marked their return with a spell in a steam bath on Monday, conforming to an age-old Russian tradition. On Tuesday, the three met for a stroll. It will take them about a fortnight to feel again as they did before the mission.

During these two weeks they will meet specialists from the Mission Control Center and the Energiya research-and-production association and prepare a report on the mission, the centre's chief Vladimir Shatalov told Soviet and foreign journalists.

Asked if a meeting with journalists was not too taxing so soon after the mission, Toyohiro Akiyama told his colleagues in a business-like manner that he viewed the encounter as the hard but unavoidable necessity. "We are all in a world where life is impossible without information exchange," he said.

Asked what weightlessness like to him, Akayama said it could only be compared to a beautiful girl, one can only dream about later.

What does the earth look like from space? The Japanese cosmonaut was asked. "It looks beautiful, but when I tried to film it, I could not help thinking that there were too many clouds and the visibility was poor."

Gennadiy Manakov and Gennadiy Strekalov told journalists that the mission plan had been fulfilled and work had been done neatly and in good coordination by all mission participants. They said that the results of the expedition would be set out in detail in their reports.

#### **Commentary Views Political Benefit From Soviet-Japanese Flight**

*OW1212093090 Moscow in Japanese to Japan  
1000 GMT 6 Dec 90*

[Commentary by station commentator (Oleg Chedrov) ]

[Text] This flight is being conducted under a commercial contract with the private sector. A Japanese television company, TBS, is its sponsor. Under the contract, TBS will broadcast reports from space and the flight control center almost 24 hours a day on both radio and television. Judging from reports from Japan, public interest in the flight seems high. This, I believe, is because the Japanese people are interested not only in space but also in the Soviet Union, their neighbor.



The Soviet news agency TASS and the Japanese KYODO news service conducted opinion polls in their respective countries just before the flight. The results of the Japanese poll were very interesting. A majority of the respondents sympathized with reforms under way in the Soviet Union and called for improved relations and expanded cooperation between the two countries. At the same time, the poll proved that a considerably large number of Japanese people are wary of their northern neighbor.

I would not say that this is actually true, but, for me, this dichotomy determines in many respects the contradiction in Soviet-Japanese relations, which has become salient in recent years. To inject vitality into political relations, many things must be conducted at the state level, of course. In this regard, high hopes are pinned on President Gorbachev's visit to Japan next spring, but it is a known fact that any top-level agreement can take root only when supported by the general public.

This is a delicate question which has not yet been fully studied. But everyone is convinced that things like a joint space flight is at times very effective. As a matter of fact, joint operations in orbit by cosmonauts of the two countries will help break down distrust in each other and create a more desirable image of partnership in the hearts of Japanese and Soviet peoples. Therefore, although I regard him with envy professionally and personally, I wish Mr. Akiyama, my colleague, success.

#### Live Relay of 'Mir' Crew Landing Carried

PM1312143390 Moscow Television Service  
in Russian 0930 GMT 10 Dec 90

[Report by P. Orlov; from the "Vremya" newscast]

[Text] [Orlov] Last night the crew comprising Gennadiy Manakov, Gennadiy Strekalov, and Toyohiro Akiyama left the "Mir" station, bidding farewell to those who will remain there for six months. The farewell was warm. You were able to see it again this morning in the "120 Minutes" program. Now the trip back to Earth lies ahead of them, while Musa Manarov and Viktor Afanasyev will stay aboard the "Mir" station to continue the work for another six months.

Meanwhile, people at the Flight Control Center are waiting for the cosmonauts and for progress reports on the landing. Here are the new diagrams which depict all stages of the flight. There you can see that the craft has entered the dense layers of the atmosphere.

Japanese television broadcast a live relay of this event. Now you see on the screens. [video shows a clip of craft descending on a parachute]

This is the first direct relay from Arkalyk, where our cosmonauts return to Earth, in the 15 years that have passed since the landing of the Soyuz-Apollo craft and the Klimuk-Sevastyanov landing in the same year. The first direct relay to the Flight Control Center. It has been

organized jointly by the Glavkosmos [Main Administration for the Creation and Utilization of Space Technology] and the Japanese TBS [Tokyo Broadcasting Service] Company.

The landing has taken place. The soft landing engines went into operation.

[Unidentified voice in the background] The craft is behind the trucks, the craft is on its side. Excellent. [applause] It appears that the hatch cover has already been blasted off... aerial....

[Orlov] After the successful soft landing, everything went according to the usual schedule. A special ramp is being attached to make it easier for the cosmonauts to slide down. These are literally the last 1.5-2 meters separating them from our planet. But first of all the hatch is carefully opened. The first to emerge, as is the custom, is crew commander Gennadiy Manakov. [applause]

Normally, the second to emerge is the flight engineer. But here an exception was made. The Japanese cosmonaut-journalist is atop the craft, he greets all who can see him now, and that is practically the whole world, in addition to those here at the flight control center. And finally Gennadiy Strekalov, the flight engineer, the most experienced in this crew.

#### Crew Continues Semiconductor Materials Production

LD1412145690 Moscow TASS in English 1310 GMT  
14 Dec 90

[By TASS correspondent at Mission Control Center]

[Text] Moscow December 14 TASS—Soviet cosmonauts Viktor Afanasyev and Musa Manarov continue their work on board the orbital complex Mir.

They have set about producing high-quality semiconductor material in zero gravity for the needs of modern microelectronics.

They launched a 140-hour process of growing a zinc oxide monocrystal on the Gallar installations on December 13. Today the cosmonauts are expected to prepare the Krater-V technological installation for work.

Under the research program, the cosmonauts will perform experiments to gauge the characteristics of cosmic-ray radiation and evaluate the condition of structural materials' samples mounted on the outer surface of the orbital complex.

According to telemetric data and crew reports, the flight is proceeding normally. The two cosmonauts are in good health.

**Cosmonauts Continue Work, Experimentation**

*LD2512133390 Moscow TASS in English 1208 GMT  
25 Dec 90*

[Text] Moscow December 25 TASS—Cosmonauts of the eighth resident crew—Viktor Afanasyev and Musa Manarov—continue work aboard the Mir space station.

The process to grow the monocrystal of a semiconducting material with improved characteristics has been completed in the Krater electric heating furnace. An experiment to study the effect of micro-gravitation on heat-and-mass exchange in liquids in conditions of a space flight was performed using the Pion technological plant.

The cosmonauts continued their work under the program of astrophysical research using the Roentgen international orbital observatory installed in the Kvant Module. They obtained new scientific information [word indistinct] an X-ray pulsar in the Great Magellanic Cloud.

The crew will carry out work under the equipment maintenance plan and bio-chemical experiments today. Under the program to study the environment, cosmonauts are planning to take pictures of separate parts of the country's territory.

The flight is proceeding as scheduled. Both cosmonauts are in good health and feeling well.

**Space Station Manning, Funding Problems Discussed at News Conference**

*PM0201100391 Moscow Television Service in Russian  
1800 GMT 25 Dec 90*

[Report by P. Orlov, V. Dubov, and V. Dolina; from the "Vremya" newscast]

[Text] [Announcer] The work in orbit by Gennadiy Manakov and Gennadiy Strekalov and also the Soviet-Japanese spaceflight were described today at a news conference at the USSR Foreign Ministry press center.

[Orlov] The Japanese TBS [Tokyo Broadcasting Service] company has plans for Toyehiro Akiyama to write a book about his flight. Well, that is the plan. It looks as though Gennadiy Manakov and Gennadiy Strekalov have already finished their book.

They have spent two weeks with pen and paper. Whenever there was a minute free they were surrounded by specialists asking: How did everything work; what should be changed; what can be improved?

The cosmonauts insist that two people on the station is too few. Manakov and Strekalov, for instance, were improving smelting techniques in space, but they were naturally unable to be in all the units and modules at once.

In weightlessness even bolts can work loose. God knows why, but it is necessary to keep an eye on them. Generally, this is why they slept normally only once in three days.

It emerged at the news conference that weightlessness did not suit Toyehiro Akiyama at all. Especially during the first three days, when he could not swallow any food. Rather the opposite. His bosses, having seen all the materials that he provided, are pleased with their special correspondent's work. They are also pleased with the help received from all four Soviet cosmonauts.

At today's news conference Akiyama himself took advantage of the favorable atmosphere to ask for a vacation. The TBS job is finished.

The commercial side of the project remains confidential; however, it was announced at today's news conference how the profits will be divided.

[Unidentified speaker] Fifty percent of the money will go to the state, to be paid into the budget, and 50 percent will be used by the manned flights department for its own purposes. Equipment has been purchased for sums amounting to more than \$1 million—this much I am allowed to state. It is equipment for the production of disposable syringes.

[Orlov] Another three commercial flights lie ahead. But, as was stated at the news conference today, the space sector has sufficient funds only for the next three months.

The prospect of a forced vacation does not bode well for anyone. Apart from Toyehiro Akiyama perhaps. For him the flight is over. But for us?

**Cosmonauts Prepare for EVA to Repair 'Kvant-2' Hatch**

*LD2912132290 Moscow TASS in English 1220 GMT  
29 Dec 90*

[Text] Moscow December 29 TASS—Soviet cosmonauts Viktor Afanasyev and Musa Manarov are preparing for an unusual Christmas, celebrated on January 7.

On this day, they are expected to work in outer space to repair a hatch of the Kvant-2 module, which caused problems for the previous expedition of Gennadiy Manakov and Gennadiy Strekalov.

"The cosmonauts are testing their space suits and oxygen containers, equipment and tools they will need during their exit to outer space," flight head Vladimir Solovyev told TASS. "They are undergoing physical training, including training on bicycle ergometers for arm muscles. They are also involved in astro- and geophysical experiments."

### EVA Scheduled for 7 Jan

*LD0601122591 Moscow TASS in English 1203 GMT  
6 Jan 91*

[by TASS correspondent Rena Kuznetsova]

[Text] Moscow January 6 TASS—Soviet cosmonauts Viktor Afanasyev and Musa Manarov, who work on board the Soviet orbital complex Mir, are expected to have a space walk on Monday.

According to preliminary estimates, this will happen at 19:47 Moscow time.

The main aim of the space walk will be to repair the lid of the outer hatch of the Kvant-2 module which is part of the orbital complex. Malfunctions developed during a space walk of members of the sixth main expedition, Anatoliy Solovyov and Aleksandr Balandin, in July last year. Solovyov and Balandin worked on board the station from February to August 1990.

Their successors, Gennadiy Manakov and Gennadiy Strekalov, did not manage to correct the malfunction either. They completed their flight at the end of last year.

The present crew have been working in orbit for the second month. It is planned that they will have four space walks. Extravehicular activity (EVA) has become usual for the Mir crews. EVA was prompted first of all by the need to take care of the huge orbital complex.

Suffice it to recall that the crew of the fifth main expedition on board the Mir complex—Aleksandr Viktorenko and Aleksandr Serebrov—for the first time tested the cosmonaut transformation facility in open space. This was first done by Serebrov on February 1, 1990. The maximum distance from the exit hatch was 33 meters.

Mission commander Viktorenko continued the tests of the facility on February 5, getting away from the station at a distance of 45 metres.

### Cosmonauts Complete EVA, Airlock Hatch Repaired

*LD0801023591 Moscow TASS International Service  
in Russian 0000 GMT 8 Jan 91*

[Text] Flight Control Center, 8 Jan (TASS)—Viktor Afanasyev and Musa Manarov have carried out a space walk to repair the exterior hatch of the "Kvant-2" module and to perform planned work on the external surface of the station.

As already reported, the examination carried out by the previous crew showed the necessity of changing one of the fastening units of the hatch cover. For this purpose a new unit was delivered to the station on the "Soyuz TM-11" craft.

On 7 January at 2003 Moscow time [1703 GMT] Viktor Afanasyev and Musa Manarov opened the airlock compartment of the "Kvant-2" module and went out onto the exterior surface of the "Mir" complex. With the help of special devices and instruments, the cosmonauts dismantled the hatch cover fastening unit which had gone out of action and installed a new one, which had been constructed taking into account the special features of assembly in conditions of open space.

After the functioning of the hatch was checked, the crew continued working on the station's external surface. The metal support construction which will be used in the planned work with the solar batteries was carried out from the airlock compartment and installed on the module's docking device. Then the cosmonauts removed the television camera which was included in the video spectrum complex of the "Kvant-2" module and also the cartridge with samples of the super-conductive materials which remained outside the station during the year. The total time the crew spent in open space was five hours and 18 minutes. Viktor Afanasyev and Musa Manarov are feeling well.

### 'Progress M-6' Cargo Spacecraft Launched 14 Jan

*LD1401175391 Moscow TASS International Service  
in Russian 1722 GMT 14 Jan 91*

[Text] Moscow, 14 January (TASS)—In accordance with the program for further operation of the "Mir" research complex, the "Progress M-6" cargo spacecraft was launched in the Soviet Union at 1750 Moscow time today.

The craft was launched for the purpose of delivering expendable materials and various kinds of cargo to the "Mir" manned complex.

The "Progress M-6" craft was placed in an orbit with the following parameters:

- apogee, 224 km;
- perigee, 192 km;
- period of revolution, 88.4 minutes;
- inclination, 51.6 degrees.

According to telemetric information, the onboard systems of the automated cargo craft are operating normally.

### Experiments Continue on 'Mir' Station 15 Jan

*LD1601010991 Moscow TASS in English 1111 GMT  
15 Jan 91*

[Text] Moscow January 15 TASS—Soviet cosmonauts Viktor Afanasyev and Musa Manarov today were involved in preventive and scheduled maintenance on board the Mir space station.

They are expected to replace a block of storage batteries and test radio and telecommunications equipment.

Today's scientific research schedule includes space radiation measuring and the evaluation of effects of outer space on radio electronic equipment. Samples of such equipment are mounted on the surface of the Kvant-2 module.

On Monday, with the help of the Mariya magnetic spectrometer, they performed a series of experiments to study generation mechanisms of elementary charged high-energy particles and their distribution in circumterrestrial space.

According to medical tests, the cosmonauts' health is normal.

### 'Progress M-6' Docks With 'Mir' 16 Jan

*LD1601200191 Moscow TASS International Service in Russian 1912 GMT 16 Jan 91*

[Text] Moscow, 16 Jan (TASS)—Today at 1935 Moscow time, the "Progress M-6" cargo spaceship docked with the "Mir" manned complex.

The mutual search, rendezvous, mooring, and docking were carried out with the help of the automatic onboard equipment. These processes are controlled by the Flight Control Center, and by the cosmonauts Afanasyev and Manarov.

The "Progress M-6" has docked with the complex on the side of the "Kvant" module. Fuel for the unified engine installation, foodstuffs, water, equipment, apparatus, and mail have been delivered in orbit.

According to the telemetric data and the reports of the crew, the onboard systems of the "Mir" manned complex are operating normally. Viktor Afanasyev and Musa Manarov are feeling fine.

### Significance of 'Mir' Cosmonauts' Biological, Technical Research

*907Q0152 Moscow PRAVDA in Russian 9 Aug 90 Second Edition pp 1, 6*

[Article by PRAVDA special correspondent A. Tarasov, from Flight Control Center: "Back Home Again"; first paragraph is source introduction]

[Text] Today, Anatoliy Solovyev and Aleksandr Balandin are supposed to return to earth. Gennadiy Manakov and Gennadiy Strekalov will continue the space watch.

At first we saw someone's bare foot hooked on a hand-rail. And we could see that it was someone with a hand-held camera. It was "BIEO-6," which stands for flight engineer of the 6th main crew, Aleksandr Balandin. In the scene, he was focused on a garden row with an abundance of shoots, while his commander explained that the shoots were radishes and lettuce in the Soviet-Bulgarian Svet greenhouse, which is distinguished by ideal, electronically controlled "weather." And here is a

transparent vessel with wheat sprouts. In the vessel, the day is a "polar day"—there is a round-the-clock sunlamp for greater heartiness...

This, as it were, glass plate will be returning together with the wheat. In fact, it is a light-generating unit that contains a polyacryamide gel—a polymer "drench" in which proteins will be electrophoretically separated later on the ground. And the space gel cleans the proteins 80 times better than does a ground gel. And here are old familiar friends—snails. Fifteen space wanderers that are, it is true, very, very unhurried...

"Are they trying to get out of their suits?" asks Galina Nechitaylo, the head of the biological staff on the ground.

"They are trying, they are, indeed," Strekalov says, confirming that they survived. This is of considerable importance, since two preceding snail delegations, unfortunately, perished in space. Either they were extremely overmoistened or they proved to be too delicate. Now they are treated more carefully and are handled only briefly: prior to the launch and after the landing.

"But why again snails, again wheat and again a magnet?" I asked in turn. "From one flight to the next, it's the same things?"

"To us, it's still not enough," G. Nechitaylo asserts, in my opinion, not for the first time. "The experiments require a great deal of repetition, until such time as a closed ecological system, including people, plants, fish and microorganisms and so on, is sent into space. In order to do that, we need to learn an awful lot. Why, for example, seeds and plants age faster in weightlessness than on the ground? And how can it be prevented? Wheat is part of a program of very precise measurements: biochemical and highly structured measurements, with an electron microscope, to show the state of the walls and the internal components of a cell... And how do we find out why a tissue culture of ginseng in space increases its biological activity severalfold? We suspect that it is the result of stress..."

The stress of a biological cell! Can it be that each cell of our human body also experiences this? What heroes we must be then!

And it's no less true for the snails, since they have very developed ganglia—nerve centers that make it possible to study the reaction of the nervous system to all these things... But to take the past experience with the newts—of the three, the one that felt the best was, judging by the reactions, the one who had one vestibular organ removed. That led the biologists to the sound conjecture that all our troubles with zero-gravity illness stem from an imbalance of the vestibular pair. It would be like being stunned by a blow on the ear—without being the least bit drunk... "Oh, just look at how many marvelous discoveries are being prepared for us" by the 21st Century!

And there are those who mumble: the same thing, over and over, it just takes time and space away from serious matters. Others are convinced that they are the experiments of the 21st Century that will provide the key to the Mars flights. The cosmonauts themselves take a simple view: "Every tiny leaf, every living twig here is like home to us; it makes us happy and cheers us up." That is why, throughout their entire mission, the Vulkany [crew designation] willingly looked after their new "tenant"—an attractive dwarf lemon tree. In the meanwhile, the longest-lived residents of the Vazony [crew designation] were orchids. But the lemon tree, taken from the Kiev Botanical Gardens, is already half a century old. Perhaps it will live just as long on the station.

But the crew change is coming closer and closer. Even now, a report is coming in about the completion of the last furnace heat. The young specialists in charge of the production part, Mariya Bocharova and Aleksandr Ivanov, are sending their most sincere gratitude to the Rodniki [crew designation] from the Flight Control Center. When the Kristall module was two months late and the trip was "all fouled up" and the hatch was jammed, many people no longer believed that they would be able to fire up all five furnaces in that orbital shop. However, the furnaces were not only fired up, but they also produced the products needed for the return. There were nearly 30 heats lasting six-240 hours, and samples of semiconductors ranging from heavy rods to the finest, fragile films of silicon epitaxy are being packed in the return baggage. That is very important for the developers, because it will enable them to use the initial results to make adjustments for all subsequent missions.

Here a simple extension of 10 days wasn't enough. Not everything worked the first time. First, a program locked up, then a drum jammed in the Kristallizer [crystallizer], then the heaters in Zona-3 burned out. The cause has to be searched for and eliminated, which eats into personal time, and no one wants to throw the other studies and repair and maintenance off schedule, either. Especially the photography with the new camera—just try returning without shots of the tens of millions of square kilometers that were supposed to have been shot. And so they search for the problems, eliminated them, and turned everything on—and all in their own low-keyed, soft-toned, reserved and diligent way.

Of the planned 520 experiments, 506 were performed. That is much better than the pessimists thought it would turn out.

"We would really need another three-four days for transmitting data," Strelakov says, "but we can't hold these guys up..."

And here on the ground, at 1130 hours Moscow summer time, we are waiting for them.

### Report on Post-Flight Press Conference of Cosmonauts Solovyev, Balandin

907Q0153 Moscow *RABOCHAYA TRIBUNA*  
in Russian 12 Aug 90 p 4

[Article by *RABOCHAYA TRIBUNA* special correspondent A. Filippov, from *Zvezdnyy Gorodok*: "On Mars, They Will Remember the 'Rodniki': Press Conference of A. Solovyev and A. Balandin"; first paragraph is source introduction]

[Text] *On the evening of 9 August, immediately after the landing, cosmonauts A. Solovyev and A. Balandin were transported by a special aircraft to Zvezdnyy Gorodok's medical dispensary. They were immediately surrounded by doctors.*

There is nothing unusual in this. It is the mandatory post-flight examination. And, at the meeting with the journalists, the crew members appeared in a specific "habit." Each was covered with sensors and had a portable electrocardiograph on a waist-belt.

The sixth main crew to go to the Mir station can also be referred to another way. As the first production crew. Because it was A. Solovyev and A. Balandin who received the Kristall orbital module and made it part of the orbital complex's system. And then they were the first to open the doors of its six furnaces. They performed industrial production heats of semiconductor materials. Having handed over the "hot" shop to G. Manakov and G. Strelakov, they brought 23 half-meter crystals of gallium arsenide, zinc oxide and other materials back to Earth.

That represents the main material success of the sixth mission. I am talking about the fact that there is something tangible. In addition, according to the specialists' rough estimates, out of the 520 experiments planned, 506 were performed over the course of the mission. Almost 100 percent. It could have been less. But it helped that the mission was extended by 10 days.

And now, from the ecological and environmental results, it is already clear that the mission was extraordinarily effective. For the time being, our preeminence here is indisputable. We have obtained the world's best photos of the earth's surface. They have unprecedented resolution and chromatic transmission. In all, 21 million square kilometers of the planet's surface were photographed.

The final results of the mission will be summed up later—after a study of the report being written by the cosmonauts.

But in the work performed by each crew, there are features and details that, with the passage of time, will be of ever greater significance. They are the experiments that are working for the future. Over the past six months, the Rodniki were engaged in in-orbit research involving preparations for a Mars flight.

I can't help but think that, in the next century, the crew of the Mars interplanetary mission will have a kind word for A. Solovyev and A. Balandin. Especially when they sit down to a golden-brown chicken in their own space kitchen or when they wolf down a fresh omelet for breakfast during the flight to the Red Planet. After all, the Rodniki conducted the first experiments in weightlessness with a Japanese quail. It is a big contribution to the development of a closed life-support system. And there everything was a first during the six months. For the first time, nestlings were hatched in an incubator. And, alas, for the first time, they died. For the first time, mature quail were launched into space. One cockerel and three hens. And, for the first time, a hen laid an egg in a space ship. The directions for further research are already evident.

"The 180 days of the flight went by for us like a single day," noted A. Balandin, responding to a question from RABOCHAYA TRIBUNA's correspondent. "The Mir station is a unique facility, acutely necessary for the planet's ecology and the country's national economy. It represents our preeminence and pride. Its American analog, the Freedom station, is still in the computer design stage. The Soviet Union has had an orbital complex aloft for a long time. The volume of work on it must be increased. Two-man crews on a long-duration flight are no longer enough to get maximum use of the orbital complex's potential."

#### **Cosmonauts Prepare for Second EVA**

*LD2301083191 Moscow TASS in English 0736 GMT  
23 Jan 91*

[By TASS correspondent Rena Kuznetsova]

[Text] Moscow January 23 TASS—Soviet cosmonauts Viktor Afanasyev and Musa Manarov, who have been

working aboard the Mir space station for six weeks, are expected to venture into open space today. The opening of the hatch is scheduled for 13:50 Moscow time [1050 gmst]. The cosmonauts will be outside the station until 17:25 Moscow time, a Mission Control Center spokesman told TASS.

During this time, the crew are planning to assemble a telescopic transportation device on the exterior side of the Mir station, which is designed to move [solar] batteries from the Kristall module to the Kvant module. If they have time, the cosmonauts will explore the ionosphere and magnetosphere of the Earth and will also make a video film of the Earth's surface.

The spacewalk will be the second venture outside the station by the eighth resident crew. Afanasyev and Manarov made the first spacewalk on January 7 to repair the exterior hatch of the Kvant-2 module. All in all, the cosmonauts are expected to carry out four space-walking ventures during their expedition.

Cosmonauts' work outside the station became a habitual matter for the space station's crews, caused above all by the need to service the giant space station.

The space station's fifth resident crew—Aleksandr Viktorenko and Aleksandr Serebrov—tested a device for cosmonauts' movement in open space. Aleksandr Serebrov was the first to try the device in February 1990. The maximum possible distance from the escape hatch then amounted to 33 meters. Aleksandr Viktorenko, the commander of the crew, continued trials on February 5. He withdrew from the station to a distance of 45 meters.

Pilot-cosmonaut of the ussr Aleksey Leonov was the first man to walk into open space on March 18, 1965. Jean-Loup Chretien, a French astronaut, was the first member of the Mir station's international crew to venture into space in December 1988.

### **Destructive Reentry of 'Salyut-7' Space Station To Take Place Early in 1991**

*LD0312082290 Moscow TASS in English 0805 GMT  
3 Dec 90*

[Text] Moscow December 3 TASS—The Salyut-7 Soviet space station has neared the final stages of its flight and is expected to enter the dense layers of the atmosphere in January-February and burn out of existence.

The station was launched in April 1982. It was manned for a total of 810 days. During the past four years the unmanned craft remained in orbit as a test of its maximum life.

The station orbital parameters are as follows:

- maximum distance from earth—326 kilometers,
- minimum distance from earth—309 kilometers,
- inclination—51.6 degrees,
- revolution period—90.6 minutes.

The Mission Control Center is monitoring Salyut's flight.

The exact date of its entry into the atmosphere will be announced separately.

### **'Salyut-7' To Disintegrate in Earth's Atmosphere**

*LD2912215290 Moscow Domestic Service in Russian  
1600 GMT 29 Dec 90*

[Text] The flight of the Salyut-7—Cosmos-1686 orbital complex is drawing to a close. The Flight Control Center and the monitoring stations on the ground are supervising the progress of the flight and carrying out trajectory measurements of the parameters of the orbit.

On 29 December, the maximum altitude of the station was 305 km, while its minimum altitude was 275 km. According to the forecast of the specialists, the Salyut-7—Cosmos-1686 will enter the dense layers of the Earth's atmosphere and disintegrate in February 1991. As it descends, the orbital complex, weighing about 40 tons, will disintegrate into small individual parts, most of which will burn up in the dense layers of the atmosphere. There are no radioactive or any other harmful substances aboard the station. Information about the precise date and the time of the station entering the atmosphere and about the likely site of impact will be published 24 hours before the event. All states on whose territory individual parts may hit the Earth will be warned in good time.

### **Dunayev Says Parts of 'Salyut-7' May Reach Earth's Surface**

*LD2712123290 Moscow World Service  
in English 1200 GMT 27 Dec 90*

[Text] A Soviet aerospace official says the orbiting research complex incorporating a station and spacecraft is expected to burn out on reentry in January or February.

Mr. Aleksandr Dunayev said the Salyut-7 station, which had failed to obey ground commands, was transferred to a rameter orbit in 1986. However, he said, the station was now out of control which does not rule out the possibility of some parts of the complex reaching the Earth's surface.

### **Comments on Reentry of 'Salyut-7'—'Cosmos-1686'**

*LD0401220691 Moscow Central Television First  
Program Network in Russian 1800 GMT 4 Jan 91*

[Report by commentator Petr Orlov, including remarks by Dr. Gorshkov, chief of the Orbital Station Design Department of the Energiya Scientific Production Association ; from the "Vremya" newscast—recorded]

[Text] [Announcer] According to a report from the Flight Control Center, the Salyut-7 Soviet orbital station will enter the dense layers of the atmosphere in February and cease to exist. Details of the report by our commentator Petr Orlov.

[Orlov] Salyut-7 is returning, but not as planned and much earlier than expected. In 1986, when Leonid Kizim and Vladimir Solovyev flew to the new station, Mir, the Salyut-7 was transferred to a higher orbit and left there until better times and namely until Buran could return it to earth. According to the most modest estimates, Salyut could stay in orbit for another eight-10 years, but in actual fact, it has turned out to be half of that.

[Gorshkov] Since 1987, to our surprise and everyone else in the world, solar activity has increased sharply to such an extent, as far as I know, that such an increase in atmosphere density at these heights had not been registered up until then; density increased three to four times. And the station began to fall sharply.

[Orlov] And that was not due to mistakes. The same thing happened to one of our satellites and the U.S. Skylab station before that. The fact of the matter is that it is practically impossible to forecast such things. Moreover, while our satellite burned up, Skylab, weighing 80 tons, was not destroyed completely in the atmosphere. Nothing is simple as far as our station is concerned either, although it weighs less. The fact of the matter is that Salyut is not returning to earth alone. Another entity [obekt] is attached to it, called satellite Cosmos-1686. In

fact, this is one of our largest Soviet space ships undergoing secret tests at that time. Not even all the cosmonauts have seen it. Moreover, a photograph of it has not been published anywhere. But that invisible ship weighs almost 20 tons. Mir station modules are now made on the basis of it. But unlike them, Cosmos has a reentry module which should not burn up in the atmosphere and did not burn up when it underwent tests, this is extremely unfortunate. However, experts look upon the forthcoming collision with the Earth rather optimistically.

[Gorshkov] There is practically no likelihood of it causing any kind of damage.

[Orlov] Today, many recalled the unique flight of Vladimir Dzhanibekov and Viktor Savinykh who revived Salyut-7 when it fell silent the first time—in 1985. But a repetition of such a thing will not happen today. There is no opportunity and mainly there are no resources. What if we were richer and were able to send a ship to save the station? And what if something were to happen to a crew today? One of the rescue cosmonauts, Vladimir Titov, is not confident that in every case they could come to the rescue of a crew. It is worth thinking about when preparing to bid farewell to the falling Salyut. Or, as already is the case, will money be allocated for space safety only when something falls down upon one's head?

#### Further Comments by Gorshkov on 'Salyut-7' Return

*LD0501145391 Moscow Domestic Service  
in Russian 0650 GMT 5 Jan 91*

[Remarks by Leonid Alekseyevich Gorshkov, chief of the Orbital Station Design Department of the Energiya Scientific Production Association, on "the fate of the Salyut-7 orbital station" at a news conference with unidentified correspondents on 4 January; place not given—recorded]

[Text] [Gorshkov] After we finished work on this station in 1986, the decision was made to raise the station's orbit to a height at which it would continue in flight, according to our assessments over a 10-20 year period. We planned to work with it using our Buran vessel. We planned very interesting experiments to see how materials behave over such a unique time. I must say that even now the station is still operational: the energy supply system is working, and the solar batteries are rotating, constantly turning toward the sun. Very interesting experiments were planned overall.

However, since 1987, to our surprise and to that of everybody in the world, solar activity has increased sharply, to such an extent—as far as I know, such an increase in atmospheric density at these heights had not been registered up until then—that density increased three to four times. The station began to fall sharply. In effect, we were unable to influence its orderly descent from orbit.

Now, according to forecasts, somewhere around the beginning of February the station will fall from orbit. Currently, one can only say that the region in which it will fall from orbit will be somewhere between 51 degrees north and 51 degrees south. We will know more details a few hours in advance. We have no fear that this could cause any damage.

[Correspondent] What is the station's mass now?

[Gorshkov] A total of 40 tons. It includes Salyut-7—the basic unit—and Cosmos-1669 [figure as received]. This module is the prototype of the modules we are now using.

[Correspondent, in English with superimposed Russian translation] THE NEW YORK TIMES: How big is the largest fragment which could potentially reach the Earth's surface?

[Gorshkov] About three tons, if any of the parts of the sections which have heat protection reach the Earth's surface. It is very difficult to say what size the other fragments will be, but we think there could be somewhere around a few dozen such fragments of up to 10 kilograms.

Considering the concern I sense in the question, I would like to say that it is known that up to tens-of-thousands of tons of meteorites fall every year in this belt.

#### 'Salyut-7 Reentry Forecast for 10-11 Feb

*LD0401192691 Moscow TASS in English 1852 GMT  
4 Jan 91*

[By TASS correspondent Rena Kuznetsova]

[Text] Moscow January 4 TASS—"The Soviet Salyut-7 space station will plunge from the near-earth orbit and burn in the dense layers of the atmosphere," Leonid Gorshkov, head of the department for orbital station design of the Energiya Science and Production Association, said at a briefing at the Soviet Foreign Ministry Press Centre today.

He expressed hope that if pieces reach the Earth's surface, they would cause no harm to people.

Gorshkov recalled that Salyut-7, which was launched into near-earth orbit in April 1982, was the last in a series of second-generation orbital stations at which long-term manned flights were made. Its use ended in 1986.

Mir, a new-generation station, is in orbit now. It hosts the crew of the main eighth expedition—Viktor Afanasyev and Musa Manarov.

According to specialists' estimates, the Salyut-7 station could have lasted several more years. The operation of the station's systems and units in space conditions was of



interest to scientists and designers. There were plans to use Salyut-7 to practice the manoeuvres of the Buran shuttle.

However, solar activity has significantly increased since 1987 and the Salyut-7 station began to descend. Specialists decided it was inexpedient to "revitalise" the station.

Specialists in ballistics calculated that Salyut-7 is to enter the dense layers of the atmosphere and cease to exist between February 10 and 11 (plus-minus ten days). Fragments that do not burn up and that reach earth are no more dangerous than ordinary meteorites, Gorshkov said. The site where fragments will fall can be calculated only several hours before the fall. Gorshkov emphasised that there are no any radioactive or other harmful substances aboard the station.

### Warning To Be Issued Before 'Salyut-7' Reentry

PM0501152991 Moscow SOVETSKAYA ROSSIYA  
in Russian 5 Jan 91 First Edition p 2

["Before The Event" report by M. Chernyshov: "Where Will 'Salyut' Come Down?"]

[Excerpt] [passage omitted] All states that launch spacecraft obviously take into account the possibility of emergencies. There is an international treaty whereby a country is responsible for damage caused to other countries by its space vehicles on the ground, in the air, or in space. The Soviet Union is a party to the treaty and all that it entails. Through the selection of orbits and by means of certain other measures, everything possible is done to prevent satellites and fragments of satellites from reaching the earth.

But it is not feasible to make an absolutely safe version. Our station is a combination of two elements—"Salyut-7" and "Cosmos-1686." The total weight is 40 tons and the orbiting altitude is 305-275 kilometers. There are no radioactive or other dangerous substances on board. In February the complex will increasingly make inroads into the dense layers of the atmosphere. Eventually the remains of this "meteorite" will reach the earth's surface or will scatter across the ocean. That is the general picture.

"It is perfectly clear," space flight deputy leader Viktor Blagov said, "that most of the complex will not reach the earth but will burn up in the dense layers of the atmosphere. But it includes elements which can withstand the heat. In particular, the so-called reusable vehicle, which is part of the "Cosmos-1686" satellite-spacecraft. Although no one can say for sure in what form it will reach the earth, the likelihood of pieces coming down is not ruled out.

"At the moment we are unable to calculate the exact area where it will come down. But the situation cannot be described as out of control. The station is being constantly tracked by our facilities.

"We are being helped by U.S. tracking stations too. Generally speaking, the likely drop zone is a relatively narrow corridor 'tied' to a projection of the orbit. The exact time of the station's entering the dense layers of the atmosphere will be known 24 hours before it falls. All states will receive prompt warning of this. As the station descends, we will obtain increasingly accurate data and, in the event of a specific danger arising, there will be time left to warn the population and to take appropriate measures. It is possible to hope that all will end happily...."

### Official Stresses Minimal Damage Likely From 'Salyut-7' Reentry

PM0801113591 Moscow PRAVDA in Russian  
7 Jan 91 Second Edition p 1

[Report by special correspondent A. Tarasov under the rubric "Attention: Salyut-7": "Anton Davydovich Requests a Landing"]

[Text] The first person to whom the space department allocated the role of a heat shield against questions about Salyut-7 was our good acquaintance Leonid Alekseyevich Gorshkov, none other than the chief of the orbital stations design department of the "Energia" Science and Production Association personally. At a briefing in the Foreign Ministry Press Center he presented a picture of an orbital slalom.

"The station is now functional," he began by saying. "The power supply system is working."

But then he specified that this functionality is limited, since there is no fuel in the tanks: It was all expended on raising the orbit in 1986. In addition, the station has lost its controllability, which has doomed it to an arbitrary descent.

It had been planned that it would be able to exist in a high orbit for 10-20 years, after which it would become technically possible (by means of "Buran," in particular) to bring the main units home. Let us agree that this would be a highly tempting experiment for spacecraft builders. But the sun rebelled. One year after raising the orbit, solar activity sharply increased the density of the atmosphere. Rapid braking began....

"But the solar cycles and the peaks of solar activity are well known, are they not? Why was this not taken into account?"

"The activity proved unpredictably high. I cannot recall such an increase in the atmosphere's density at such altitudes in all the years.... The atmosphere became three to four times denser and upset all the ballistic calculations.

"What is the complex like which is heading toward the earth? It is a 40-ton mass, which includes two mighty units: Salyut-7 itself and Cosmos-1686—the prototype of the present modules."

"What is the likely debris that might reach the earth's surface?"

"The largest piece is on the order of three tonnes," Leonid Alekseyevich admitted with no particular enthusiasm. "Several dozen small ones, each weighing less than 10 kg."

The three-tonne piece turned out to be none other than the reentry vehicle of the Cosmos. Just imagine: Such a heat-resistant sphere, which, moreover, has not been undocked from the whole Salyut, is heading for the earth without any parachute.... Where will it fall?

"At present it is possible to speak of the whole sector of the planet between 51 degrees north and 51 degrees south, over which the flight path passes. We will know more accurately a few hours before it falls."

"Will the population of the 'risk zone' have time to take measures to protect or evacuate themselves?"

"I do not think this will be necessary. We have no fears that falling debris might harm anyone. The debris is falling over too large a territory, in a belt approximately 8,000 km long and 100km plus or minus 100 wide.... [as published] The chief thing on which our optimism is based is the fact that empty spaces predominate on earth over these territories. Between 100 and tens of thousands of tons of meteorites of various sizes fall onto this belt of the planet every year, and we have not heard of any trouble...."

"Have the questions of rescuing such objects been raised? Maybe an automatic craft could repeat the feat of Dzhaniybekov and Savinykh—dock, deliver fuel, and carry out an order from earth for a controlled descent?"

"First, automatic equipment would be unable to carry out Dzhaniybekov's docking with an unresponsive and irregularly departing object.... Second, this is simply not necessary and entails unnecessary expenditure and extra risk. For the sake of what? I repeat, the likelihood of damage is minimal. The same as, let us say, if you were now to go out into the street and the first 10 men you encountered turned out to be Anton Davydovichs, and the first 10 women you met were Margarita Sergeyevnas...."

So, 10 February plus or minus 10 days. There is still time to insure oneself against all risks. It is not too late to announce a planetwide lottery: Whoever guesses the place where the sphere will fall will receive a free flight back to where he flew from, at the expense of the USSR Main Administration for the Creation and Utilization of Space Technology....

#### **Orbital Parameters of 'Salyut-7' Reported**

*PM1801112091 Moscow PRAVDA in Russian  
17 Jan 91 Second Edition p 6*

[TASS report: "On the Flight of the 'Salyut-7' Station"]

[Text] Flight Control Center, 16 Jan—The ground tracking services are continuing round-the-clock observation of the flight of the "Salyut-7—Cosmos-1686"

complex. Its current orbital parameters are as follows:  
Maximum distance from the earth's surface—278 km.  
Minimum distance from the earth's surface—259 km.  
Orbital period—89.6 minutes.  
Orbital inclination—51.6 degrees.

Experts calculate that the "Salyut-7—Cosmos-1686" complex will cease to exist during the first half of February 1991.

#### **Salyut Station Program Victim of 'Political Games'**

*PM2201164591 Moscow IZVESTIYA in Russian  
18 Jan 91 Union Edition p 8*

[Report by S. Leskov: "'Salyut-7' Is Falling. No One Knows Where and When"]

[Text] The "Salyut-7" station is continuing its descent toward the planet. According to the latest information from the Flight Control Center, the station is expected to fall to earth within the period 2-12 February. The precise area can only be indicated a few hours before the event.

It appears from senior officials' explanations that nobody is to blame for the critical situation. The drastic change in the station's orbit has been produced, according to the official story, by the unpredictable upsurge in solar activity over the last three years.

Certain facts cause us to doubt this story. Following IZVESTIYA's publication of an article on events surrounding "Salyut-7" (this year's issue No. 6), V. Salnikov, who spent 25 years working at the USSR Council of Ministers Military-Industrial Commission, appealed to the editorial office. Vladislav Alekseyevich said that back in 1986 he had insisted on using up the fuel on board for the craft to land. Otherwise, as calculations showed, the station would commence an uncontrolled descent early in 1991. We would remind you that the forecast was made five years ago...

By the way, even now V. Salnikov's prompt forecast conflicts with official data. According to a "private" individual's prediction, the station will fall to earth 24 January. But it is obvious that, in the unforeseen situation, more meticulous calculations have been carried out at the Flight Control Center...

To be honest, references to the vagaries of the sun are reminiscent of our constant complaints about the bad weather that disrupts the harvest campaign every year...

"It is annoying to hear this tale about the unpredictability of solar activity over the last few years," S. Avdyushin, director of the Institute of Applied Geophysics, confirmed my doubts. "This upsurge is by no means a surprise, we issued warnings about it. 'Salyut-7's' trajectory was computed using a model that failed to take

the increase in solar activity into consideration at a time when a reliable model existed whereby the atmosphere 'expanded' during that period—as actually happened."

So, we are dealing with an unfortunate technical examination and mistrust of a specialist's opinion. All this is as old as the hills and would not merit another mention were it not for the fact that other extremely sensitive questions typical of our scientific management were not entangled in the subject of the uncontrolled station.

You get the impression that 'Salyut-7's' fate was in many respects determined not by technical expediency but by the political aspects of space exploration, on which public attention was focused. "Salyut-7" was, after all, in many respects sent off to the higher strata of the atmosphere to be mothballed because the new "Mir" orbital station "had" to be launched in 1985 in time for the latest party forum and there were not enough funds to operate two such major facilities. Is that not the reason why "Mir" went into orbit clearly unfinished, after being insultingly but justly dubbed a "space construction schedule overrun." It was a pity to "scuttle" the operational "Salyut-7" right away.

The political games in space exploration did not begin today. "Salyut-7" has experienced them in full measure since its inception. Let us ponder the following question: How did a three-ton incombustible module, which also presents the main threat in the descent, end up in the "Cosmos-1686" freighter docked to the station? Why could this freighter not have been undocked from the station and, while there was still fuel in the tanks, "brought down" in the assigned area? It transpires that undocking was only possible mechanically in this case, using cosmonauts, and the last crew had left the station hastily in November 1985 due to the worsening of V. Vasyutin's illness, which had been overlooked by medical personnel on earth. (Incidentally, the subsequent flight by the female crew—Savitskaya, Ivanova, and Dobrokvashina—was thwarted as a result).

The clue to this lies in the sixties, when three outstanding chief designers—Korolev, Glushko, and Chelomey—fought implacably for their space programs to be given priority. All three were complex, unyielding men. They valued their designs but funds allowed them to implement only one program. The chief designers tried to enlist support at the very top and the outcome of the technical disputes within this "triumvirate" was often determined not by scientific expediency but by political leaders' sympathies. The favor of not even Khrushchev, Brezhnev, or Ustinov, but of a totally forgotten Central Committee agent could determine the prospects for the development of the highly complex sector for years ahead. It would be instructive to trace how drastically space program funding changed depending on reshuffles within the party and state elite.

All these rapid changes could simply not help but take their toll on the particularly prestigious work on orbital stations. This series of several stations received the single

name "Salyut," but, strange as it may seem, it had more than one master—two at once. Some of the stations were designed at Korelev's design bureau (later Glushko's) and some at Chelomey's design bureau. The stations differed greatly from one another but were given the same name to ensure that our wily enemy would get lost in our space industry's blind allies. Every design bureau naturally developed transport ships in addition to the station, to service their stations and with their own docking units.

A great deal of the work was in vain, due to a partial change in the political winds. For instance, no more and no less than eight transport ships, manufactured to serve their station, stood in the Chelomey Design Bureau "hangars" for 15 years. They were distinguished by a reentry vehicle with a heat shield carrying a payload of 300 kg (that is a dream even today). This was the prototype of the modules currently docked at the "Mir" orbital complex. But no one wanted to exploit their rivals' achievements, thus holding back the logical development of space exploration. It was only in 1985 that Chelomey's ship, "Cosmos-1686," was launched and docked with "Salyut-7." According to plan, V. Vasyutin's crew should have undocked the apparatus from "Salyut-7" in January 1986 but, as we recall, the cosmonauts urgently returned to earth on physicians' orders. As a result not only was the unique apparatus on board the "Cosmos" not even tried out, but the incombustible module devised for noble purposes may literally cause a considerable stir in its descent now.

I am quite convinced that the story of the development and operation of the "Salyut-7" station is far more dramatic than its impending fall to earth. There is a tremendous likelihood that the reentry vehicle will fall into a deserted area. The problem resides elsewhere. In today's contradictory situation as regards space exploration, the cost of every thoughtless step that may harm its reputation is rising sharply. "Salyut-7" has not merely brought with it the burden of old mistakes, but has also generated new ones. Let us hope that the lesson will be beneficial. But where is the guarantee that seeds of similar conflicts with far more considerable consequences are not ripening in the heart of space exploration today? You once again reflect on the need to develop a single coordinating center like NASA in our space industry.

#### Scientists' Discoveries on Quasars, Supernovas Noted

LD1611215290 Moscow TASS in English 2050 GMT  
16 Nov 90

[By TASS correspondents Veronika Romanenkova and Andrey Surzhanskiy]

[Text] Moscow November 16 TASS—Radio frequency impulses, which for many years were considered by

scientists as signals from other civilisations, are produced by out-of-galaxy objects named quasars, gigantic exploding stars.

The discovery made by Soviet astrophysicist Gennadiy Sholomitskiy from the Soviet Academy of Sciences' Institute of Space Research, and the method of research worked out by him, allow to discover very small space objects and determine their dimensions and remoteness from the earth. The work was today introduced in the Soviet state register of discoveries.

Sholomitskiy was the first to discover experimentally the increase and decrease in flows of radio waves from supernova stars. Sholomitskiy told TASS that special receiver equipment helped him make the discovery.

Scientists believed that the astronomical objects do not change their nature and qualities for millennia. But theoretical research, later confirmed experimentally, shows that evolution processes occur in them every month and every week, Sholomitskiy said.

According to the scientist, the discovery has changed the concept of the structure of our universe and has become the foundation for new in principle methods for its studies. The methods have already helped find lots of "interstellar neighbours." The results of the discovery are successfully used during studies of continental movements, in the time service and in resolving other applied tasks.

Another discovery was registered today. It was made by Yuriy Pskovskiy from the State Astronomy Institute. By comparing certain parts of spectrum of various astronomical objects, the scientist has defined more precisely the nature of supernova (exploding) stars and determined their physical characteristics. He believes the method will allow to determine the distance to objects in other galaxies.

### RT-70 Millimeter Radiotelescope

907Q0147 Moscow *ZEMLYA I VSELENNAYA*  
in Russian No 4, Jul-Aug 90 pp 26-31

[Article by L. M. Gindilis, candidate of physical and mathematical sciences, Main Astronomical Institute imeni Shternberg, Moscow State University; first paragraph is source introduction]

[Text] *As already reported in our journal (ZEMLYA I VSELENNAYA, No 3, 1990), construction of a radioastronomy observatory of the Astronomy and Space Center (ASC) of the USSR Academy of Sciences Physics Institute is under way on the Suffa Plateau in Uzbek SSR. The main instrument of the observatory will be the 70-meter RT-70 radiotelescope, which is designed for operation in the millimeter wavelength range.*

### Prototype and Modernization

Back in the late 1970s, the 70-meter radiotelescope of the Center for Deep Space Communications (CDSC), operating in the decimeter and centimeter ranges, already went on line in the USSR (*ZEMLYA I VSELENNAYA*, No 4, 1989). Because that telescope has good parameters and is of sound design, it was decided that it would be used as a prototype in the creation of a new radiotelescope intended for operation in the millimeter range. It would have been better, of course, to design such a radiotelescope from scratch, but there was no suitable industrial base with which to do it. The only way to do it was to modernize an existing design on the basis of the available industrial technology.

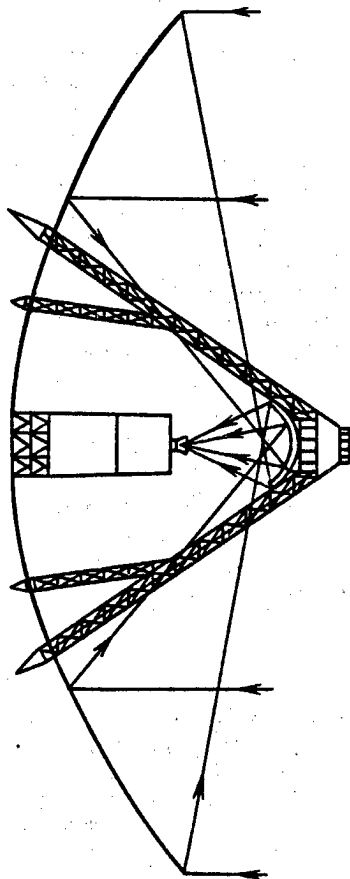
The upper wavelength limit for the millimeter telescope is 1.2 mm. In order to ensure efficient radiotelescope operation at that wavelength, the total deviation (that is, caused by various factors) of the reflecting surface of the mirror from the computed paraboloid cannot exceed 70  $\mu\text{m}$  (and that with a mirror diameter of 70 m!). The width of the radiation pattern at a wavelength 1.2 mm is 3.5". Accordingly, the accuracy in pointing at and tracking radio sources must be 0.3 second of arc.

In order to meet those requirements, it was necessary to develop new, highly precise reflecting panels for the primary mirror (manufactured to an accuracy of 20  $\mu\text{m}$ ), an adaptive system compensating for deformation of the support structure, and a pointing system. Let us talk about how some of those problems were solved.

### Optical Configuration

First of all, a new optical configuration had to be developed for the radiotelescope. In the old system, the primary mirror was a quasiparaboloid. That provided a maximum utilization factor for the radiotelescope as a result of irradiation that was more uniform. In fact, that is achieved at a price—losses in the principal focus (a quasiparabolic surface does not have a focus). But a specially designed counterreflector (KR) compensates for the phase distortions introduced by the quasiparabola and focuses the radiation in a secondary focus (which is why the telescope can operate in that focus only). That is not entirely convenient, especially when working with millimeter wavelengths, when an exceptionally high accuracy is required. Indeed, operation in the secondary focus is accompanied by errors associated with inaccurate installation of the counterreflector.

In the new system, in order to be able to work in both the principal focus and the secondary focus, the primary mirror is a paraboloid, and the secondary mirror (or counterreflector) is elliptical, i.e., a classical Gregorian two-mirror system is used. One of the foci of the elliptical mirror matches the focus of the paraboloid; a second focus is situated near the base of the mirror system (near the apex of the parabola). A. Ye. Andriyevskiy proposed the fundamental ideology for the

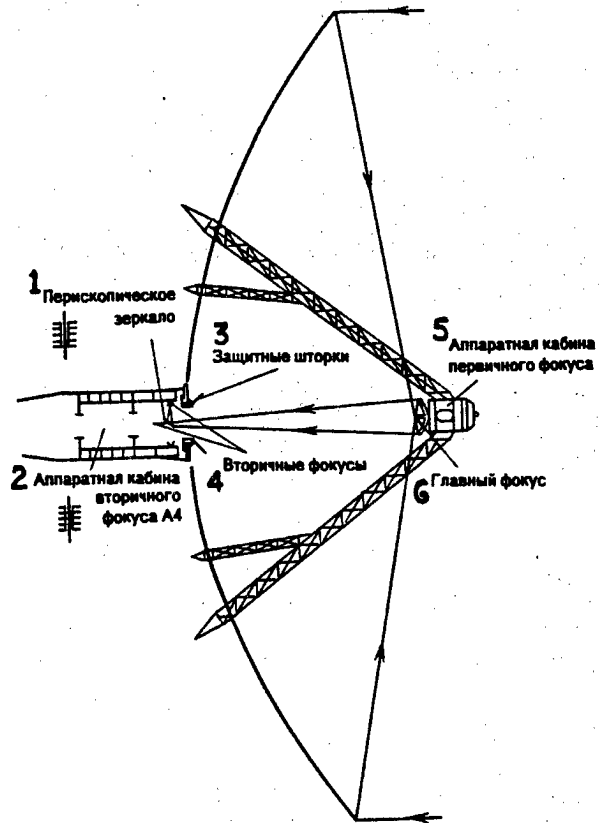


Optical configuration of CDSC radiotelescope.

configuration and the design approach. Highly precise reflecting panels were developed on the basis of his technical proposals.

Three removable instrument compartments (IC) are designed for work in the principal focus in different wavelength ranges. IC A1 is used for the S range (1-6 mm), IC A2 is intended for work in the M range (6-8 cm), and, finally, IC A3 is used either for the L range (8-21 cm) or when working in the space-ground radiointerferometer program (ZEMLYA I VSELENNAYA, No 1, p 4, 1983; No 4, p 20, 1987—*Editor*). In the latter case, it is outfitted with the same set of instrumentation that is aboard the KRT space radiotelescope.

For work in the secondary focus, two counterreflectors are used: a Kr-1 with a 3-meter diameter (more precise) for the S range, and a KR-2 with a 5-meter diameter for the M range. The IC for the secondary focus, A4, is mounted at the base of the mirror system. The counterreflectors KR-1 and KR-2 are structurally connected to the ICs A1 and A2, respectively. Thus, in the S and M ranges, it is possible to work in both the principal focus and secondary focus without changing the ICs. In addition, simultaneous observations can be made in the



Optical configuration of RT-70 millimeter radiotelescope.

Key: 1. Periscope mirror—2. Instrument compartment of secondary focus, A4—3. Protective shutters—4. Secondary focuses—5. Instrument compartment of principal focus—6. Principal focus

principal focus and secondary focus at different frequencies (in the principal focus, at a higher frequency; in the secondary focus, at a lower frequency).

Each counterreflector has five degrees of freedom. Special drives are used to move the counterreflector in small increments along three mutually perpendicular axes—X, Y, Z (Z is the focal axis of the main mirror)—and rotate it about the X and Y axes. The IC A3 has no counterreflector: observations are made in the long-wave range in the principal focus only.

A periscope mirror is mounted in IC A4. It is used to direct the radiation to any one of the six primary feeds of the radio receiving equipment, which are situated along the IC periphery (every 60°). That capacity is achieved through stepped rotation of the periscope mirror at 60° increments around the focal axis of the main mirror. Moreover, it performs certain other additional functions.

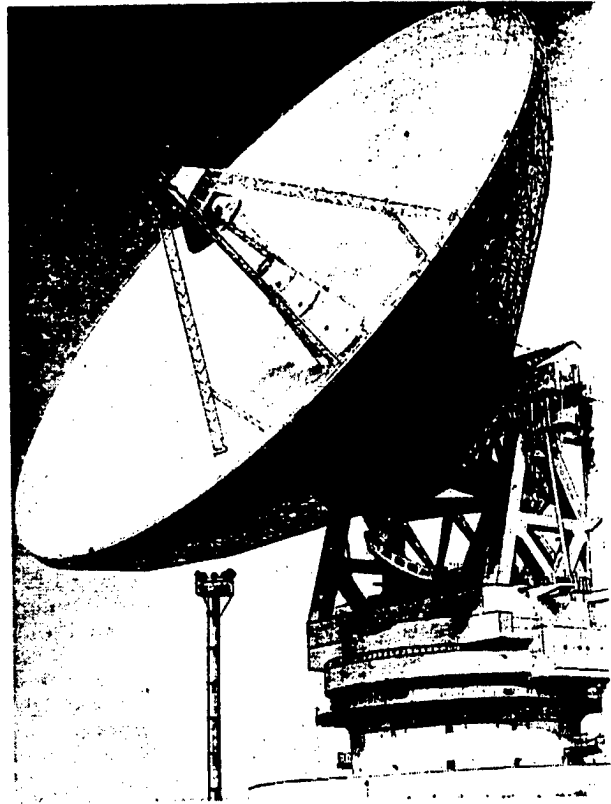
#### Adaptive Surface

When the radiotelescope is rotated, its reflecting surface is deformed as a result of gravity. Such deformations are

weight deformations. For the RT-70, the maximum weight deformations at the edge of the mirror constitute 30 mm (measures are being taken to halve that). Most such deformations are so-called homologous deformations. What are homologous deformations? The supporting framework to which the reflecting panels are attached is designed in such a way that when the mirror is rotated through the angle of elevation, its reflecting surface is deformed not arbitrarily, but in such a manner that the parabolic surface become another a parabolic surface, but with a different parabola orientation and with a different position of the focus. Such deformation does not hinder the operation of the radiotelescope: the counterreflector must merely be moved into a position corresponding to the position of the new focus. Many large radiotelescopes, such as that at Bonn, operate in this way. When the mirror is rotated, the counterreflector is continuously moved, at all times remaining in the focus of the "current" paraboloid.

Of course, the shape of the paraboloid is not maintained with absolute accuracy. There are residual nonhomologous deformations that make the shape of the surface deviate from the parabolic. For the RT-70, those deformations amount to 1-3 mm. That is no impediment to radiotelescope operation in the decimeter and centimeter wavelength ranges, but is completely unacceptable at millimeter wavelengths. After all, as was already noted, the deviations must not exceed  $70 \mu\text{m}$ . In order to solve that problem without changing the entire supporting structure, it was decided to apply the adaptive principle. The reflecting surface of the RT-70 mirror consists of 1,200 panels. Let us assume that the panels are ideally precise and, after adjustment, form the surface of an ideal paraboloid. If the mirror is now turned through the angle of elevation, then nonhomologous deformations will result in the positions of the panels deviating from the surface of an ideal paraboloid. We can measure those deviations, and if each panel is outfitted with change-of-position mechanisms, any panel can, in principle, be readjusted to match the surface of an ideal paraboloid. Such adjustment must be performed automatically in real time, with constant compensation for nonhomologous deformations so as to maintain the parabolic shape of the mirror surface. In practice, such a method has never been used—the RT-70 is the first to use it.

In order to effect such a system, the highly precise reflecting panels of the RT-70 were outfitted with change-of-position mechanisms that have electric stepper motors; they effect movement of the panels through the normal to the surface within +10 mm. The accuracy in mechanism performance is  $10 \mu\text{m}$ . A. Ye. Andriyevskiy was the designer of the mockup of the mechanisms. A mathematical model of the adaptive system was developed at the Space Research Institute, USSR Academy of Sciences, by the I. D. Novikov group. The model works in the following way. First, the distances from the reference mark to the adjustable points are measured. Then the measured distances are used in



70-meter radiotelescope at the Center for Deep Space Communications (CDSC)—a prototype of the RT-70 millimeter radiotelescope.

computing the coordinates of the points in a coordinate system referenced to the telescope. The coordinates are used in determining the distances from those points to the surface of the paraboloid, which was obtained in the preceding cycle and whose parameters are stored in a computer memory. If those deviations are less than the acceptable values, the cycle is then ended. If they are greater than the acceptable values, the process proceeds to the next step: the distances to the paraboloid are compared with jack-position data, which are also stored in the computer memory. If the deviations are less than the travel of the jacks, a command is sent to the actuating mechanisms to move the adjustable points to a paraboloid surface; after that, the cycle is repeated. If the deviations are greater than the travel of the jacks, the process proceeds to the next operation. Then a new paraboloid, optimally "inscribed" at the experimental points corresponding to the measured position of the panels, is then computed. After that, the process again proceeds to the operation for determining the distance from the adjustable points to the new paraboloid.

How are the coordinates of the adjustable points determined? There are several methods. The best developed is

the radio phase-meter method. Assume that we have positioned a radio transmitter and a radio receiver on the mirror axis and that we have placed a reflector on each panel. The transmitter signal, returning from the corresponding reflector, goes to the receiver; by measuring the difference in the phases of the transmitted and reflected signals, one can determine the distance to the panel on which that reflector was placed. If the transmitter is mounted on the mirror axis, one need only know the distance only from just this one transmitter to determine the coordinates of the adjustable points. For practical purposes, the transmitter must be moved off the mirror axis, which means that there must be several transmitters. Other variations of the method are also possible—for example, the use of a counterreflector. But the essentials remain as before: it is, in essence, a radio rangefinding method.

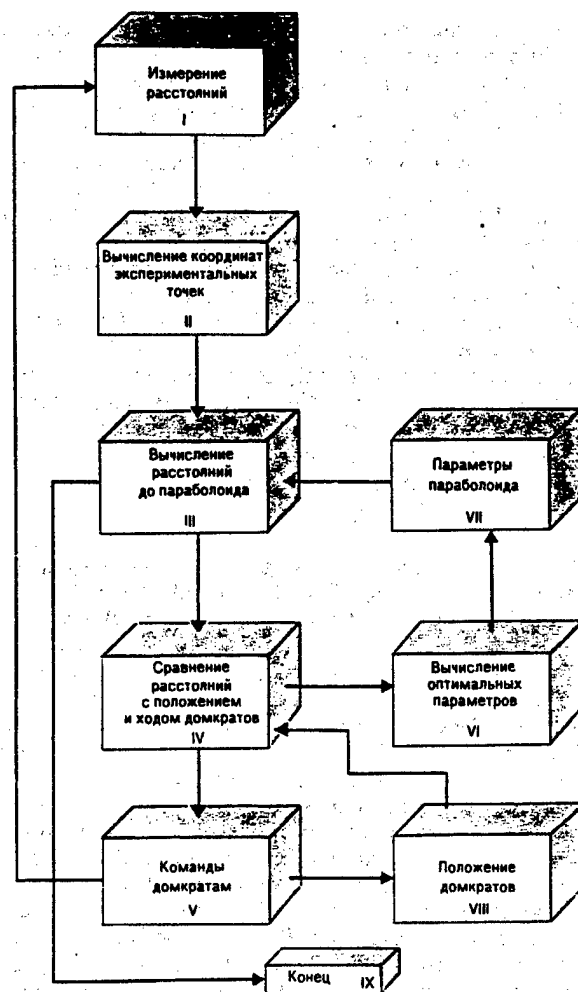
In place of a radio rangefinder, one may use an optical laser rangefinder, but that makes it difficult to achieve the required accuracy (about 25  $\mu\text{m}$ ). In that regard, the zero method, advanced by A. Ye. Andriyevskiy, is attractive. It does not involve measurement of the absolute values of angles or distances. The method is based on preserving some initial paraboloid. Any deviation from that paraboloid results in a mismatch signal that returns the deviating point to its initial position by acting on electrical jacks. A drawback to the method is that it requires an increase in the travel of the jacks. In addition, its specific application involving the use of lasers with existing supporting framework design encounters great difficulties.

A series method, proposed by I. M. Lisovich and G. S. Tsarevskiy, was also examined; one of the panels is used as a reference panel, and a second panel, then a third, etc., are successively referenced to it (in a series). This method results in an accumulation of errors with increasing distance from the reference panel.

All those measurement methods are essentially based on an initial paraboloid, which assigns the zero points of the adaptive system reading devices. That initial paraboloid is determined in the adjustment process. The radioholographic method is used as the main adjustment method for the RT-70.

#### Radioholographic Adjustment

Any deviation of the mirror surface from an ideal paraboloid will result in a phase change in the mirror aperture. The amplitude-phase distribution of the field in the mirror aperture in turn determines the complex radiation pattern  $RP^*$  at the far end. (The  $RP^*$  is the Fourier transform of the field distribution in the mirror aperture.) Consequently, if we measure the complex radiation pattern  $RP^*$ , then we can use an inverse Fourier transform to retrieve the field distribution in the mirror aperture and use that to determine the deviations of the mirror surface from a paraboloid. For the RT-70, the deviations are determined at the adjustable points. If a command is now sent to the actuating mechanisms,



Mathematical model of adaptive system, control algorithm.

Key: I. Distance measurement—II. Computation of coordinates of experimental points—III. Computation of distances to paraboloid—IV. Comparison of distances with position and travel of jacks—V. Commands to jacks—VI. Computation of optimal parameters—VII. Paraboloid parameters—VIII. Position of jacks—IX. End

they move the adjustable points to match the surface of the initial paraboloid. The corresponding positions of the electrical jacks determine the zero points of the adaptive system.

The successive steps are thus as follows: measurement of complex radiation pattern  $RP$  → inverse Fourier transform → amplitude-phase distribution of field in mirror aperture → errors in mirror surface.

The radioholographic method has been used extensively in recent years for the adjustment of many large radio-telescopes. A special feature of its application to the

RT-70 is that, with the RT-70, the adjustment is closely related to operation of the adaptive system, in determining the zero points of its reading devices. But since the position of the zero points is not maintained with a sufficient accuracy, the adjustment must be periodically repeated. How often it must be adjusted is determined in the course of operation. Indirect data, including experience in the operation of the RATAN-600, show that the adjustment must be carried out once a day. This imposes a rigorous limitation on adjustment time: it must not exceed one hour.

In order to determine the full (two-dimensional) radiation pattern, some radio-emission point source must be scanned. That gives the power radiation pattern. In order to obtain the complex radiation pattern, one must have information not only on amplitude, but also on phase. The reference antenna method is used for this purpose. The antenna under study (in our case, the RT-70) scans the radio source, and the reference antenna tracks it. The signals from the main and reference antennas are summed, and the resulting interferogram is used in determining the complex radiation pattern.

A ground-based generator, a generator in geostationary orbit, or a cosmic radio source is usually used as a radiation source in the practice of radiographic measurements. The RT-70 will be able to use all three types. Plans call for a ground-based generator to be set up on the neighboring Shau-Kartau Mountain (altitude, 4,030 m), about 10 km from the RT-70. Highly sensitive receiving apparatus will not be needed to ensure the necessary adjustment accuracy (25-30  $\mu\text{m}$ ), and a simple horn antenna can be used as the reference antenna. The main drawback to this method is that the measurement is made near the horizon (angle of elevation about  $10^\circ$ ), which is why radioastronomical observations, which are made at high angles of elevation, require a considerable reduction from the initial paraboloid to the working paraboloid, something that is always associated with errors. The use of geostationary satellites (angle of elevation about  $40^\circ$ ) makes it possible to partially eliminate that difficulty. Highly sensitive apparatus is not required here, either, and, again, a horn antenna can be used as the reference antenna. When cosmic sources are used to perform the adjustment, the procedure can be done at different angles of elevation (including those near the sources under investigation). That offers a considerable advantage. The principal difficulty involves the low flux of radio emissions. A highly sensitive receiver and a rather large reference antenna are needed to ensure the necessary accuracy. The receiving antenna of a satellite communication system is expected to serve as the reference antenna (ZEMLYA I VSELENNAYA, No 3, p 26, 1990—*Editor*).

### Scientific Objectives

In conclusion, let us say several words about the scientific objectives that can be addressed with the new radiotelescope. The RT-70 will make it possible to carry out a broad astrophysical research program. Plans call

for much attention to be devoted to an investigation of the interstellar medium via radiospectroscopy methods, especially in the millimeter range, where there are many molecular lines. Various molecular compounds, including organic compounds, in the interstellar medium will be investigated, which is of considerable interest in terms of the origin of life in the universe. Star formation foci and developing planetary systems will also be investigated. A special program will be devoted to investigation of radiopulsars associated with rapidly rotating neutron stars, which arise in the final stage of star evolution.

In addition, plans call for considerable attention to be focused on extragalactic objects—radiogalaxies, the nuclei of remote galaxies, and quasars. Those objects, situated at the edge of the observable universe, will yield information on the early stages of the evolution of the universe, when the formation of stars and galaxies began. Those observations should yield valuable material for solving fundamental cosmological problems.

With the RT-70, attempts will be made to search for the signals from extraterrestrial civilizations. With that in mind, plans call for a study of the line of positronium  $\lambda = 1.47$  mm, at which, according to N. S. Kardashev, signals from extraterrestrial civilizations can be expected.

Additional possibilities are opened by the use of the RT-70 as part of a ground-space radiointerferometer. The resolution of the interferometer will be  $10^{-5}$ - $10^{-6}$  second of arc. That will make it possible to register details of objects measuring about 100 km several parsec away or to register objects measuring one astronomical unit about a megaparsec away.

Prospects that are even more captivating will open up when space-based radiotelescopes are put into near-Sun orbits. The baseline of the interferometer base would thus be comparable to an astronomical unit. With such a baseline, the radiointerferometer would enable the determination of the trigonometric parallaxes for extragalactic objects all the way to the edge of the observable universe! That would open up a completely new era in astronomy. Similar to the way triangulation on Earth has made it possible to measure the distance between remote points, to plot precise maps, to determine the curvature of the Earth's surface, and to ascertain the size of our planet, so in the future in space will triangulation lead to the construction of a precise three-dimensional map of the universe around us and to measurement of the curvature of space. And in turn, that will enable us to make a more precise determination of the history of the universe and to speak of its future with greater certainty.<sup>1</sup>

Large ground-based radiotelescopes like the RT-70 should play an important role in solving that problem. In addition to solving astronomical problems, the RT-70 telescope will also be used to solve important geophysical problems. For example, by observing reference radio



sources, it will be possible to track the change in the interferometer baseline. And that will make it possible to do things like measure the displacement of continental plates and the movement of the Earth's poles and investigate the nonuniformity of the Earth's rotation.

But all that will come to pass when the radiotelescope is put into operation. For the time being, it is in the development process. Many problems remain to be solved.

#### Footnotes

1. Sharov, A. S. and Novikov, I. D., "Chelovek, otkryvshiy vzryv Vselennoy" (The Man Who Discovered the Explosion of the Universe), Moscow, p 162, 1989.

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UDC 531.391

#### Evolution of Rotation of Axisymmetric Viscoelastic Body in Elliptical Orbit

907Q0160A Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 26 Jun 89) pp 483-495

[Article by Yu. G. Markov and I. S. Minyayev]

[Abstract] A study was made of the rotation of a dynamically symmetric viscoelastic-solid body about its center of mass in a central Newtonian gravitational force field. It is assumed that the system's center of mass revolves in an elliptical orbit and that the motion of the center of mass is independent of the system's motion relative to the center of mass. It is assumed that the elastic part of the system is quite rigid and that the damping time for free elastic oscillations is much less than the characteristic time of system motion as a whole. The elastic body is axisymmetric, homogeneous and isotropic. The problem thus formulated, the asymptotic method for the separation of motions developed by V. G. Vilke for systems with distributed parameters is applied to make a detailed study of the processes of slow motion of the vector of kinetic moment relative to the orbital plane. It is shown that eventually there is a gravitational capture of the system in which the angular momentum of the body tends to be normal to the orbital plane. References 7 (Russian).

UDC 629.195.1

#### Plane Oscillations of Satellite Under Influence of Gravity and Light Moments

907Q0160B Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 12 May 89) pp 496-505

[Article by V. V. Beletskiy and Ye. L. Starostin]

[Abstract] If a satellite orbit is sufficiently high, the moments created by the pressure of solar radiation become comparable in intensity to the gravity moments, and they must be taken into account in an analysis of

satellite dynamics. Consideration of light pressure implies destruction of the gravity-gradient position and may lead to small oscillation instability near that position. The possibility of such instability must be taken into account in developing systems for the passive stabilization of satellites. In order to clarify the problem, a study was made of plane motion relative to the center of mass of a symmetric, umbrella-shaped planetary satellite in a circular orbit. The satellite is subjected to the influence of gravity and solar radiation. An asymptotic method is used to investigate small satellite oscillations in the vicinity of the main resonance. An approximate amplitude-frequency curve is constructed for the induced oscillations. The zones of parametric instability of periodic oscillations of such a satellite are defined. The results are represented in the form of a diagram graphically showing the regions of existence and stability of periodic librations on the plane of determining parameters. Figures 9; references 11: 8 Russian, 3 Western.

UDC 521.43

#### Calculating Disturbances Caused by Atmospheric Drag of Satellite

907Q0160C Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28, No 4, Jul-Aug 90  
pp 531-538

[Article by V. A. Tamarov and Ye. P. Strezhenkova]

[Abstract] The researchers propose an analytical method for calculating disturbances caused by atmospheric drag on a satellite. The method uses a model of the atmosphere that has a variable scale of altitudes. The satellite's orbit is described with a system of Eulerian elements  $M$ ,  $\omega$ , and  $\Omega$  that are nonlinear in terms of time. The accuracy of the theory is limited to the second order relative to the compression of the Earth. The researchers present formulas for the calculation of the direct effect of satellite drag in an immobile atmosphere, as well as formulas that allow for the rotation of the atmosphere. The correctness of the formulas is confirmed via a numerical integration technique advanced by Everhart (CELESTIAL MECHANICS, 1974, Vol 20, p 261). References 8: 7 Russian, 1 Western.

551.510.536

#### Processes of Magnetization and Stratification of Easily Ionized Cloud of Neutral Gas Dispersing in Geomagnetic Field

907Q0160D Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 21 Aug 89) pp 555-559

[Article by S. I. Kozlov and Ye. L. Stupitskiy]

[Abstract] A phenomenon observed in artificially formed ionized clouds is examined—i.e., the commonly detected stratification of such a cloud. Previous research on that phenomenon pertains to a relatively late stage in disturbance development, tens of seconds after the injection of matter. The objective of the work reported here

was to show the possibility of the appearance of such stratification in the earliest stage of ionized cloud formation with the inertial dispersion of neutral gas. The mechanism of such a stratification process is examined. The reason for stratification of the ionized component is a distinct interrelationship between the processes of photoionization and the "freezing" of the geomagnetic field into a dispersing cloud of particles of ionized gas. Despite the qualitative character of the analysis, the estimates made are entirely valid and make physical sense. Cloud stratification in the early dispersion stage can be a source of geomagnetic disturbances with a characteristic period  $t_H$  and can exert an appreciable effect on the development of Rayleigh-Taylor instability at later points in time in the existence of such an ionized cloud. Figures 1; references 5: 2 Russian, 3 Western.

UDC 533.95:551.510.535

#### Distribution of Potential and Field of Electron Beam Injected in Ionosphere in Vicinity of Artificial Earth Satellite

907Q0160E Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 21 Aug 89) pp 560-564

[Article by A. Yu. Bogomolov and V. A. Fedorov]

[Abstract] The distributions of potential and of the electrical field of an electron beam injected in the ionosphere in the vicinity of an artificial earth satellite are determined near the point of injection and in the vicinity of maximum beam broadening, with allowances made for the possibility of different distributions of plasma particles. The potential and field distributions are investigated on the assumption that the beam field is axially symmetric, that the motion of beam electrons is laminar, that beam broadening under the influence of Coulomb forces occurs slowly, and that the time of interaction between beam electrons and the fields of the artificial earth satellite is short. The study clarifies the dynamics of such an injected electron beam, revealing that the electrical field of a charging satellite exerts a great influence both on the dynamics of beam electrons and on beam geometrical parameters. Accordingly, the electrical field of a satellite must be taken into account when studying the distribution of potential and field of the electron beam in the vicinity of a satellite. References 4: 3 Russian, 1 Western.

UDC 543.591

#### Primary Cosmic Ray Nuclei With 6 /H Z /G in the Energy Range $10^{12}$ - $10^{14}$ eV, as Determined From Experimental Data Collected by Cosmos-1543 and Cosmos-1713 Artificial Earth Satellites

907Q0160F Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 5 Jun 89) pp 565-570

[Article by I. P. Ivanenko, I. D. Rapoport, V. Ya. Shestoporov, Yu. V. Basina, R. M. Golynskaya, L. B.

Grigoryeva, I. P. Kumpan, L. G. Mishchenko, D. M. Podorozhnyy, G. A. Samsonov, V. A. Sobinyakov, I. M. Fateyeva, L. A. Kheyn, L. O. Chikova and I. V. Yashin]

[Abstract] The results of measurements of the energy spectra of medium and heavy nuclei of primary cosmic rays (PCR) in the energy range  $10^{12}$ - $10^{14}$  eV using the Sokol and Sokol-2 apparatus carried aboard the Kosmos-1543 and Kosmos-1713 satellites are given. In experiments that took place in 1984-1986, particle energy was measured with an ionization calorimeter (IC). Particle charge was measured with solid-state Cerenkov detectors of two types situated above the IC. An upper unit, with diffuse collection of light, consisted of four sections with plexiglass radiators 1 cm thick for measuring charges 6 /H Z /G 30; beneath it was an 11-section detector with plexiglass radiators 5 cm thick intended primarily for measuring charges of protons and  $\alpha$ -particles. The total effective time of the two experiments was about 600 hours. Table 1 gives the results of a comparison of the form of the spectra for individual groups of nuclei and the form of the total spectrum; Table 2 gives the experimentally determined charge composition of PCR with E /g 2 TeV and E /g 10 TeV. Table 3 gives the charge composition for charges 6 /H Z /G 14 with E /g 2 TeV. Figures 4; references 16: 13 Russian, 3 Western.

UDC 523.72

#### Correlation Between Relative Helium Content and Solar Wind Conditions, as Determined From 'Prognoz-7' Satellite Measurements

907Q0160G Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 27 Apr 89) pp 571-580

[Article by Yu. I. Yermolayev and V. V. Stupin]

[Abstract] The results of separate measurements of the energy distributions of solar wind protons and  $\alpha$ -particles were used in studying the relationship between the relative content of  $\alpha$ -particles and the hydrodynamic parameters of the solar wind: velocity and temperature of protons  $V_p$  and  $T_p$  and the concentration  $n$  of ions, as well as the flux intensity  $nV_p$ . It was found that the content of helium relative to protons  $n_\alpha/n_p$  is maximal in the ranges of parameters  $V_p = 400$ - $500$  km/s,  $n = 4$ - $7$  cm<sup>-3</sup> ( $nV_p$  about  $2.5 \times 10^8$  cm<sup>-2</sup> x s<sup>-1</sup>) and  $T_p = (4$ - $10) \times 10^4$  K, but beyond their limits decreases appreciably. This means that in slow, cold, dense fluxes, which are related to a closed configuration of the coronal magnetic field, the relative content of helium increases with an increase in velocity and temperature and decreases with an increase in the concentration of the solar wind; but in faster, hotter, less dense fluxes, which are associated with an open configuration of the coronal magnetic field, the relative content of helium decreases with an increase in velocity and temperature and increases with an increase in concentration. In the second type of solar wind fluxes, there is an increase in  $n_\alpha/n_p$  with an increase in the intensity of the flux  $nV_p$ , which is evidence supporting

the hypothesis that in such fluxes small ionic components can be effectively transported from the corona into interplanetary space by the main stream of plasma when its value exceeds some threshold. Figures 5; references 20: 7 Russian, 13 Western.

UDC 523.72:523.42

### Solar Wind Acceleration Determined by Radio Translucence Data

907Q0160H Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 14 Feb 89) pp 581-586

[Article by A. I. Yefimov, I. V. Chashey, V. I. Shishov and O. I. Yakovlev]

[Abstract] In radio translucence method, it is not the true velocity  $v$  of the solar wind that is measured, but the velocity of motion of the diffraction pattern caused by movement of plasma inhomogeneities at the observation point. This velocity is found by two methods: from the time spectrum of amplitude fluctuations measured at a single point  $v_1$  or from the lag time of frequency fluctuations registered at two spaced points  $v_2$ . It has been assumed that both methods give the true velocity. The objective of this study is to clarify what physical processes correspond to the velocities  $v_1$  and  $v_2$  and how they are related to the true velocity  $v$  of the solar wind. The dependence of the velocity of the solar wind on heliocentric distance  $v(R)$ , obtained by the radio translucence method by the Venera-10, -15, -16 vehicles and by Viking-1, is analyzed. The results of four series of measurements of the  $v(R)$  dependence are given. The role of magnetosonic waves is discussed, and wave velocities are determined. On this basis a more reliable  $v(R)$  dependence is found, the region of transition of velocity of the solar wind through the speed of sound is determined, and plasma temperature is ascertained. It was found that the principal acceleration of the solar wind occurs in the range of distances  $R = 9-25$  solar radii. Figures 3; references 13: 10 Russian, 3 Western.

UDC 523.64

### X-Ray Experiment on 'Astron' Unmanned Vehicle

907Q0160I Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 22 Feb 90) pp 587-618

[Article by S. I. Babichenko (deceased), M. S. Burgin, S. M. Voynakov, Ye. D. Gernet (deceased), D. A. Goganov, L. S. Gurin, I. M. Golynskaya, A. V. Dyachkov, V. M. Zenchenko, V. G. Kurt, I. F. Kopayeva, B. S. Lozinskiy, T. A. Mizyakina, Ye. N. Mironova, V. I. Prokhorenko, V. I. Rubanovskaya, A. I. Rutkovskiy, A. S. Smirnov, V. A. Sklyankin, S. I. Terekhov, N. G. Khavenson, V. M. Shamolin, Ye. Yu. Shafer, A. I. Sheykhet, Ye. K. Sheffer and A. V. Shifrin]

[Abstract] The SKR-02M X-ray spectrometer carried aboard the Astron unmanned vehicle is described. The spectrometer includes two identical detectors and 10 electronic modules. The detectors are mounted in two cylindrical, sealed containers situated on either side of the UFT ultraviolet telescope. One of the containers holds the electronic modules for the SKR-02M, the other holds modules for the UFT. SRPO-304 proportional counters are used as X-radiation detectors. The counter housing, made of titanium, is a rectangular chamber measuring 318 x 65 x 65 mm. The useful area of the counter window is 150 cm<sup>2</sup>. The counter chamber is filled with a gas mixture of 92 percent xenon and eight percent methane at a pressure 250 mm Hg ( $3 \times 10^4$  Pa). Figure 2 is the block diagram of the spectrometer. The functioning of the detection, electronics, counting, stabilization and control modules and their individual components is discussed in detail. Calibration and operational modes and ground and flight tests of the spectrometer are described. The preliminary results of observations of some X-ray sources are given: Crab Nebula, NP 0532, A 0535+26, MXB 1730-335, Her X-1 and Cen X-3. Figures 15; references 78: 12 Russian, 66 Western.

581.521

### Mean Fluxes of Electrons and Protons With Energies of 1-20 keV on Trajectories of Polar-Orbiting Artificial Earth Satellites

907Q0160J Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 21 Apr 89) pp 623-625

[Article by I. V. Getselev, Yu. I. Gubar, A. P. Kropotkin, S. A. Martyanov and G. A. Timofeyev]

[Abstract] Although fluxes of electrons and protons with energies of 1-20 keV exert a considerable influence on surface layers of materials in space, the spatial-energy distribution of particles in the magnetosphere has been inadequately studied. Fluxes of both these types of particles exhibit significant space and time variations. Most observations have been made along individual trajectories, whereas a clarification of radiation conditions for spacecraft flights requires experimental data collected over considerable time intervals. The principal source of data on averaged fluxes of particles in this energy range is measurements from the ESRO-1A satellite for the latitude range 50-85°N registered during the 20-month period of October 1968 to June 1970. There is a strong dependence of flux intensity on the state of magnetospheric disturbance, characterized by the  $K_p$  index. The analyzed data were divided into four groups corresponding to four intervals of  $K_p$  values. The possible differences between years of maximum and minimum solar activity were considered. The mean electron and proton fluxes were computed for circular orbits. A figure shows the mean spectra of electrons and protons on satellite trajectories for flight altitudes 500-1000 km

with orbital inclinations 50°, 65°, 80-100°. Figures 1; references 4: 1 Russian, 3 Western.

533.9.082

### Determination of Optical Depth of Artificial Clouds in Upper Atmosphere

907Q0160K Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 26 May 89) pp 626-628

[Article by I. V. Moskalenko, A. G. Kheylo, D. A. Shcheglov and A. B. Kukushkin]

[Abstract] The availability of powerful lasers tuned to long waves makes it possible to use the remote resonance sounding method in observing and analyzing artificial plasma formations, especially under nighttime conditions in the total absence of their luminescence induced by solar radiation. At nighttime, the use of resonance sounding makes it possible to obtain precise data on the quantity of vapors of an investigated element existing in an atomic state. This article describes the first nighttime experiments with resonance laser sounding of barium clouds, carried out in 1986. The barium clouds were formed in a series of launches of MR-12 geophysical rockets near the trajectory apogee at an altitude 140 km. Motion picture and video surveys of artificial clouds were made in evening and morning experiments in different spectral lines discriminated by interference filters. These observations made it possible to obtain information on the cloud size and nature of cloud evolution. The laser resonance sounding scheme and the procedures for measuring scattered radiation and interpreting the experimental data are described. In the considered case, the results revealed a relatively great optical depth of the cloud at 554 nm of the resonance transition of the barium atom in the investigated phase of cloud evolution. Figures 2; references 5: 4 Russian, 1 Western.

UDC 533.6.011.8

### Model of Spacecraft Shielding

907Q0160L Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 6 Jun 89) pp 635-638

[Article by V. M. Sakharov]

[Abstract] The processing and interpretation of readings of cosmic ray detectors carried within spacecraft is dependent on the extent to which the volume of the detector is shielded by spacecraft matter. Although this problem is readily solved in many cases, sometimes in the planning of space experiments involving solution of a specific problem using a specific cosmic ray detector only general information is known about the spacecraft, such as its mass and size. An approach is proposed for constructing a standard model of shielding of volumes of

a spacecraft sensitive to radiation based on general information on spacecraft mass and dimensions by means of an analysis of new results of study of the distribution of matter in vehicle modules and the shielding functions for detectors within spacecraft, as well as data in the literature. The proposed test is the ratio D/M: the ratio of the dispersion D of the shielding function for any point in the spacecraft to the mathematical expectation M. The possibility of applicability of this ratio is examined relative to the Spacelab, Apollo command module and Prognoz. The D/M ratio for different spacecraft varies in a small range, regardless of their country of origin. The differences in the shielding functions for points in the same spacecraft are for the most part related to spacecraft geometry. The proposed model of a spacecraft as a randomly inhomogeneous medium makes it possible to compute the shielding function for cosmic radiation detectors with a definite degree of assurance. Figures 1; references 9: 7 Russian, 2 Western.

UDC 523.985-125

### Short-Range Predictions of Solar Flares

907Q0162A Moscow GEOMAGNETIZM I  
AERONOMIYA in Russian Vol 30 No 4, Jul-Aug 90  
(manuscript received 11 Dec 89) pp 538-544

[Article by V. A. Burov, Applied Geophysics Institute, USSR Main Administration for Hydrometeorology and Environmental Control]

[Abstract] A survey of recent literature involving theoretical research on the accumulation and release of energy in solar flares suggests that only individual flare events are described by a specific model and that no one model describes the entire range of flare events. The observational data do not support the existence of any universal mechanism of flare events. The prediction problem can be represented in terms of Boolean algebra. The introduction of a number of extremely general assumptions makes it possible to formulate a general approach to the development of prognostic schemes and to select individual elements of models and informative criteria. Experimental results from the testing of some prognostic methods are given. The author introduces a method for routine short-range prediction of flares on the basis of pattern recognition methods embodied in a series of programs. The results of application of this method in 1986-1988 are presented. References: 19 Russian, 3 Western.

UDC 523.6:523.98

### Active Longitudes on the Sun and Their Reflection in Interplanetary Space

907Q0162B Moscow GEOMAGNETIZM I  
AERONOMIYA in Russian Vol 30 No 4, Jul-Aug 90  
(manuscript received 6 Dec 89) pp 550-553

[Article by V. Bumba and L. Hejna, Astronomical Institute, Czechoslovakian Academy of Sciences, Karlov University, Prague]

[Abstract] Graphs of the longitude distribution of various manifestations of solar activity, based on the research of a number of authors, were processed. The slopes of the longitudes found to be active were computed. A composite graph of slopes for the pertinent longitudes reveals the existence of two main directions of active longitudes rotating more rapidly than the Carrington rotation. The mean synodic rotation is 26.77 days for the first direction and 27.16 days for the second. The composite graph shows that, according to data published by various authors, the active longitudes for different activity indices overlap to varying degrees and that both directions are observable without interruption over the course of several 11-year cycles—the first with an interval of 45-55 rotations, and the second with an interval of about 200 rotations. Both active longitudes are apparently reflected in the two principal slopes of boundaries of sectors of the interplanetary magnetic field; the slopes, as demonstrated by Svalgaard and Wilcox, rotate synodically over periods of 26.84 and 27.14 days. Figure 1; references: 19 Russian.

UDC 523.947:523.98

### **Supercoronal Fluctuations in Electron Concentration and the Effect of Solar Activity on the Earth**

907Q0162C Moscow GEOMAGNETIZM I  
AERONOMIYA in Russian Vol 30 No 4, Jul-Aug 90  
(manuscript received 20 Dec 89) pp 563-565

[Article by V. P. Yakubov and Ye. Yu. Chuzhkov, Siberian Physical Technical Institute, Tomsk State University]

[Abstract] Radio transparency data for near-solar space and data from vertical probing of the ionosphere were used in a cross-correlation analysis of the relationship existing among mean daily solar activity variations, electron concentration fluctuations in the solar wind, and the state of the ionosphere. Such an analysis should provide a quantitative measure of the effects on Earth produced by a disturbance of the corpuscular flow of solar wind when solar activity undergoes a change. The state of the ionosphere is characterized by the critical frequency  $f_o$  of the F2 layer. Data on frequency fluctuations of radio waves during communication with Venera probes through near-solar plasma in 1984 were used for determining electron concentration fluctuations. It is shown that changes in solar activity, in the form of variations in supercoronal electron concentration, make their way to Earth with the velocity of the solar wind. Changes in solar activity definitely determine nonstationary variations in electron concentration fluctuations in the solar wind and, consequently, in the state of the ionosphere. Data on radio probing of the eastern region of the solar supercorona can be used in six-day predictions of solar activity and in 11-day predictions of the state of the ionosphere. Figures 2; references: 4 Russian.

UDC 524.1:523.9-48

### **Properties of Radiation Characteristics of Solar Proton Events During Decay of Solar Cycle 21 and During Growth of Solar Cycle 22**

907Q0162D Moscow GEOMAGNETIZM I  
AERONOMIYA in Russian Vol 30 No 4, Jul-Aug 90  
(manuscript received 8 Dec 89) pp 566-570

[Article by N. K. Pereyaslova, M. N. Nazarova and I. Ye. Petrenko, Applied Geophysics Institute, USSR State Committee for Hydrometeorology and Environmental Control]

[Abstract] Solar proton events (SPE) registered by the Meteor satellites during the period September 1986 (beginning of the 22nd solar activity cycle) through July 1989 are analyzed. Probabilistic distributions of radiation characteristics in the 22nd cycle are compared with model distributions for the growth phases in corresponding periods of the 20th and 21st cycles. Tables 1 and 2 summarize the number of SPE in the solar activity growth phases during the three 11-year cycles and the mean radiation characteristics of SPE observed in the activity growth phases during the three cycles. The nature of proton activity in the solar northern and southern hemispheres during the periods of growth and decline also is considered. It is concluded on the basis of solar and proton activity during the 20th, 21st and 22nd cycles that the cycles and phases of the solar cycles differ considerably from one another with respect to conditions on the sun and in the interplanetary medium. The features characterizing each phase of the cycle and the difference in the cycles must be taken into account in developing models and methods for predicting radiation conditions. Figures 3; references 9: 4 Russian, 5 Western.

UDC 550.383

### **Simulation of Intensity of Protons With Energies of Tens of MeV Over South Atlantic Anomaly**

907Q0162E Moscow GEOMAGNETIZM I  
AERONOMIYA in Russian Vol 30 No 4, Jul-Aug 90  
(manuscript received 20 Dec 89) pp 599-607

[Article by V. V. Temnyy, Ts. P. Dachev, Yu. N. Matviychuk, Yu. N. Ponomarev and N. G. Bankov, Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences; Space Research Institute, Bulgarian Academy of Sciences; Space Research Institute, USSR Academy of Sciences]

[Abstract] Profiles of doses  $D_p$  from protons with an energy greater than 40 MeV were obtained at an altitude 350 km above the South Atlantic anomaly on the Mir station in 1988 using the Lyulin dosimeter. During four and a half days of flight, results were obtained which made it possible to determine the intensity distribution of penetrating protons of the inner radiation belt in

geographic and geomagnetic coordinate systems. The Lyulin data differ from previous results in that there are high-energy protons near the equatorial region in the innermost proton belt, which is separate from the inner proton radiation belt. It was possible to make improved estimates of parameters of the innermost proton belt and determine its temporal stability. The presence of protons in the equatorial plane at altitudes where atmospheric density is quite great makes it possible to estimate their lifetime as a result of atmospheric absorption. This lifetime is undoubtedly much less than the period of filling of the inner radiation belt from the  $\beta$ -decay of albedo neutrons from the Earth's atmosphere. The daily dose for the center of the proton belt at  $L = 1.25$  is estimated at 160 rad. The Lyulin detecting system also can be used in dosimetry of charged particles less penetrating than the protons of the inner radiation belt. Figures 7; references 25: 10 Russian, 15 Western.

UDC 581.383

#### Characteristics of Distributions of High-Energy Electrons Determined From Intercosmos-17 Artificial Earth Satellite Data

907Q0162F Moscow GEOMAGNETIZM I  
AERONOMIYA in Russian Vol 30 No 4, Jul-Aug 90  
(manuscript received 7 Dec 89) pp 656-661

[Article by A. I. Martynov, V. S. Makhmutov, V. M. Petrov and V. A. Shurshakov, Biomedical Problems Institute, USSR Ministry of Health]

[Abstract] Measurements by the Intercosmos-17 satellite were used in investigating the distributions of quasi-trapped and leaking electrons with  $E = 10\text{-}70$  keV relative to local time (LT) and local pitch angle for various magnetic disturbance conditions. The dependence of electron fluxes on LT obtained for  $K_p > 1$  is close to the corresponding dependence from the AE-4 model. The nature of this dependence is influenced by the level of magnetospheric disturbance, which is not taken into account in modern models. The distributions of electrons by local pitch-angle as a function of the L parameter and the  $K_p$  index were investigated. In light of the results, the estimated absorbed doses at the surface of a spacecraft may differ by tens of percent. The distributions of electron fluxes at the polar caps were computed for different levels of geomagnetic disturbance. During periods of strong magnetic disturbances, the electron fluxes approximately double in intensity, and the spatial nonuniformity of their distribution is accentuated. In model distributions of high-energy electrons, it is essential to take into account the dependence of the fluxes on the level of magnetic disturbance, as a characteristic of which the  $K_p$  index can be used for middle- and high-latitude regions. Figures 2; references 15: 11 Russian, 4 Western.

UDC 524.5

#### Description of Solar Activity Over the Last 400 Years

907Q0164A Moscow PISMA V  
ASTRONOMICHESKIY ZHURNAL in Russian Vol 16  
No 8, Aug 90 (manuscript received 4 Sep 89) pp 723-728

[Article by G. Ye. Kocharov, I. V. Zhorzholiani, Z. V. Lomtadze, A. N. Peristykh, S. L. Tsereteli and V. I. Chesnokov, Physical Technical Institute, USSR Academy of Sciences, Leningrad]

[Abstract] The temporal variation of atmospheric radiocarbon caused by solar activity over a 400-year period was investigated. The experimental data consisted of a continuous series of annual, highly precise measurements of radiocarbon in tree rings. A five-reservoir model of the carbon-exchange cycle, including the atmosphere, biosphere, humus, surface and deep layers of the ocean, was used for converting from the temporal variation of the abundance of radiocarbon in tree rings to variation in the rate ( $Q$ ) of  $^{14}\text{C}$  generation in the atmosphere. Knowing  $Q(t)$ , it is possible to compute cosmic ray intensity using the formula  $I = 385 \times Q^{2.45}$ . Particular attention is given to the period 1700-1940, including the maunder minimum, during which the intensity of cosmic rays experienced considerable changes with a characteristic time of 11 years with an amplitude of variations virtually the same as in the modern epoch. The analyzed data indicate that during this period the global characteristics of cosmic ray modulation remained constant; the conditions in the interplanetary medium regulated by the sun have not changed substantially during approximately the last 300 years. Variations in the atmospheric abundance of radiocarbon caused by solar modulation of galactic cosmic rays are reliably established during the entire investigated time interval. Figures 5; references 10: 6 Russian, 4 Western.

UDC 520.6;523.64

#### Detection of Very Fine Dust Particles Near Nucleus of Halley's Comet

907Q0164B Moscow PISMA V  
ASTRONOMICHESKIY ZHURNAL in Russian Vol 16  
No 8, Aug 90 (manuscript received 16 Mar 90) pp  
729-736

[Article by R. Z. Sagdeyev, Ye. N. Yevlanov, B. V. Zubkov, O. F. Prilutskiy and M. N. Fomenkova, Space Research Institute, USSR Academy of Sciences, Moscow]

[Abstract] An analysis of the spectra measured by the PUMA dust impact mass analyzers carried aboard the Vega-1 and Vega-2 spacecraft reveals that a large number of unidentified peaks may be associated with impacts of very small dust particles with masses of  $10^{-17}\text{-}10^{-20}$  g. The mass flow of the tiny dust particles may be as great

as several percent of the total mass flow of dust from Halley's comet. Discovery of very small dust particles in the dust envelope of Halley's comet is consistent with the hypothesis that a cometary nucleus is an aggregate of interstellar dust in which tiny particles are present. The composition of these particles was determined by an analysis of the time differences between the appearance of pulses, which made it possible to discriminate correlated ions of three mass numbers forming with the impact of one particle against the target. The method precludes the influence of plasma and instrument effects on the relative position of mass peaks in the time-of-flight spectra. No correlated ion triplets could be discovered in an analysis of spectra with small particles, giving evidence of a simple (one- or two-component) composition of the particles: graphite or metal oxides or large aromatic molecules. Figures 3; references 22: 7 Russian, 15 Western.

UDC 524.352

#### Recording of Gamma Lines From SN 1987A in Experiment Aboard 'Cosmos-1870' Artificial Earth Satellite

917Q0006 *Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 9, Sep 90 (manuscript received 30 Jan 90) pp 785-789*

[Article by G. A. Yefremov, A. F. Titenkov, G. V. Lupenko, N. I. Nazarova, I. Yu. Postnikov and V. P. Sukhanov, Nuclear Physics Scientific Research Institute, Moscow State University]

[Abstract] The DS spectrometer carried aboard the Cosmos-1870 satellite, launched in July 1987 into an orbit with an altitude about 260 km with an angle of inclination to the equator of 71°, was used in obtaining data on gamma radiation from the shell of supernova 1987A. Each satellite revolution was broken down into two segments: the first corresponded to a satellite position in which the supernova was situated in the spectrometer aperture, and the second, in which the supernova was occulted by the Earth. In addition, those segments were broken down into four zones with an identical geomagnetic rigidity. The observations over the Brazilian magnetic anomaly on the trajectory segments corresponding to it (and 15 minutes flight time thereafter) were excluded from the processing. These excluded data were later processed separately for evaluating possible distortions which would have been introduced (none were found in the pertinent range). Spectra for the occulted and unocculted variants for the period 26 July-30 December 1987 were compared. Two irregularities were observed in the spectrum corresponding in energies to the predicted gamma lines of 0.847 and 1.238 MeV. The gamma radiation fluxes for these lines were estimated. Other gamma radiation measurements were made simultaneously by other satellites and high-altitude balloons, and the data are consistent with the estimates made in this article. Figures 3; references 8: 3 Russian, 5 Western.

UDC 524.3-74:520.2

#### Ultraviolet Observations With 'Glazar' Space Telescope

917Q0007 *Yerevan ASTROFIZIKA in Russian Vol 32 No 1, Feb 90 (manuscript received 22 Nov 89) pp 5-13*

[Article by G. M. Tovmasyan, R. Kh. Oganessian, R. A. Yepremyan, S. Ye. Nersesyan, M. A. Mkrtchyan, Yu. M. Khodzhayants, M. N. Krmoyan, A. L. Kashin, D. Yugen, S. I. Serova, Yu. V. Romanenko, A. P. Aleksandrov, V. G. Titov and M. Kh. Manarov, Granit Special Design Bureau, Byurakan Astrophysical Observatory; Geneva Observatory; Flight Control Center]

[Abstract] The Glazar orbital telescope carried in the Kvant module of the Mir space station has been used for regular observations since August 1987. Sixty-one stars (listed in Table 1 with appropriate data) were photographed in a sector of sky about 77° square, predominantly in the high galactic latitudes, during the period August 1987 to November 1988. Twenty-eight of those stars with a limiting star magnitude of up to about 11<sup>m</sup> were identified; 16 of them had been observed earlier using the TD1 orbital telescope. The observational data were used in determining the monochromatic star magnitudes of those stars at a wavelength 1640 Å (listed in Table 2). One of the 28 stars, in all probability, is a hot subdwarf, a component of a binary system. Figures 1; references 4: 2 Russian, 2 Western.

UDC 629.19.01

#### One Special Case of Motion of Dynamically Symmetric Viscoelastic Body in Central Newtonian Gravity Field

917Q0022A *Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90 (manuscript received 17 Apr 89) pp 643-654*

[Article by A. P. Markeyev]

[Abstract] The motion of a large body in a Keplerian orbit in a central Newtonian gravity field was investigated. The mechanical model of the body used was a viscoelastic body which in an undeformed state is dynamically symmetric and elongated along the axis of symmetry. The body deformations represent longitudinal oscillations along the axis of symmetry and flexural oscillations of the axis of symmetry itself. The problem is examined within the framework of the linear theory of elasticity and the internal viscosity forces are stipulated using a dissipative Rayleigh function. Differential equations are written for describing deformations of the body and its motion as an entity relative to the center of mass. The existence of motion in which the axis of body symmetry is perpendicular to the orbital plane of the center of mass is demonstrated. The stability of this motion is investigated for the case of a circular orbit. Figures 3; references 18: 14 Russian, 4 Western.



UDC 629.191

**Dynamics of Solid Body-Flexible Extended Rings System Moving in Gravity Field***917Q0022B Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 5 Jul 89) pp 655-663*

[Article by V. I. Gulyayev, A. G. Chernyavskiy, Yu. D. Kravchenko, V. V. Gaydaychuk, V. L. Koshkin and Ye. E. Kotenko]

[Abstract] The problem of nonstationary rotations and translational acceleration motions of a satellite consisting of a small massive carrier body and two extended flexible rings symmetrically joined to it is examined. It is assumed that the carrier body can be rotated in conformity to a stipulated program about one of the three main central axes of system inertia. The nonlinear relative oscillations of the rings excited by these motions are investigated. A comparative analysis of the influence of the forces of inertia and attraction on kinematically excited nonstationary oscillations of such flexible elastic rings shows that in the considered time interval and with stipulated rigidity and geometrical characteristics of the system the influence of gravitational forces can be neglected. The results of numerical simulation were compared with data from a full-scale experiment and this revealed a high accuracy of the computations. Figures 5; references: 7 Russian.

UDC 629.195.1

**Parametric Analysis of Stability of Relative Equilibrium in Gravity Field***917Q0022C Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 14 Mar 89) pp 664-675*

[Article by V. V. Beletskiy and O. N. Ponomareva]

[Abstract] A study was made of the plane problem of motion of a system of two gravitationally attracted bodies, one of which is a sphere. The stability of stationary motions is investigated. The main content of the study is a parametric analysis of conditions for transition from stability to instability and (or) gyroscopic stability. The problems of stable relative equilibrium of a satellite in a circular orbit and gyroscopic stability of a diurnal satellite in the field of planetary gravitation undergo transition into one another with a change in parameters. The known stable position of relative equilibrium of a satellite elongated along the radius-vector of a circular orbit ("gravitational stabilization") becomes unstable in the case of adequately large satellite dimensions and (or) masses. The appearance of gyroscopic stabilization of a satellite elongated "across" the radius vector of the orbit is possible. With satellite masses quite large in comparison with the mass of the sphere the satellite must be regarded as the main planet and the described situation

corresponds to the known fact of gyroscopic stability of a diurnal satellite situated on the continuation of the minor axis of the planet (and instability of a diurnal satellite situated on the continuation of the major axis of the planet). The results also can be applied to an analysis of the dynamics of double stars. The last section of the article gives a concise critique of preceding research on these subjects. Figures 7; references 13; 11 Russian, 2 Western.

UDC 519.272.629.783

**General Method for Determining Characteristics of Earth's Gravity Field Using Gravi-inertial Measurements Made on Spacecraft***917Q0022D Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 15 Mar 90) pp 676-684*

[Article by V. V. Golikov]

[Abstract] A theoretical validation is given for a general method for determining the values of the tensor of second derivatives of the gravity potential force function with broad initial assumptions concerning the instruments used and the spatial orientation of their response axes. (All instruments of the proposed class and the measurements made with them are called "gravi-inertial."). The principles for constructing the gravi-inertial measuring systems best suitable for this purpose are discussed. A method for obtaining the functional dependencies of the tensor on spherical coordinates is outlined which ensures solution of the problem of studying the Earth's gravity field on the basis of such gravi-inertial measurements from space and also the problem of determining the spacecraft position parameters most suitable for such measurements. References 11: 9 Russian, 2 Western.

UDC 629.19.086

**Experimental Determination of Coefficients of Equations of Perturbed Motion of Spacecraft With Elastic Elements***917Q0022E Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 4 Apr 89) pp 685-691*

[Article by V. R. Aminov]

[Abstract] Experimental methods are given for determining the coefficients of inertial coupling and the dissipative coefficients of the equations of perturbed motion of a spacecraft consisting of a rigid body to which elastic elements (such as panels of solar cells) are attached. The presence in the equations of perturbed motion of the dissipative coupling coefficients  $\beta_{ijk}$  reflects the case of nonproportional damping in elastic elements when the damping matrix cannot be represented in the form of a linear combination of matrices of



masses and rigidities. These coefficients exert a considerable influence on the values of the coefficients of damping of oscillations of a spacecraft as a whole. Expressions are written for determining the damping coefficients on the basis of measurement of the mentioned response components and the results of their use are illustrated in the example of oscillations of an elastic element in the form of a cantilever characterized by energy dissipation at the point of attachment. The error in determining the damping coefficients by the derived formulas is in the range 0.3-1 percent. Figures 3; references 4: 3 Russian, 1 Western.

UDC 629.7

### Evolution of Rotational Motion of Two Tethered Bodies in Orbit

917Q0022F Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 25 Oct 88) pp 692-701

[Article by A. P. Alpatov, P. A. Belonozhko, A. V. Pirozhenko and V. A. Shabokhin]

[Abstract] A study was made of the evolution of kinematic parameters of two point masses, connected by a weightless, elastic-dissipative tether, moving in an unperturbed Keplerian orbit. The equations of motion of the system are derived in a form convenient for use of the averaging method. It is shown that in the first approximation the motion of the vector of the kinetic moment of relative motion of the system is not dependent on oscillations along the tether. It is established that the effect of the dissipative component of aerodynamic forces in a circular orbit is qualitatively different from the effect described earlier for a symmetric solid body. A qualitative analysis is made of evolution of the kinetic moment under the joint influence of aerodynamic and gravitational forces. A variant of a mathematical model of motion is proposed which makes it possible to take into account changes in the orbital parameters caused by the influence of perturbations. Figures 4; references 11: 8 Russian, 3 Western.

UDC 531.35

### Periodic Motion of Dumbbell in Central Force Field

917Q0022G Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 14 Feb 89) pp 702-705

[Article by A. P. Blinov]

[Abstract] The motions of a solid body of the dumbbell type in a central field of force have been studied repeatedly and in MTT, No 4, pp 37-42, 1988 the author demonstrated the existence of a periodic translational-rotational motion of the dumbbell. Continuing this work, a study is made of the orbital stability of the determined periodic motion of the dumbbell. An

approach is proposed which is applicable to any systems with two degrees of freedom with a smooth Hamiltonian allowing periodic motion of a rotational type in a given angular coordinate. In this approach it follows from the stability or instability (as defined by Lyapunov) of periodic motion of the reduced problem at a given energy level that there is orbital stability or instability of the solution of the initial problem. This is illustrated for the case of adequately great intrinsic kinetic moment of such a dumbbell, an actual construction of the mentioned motion is presented and its orbital stability is investigated. References: 9 Russian.

UDC 629.78

### Computational-Experimental Method for Analysis of Dynamic Accuracy of Stabilization of Flexible Spacecraft Under Influence of Internal Perturbation Sources

917Q0022H Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 26 May 89) pp 706-714

[Article by N. N. Sheremetyevskiy, Ye. Ye. Malakhovskiy, E. L. Poznyak and A. A. Yevmenov]

[Abstract] A method was developed for simulating the perturbed motion of an uncontrollable geostationary satellite with flexible solar cells in the presence of mechanical forces caused by the functioning of real drive mechanisms. Computations were made of the model characteristics of a representative finite-element model of spacecraft design in which the problem is reduced to examination of a system of 10th-20th-degree differential equations with a number of degrees of freedom of the initial finite-element model about  $10^3$ . In the stage of designing of a new information satellite this method made it possible to analyze the dynamic accuracy of stabilization of the body and to make predictive extremal and rms evaluations of the quality of the resulting images of the Earth's surface. The results obtained in this study made it possible to dispense with the stage of extremely expensive model research which is extremely difficult to carry out. The proposed method is quite general and allows an examination of the problem in a stochastic formulation. Figures 5; references 16: 11 Russian, 5 Western.

UDC 535.24:523.42

### Inverse Thermal Sounding Problem: 2. Retrieval of Vertical Profile of Aerosol Extinction Coefficient From Observations of Outgoing Thermal Radiation

917Q0022I Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 28 Feb 90) pp 725-735

[Article by Ye. A. Ustinov]

[Abstract] In an earlier article by the author (KOSMICH. ISSLED., Vol 28, No 3, pp 402-412, 1990) an explicit expression was derived for the variational derivative of the intensity of outgoing radiation with reliance on the

extinction factor, making a contribution to atmospheric opacity in the observed spectral range. This result made it possible to formulate the inverse problem of retrieving the vertical profile of the aerosol extinction factor. (In contrast to optical depth, the extinction factor is a local spatial atmospheric characteristic and is therefore preferable for clarity and comparability with atmospheric physical models.) With these considerations taken into account analytical expressions are now derived for the weighting functions of the corresponding linearized inverse problem. A study was made of the dependence of the range of altitudes in which it is possible to retrieve the aerosol profile on the error in measurements and the thermal structure of the atmosphere. A numerical experiment was carried out demonstrating the utility and effectiveness of the formulated inverse problem. Figures 3; references 17: 8 Russian, 9 Western.

UDC 551.510.53

### Interpretation of Electron Temperature Measurements on 'Vertikal' Rockets

917Q0022J Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 29 Nov 89) pp 736-742

[Article by A. V. Pavlov]

[Abstract] A theoretical interpretation of the results of measurements of electron temperature  $T_e$  obtained from 1970 to 1977 in five rocket launchings near Volgograd in the neighborhood of the terminator is presented. It is shown that the best agreement between measured and theoretical  $T_e$  is attained when using in the theoretical model the approximation for the rate of heating of electrons by photoelectrons proposed by W. E. Swartz, et al. (JGR, Vol 72, p 6259, 1972). In two experiments of five in order to make the measured and computed  $T_e$  values consistent it is necessary to assume that at the upper boundary there is an increased heat flow directed from the plasmasphere into the ionosphere. Data from the empirical model IRI-79 agree poorly with measured  $T_e$  in two experiments and agree well only in the "Vertikal-6" experiment. The temperature  $T_i$  of ions measured in the "Vertikal-6" experiment is in good agreement with theoretical  $T_i$  at altitudes from 400 to 600 km. The reason for the disagreement between the measurement results and the results of theoretical computations is uncertainties in the input parameters of the model and errors in measuring  $T_e$  and  $T_i$ . Figures 3; references 19: 12 Russian, 7 Western.

UDC 581.521

### Comparative Analysis of Long-Term Variations of Multicomponent Ionic Ring Current Based on Data From 'Gorizont' Geostationary Artificial Earth Satellite

917Q0022K Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 25 Oct 89) pp 743-749

[Article by A. S. Kovtyukh, M. I. Panasyuk, N. A. Vlasova and E. N. Sosnovets]

[Abstract] Long-term variations of ion fluxes were determined in geostationary orbit using data from the "Gorizont" (1985-07) satellite at midday hours during a period of 2.5 months (February-April 1985), a period with a number of geomagnetic storms and substorms. During the time of moderate geomagnetic storms the content of  $[N,O]^{2+}$  ions in the ring current approaches the content of protons in the ring; the ratio of differential densities of ions  $[N,O]^{2+}/H^+$  increases from about one percent in quiet periods to about 10-20 percent during storms. Long-term variations in the fluxes of  $H^+$  and  $[C,N,O]^Q$  ions with identical E/Q differ substantially in both amplitude and character; ions of the  $[C,N,O]$  group are characterized by sharp intensity drops, whereas the variations in proton fluxes are smoother. The amplitude and nature of variations in proton fluxes is dependent on particle energy. With an increase in energy the amplitude of their variations increases a little and the nature of variations of proton fluxes approaches the nature of variations of heavy ions. The nature of long-term variations of ring current ions observed by the "Gorizont" satellite is consistent with the restructuring of magnetospheric convection with a change in orientation of the interplanetary magnetic field. The dependence of the amplitude and nature of variations on energy may be related to softening of the energy spectra of ions with an increase in their energy and the influence of acceleration mechanisms. Impairment in E/Q similarity between the energy spectra of protons and heavy ions during a period of increased geomagnetic activity is apparently evidence of a different position of their main sources in the ionosphere during such periods. Figures 3; references 19: 8 Russian, 11 Western.

UDC 550.370

### Spatial Characteristics and Dispersion Relations of ELF Radiations in Circumterrestrial Shock Wave Determined From Results of Measurements on 'Prognoz-10' Artificial Earth Satellite. 1. Research Method, Spectral Characteristics and Polarization of ELF Waves in Spacecraft Reference System. Wavelengths in Shock Transition Region

917Q0022L Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 15 Nov 89) pp 750-759

[Article by S. A. Romanov, S. I. Klimov and P. A. Mironenko]

[Abstract] A method is proposed for investigating the spatial characteristics of events and dispersion relations for waves in the ELF range in interplanetary plasma with use of experimental data on fluctuations of magnetic density and current density obtained on one spacecraft. Turbulence was analyzed in the region of a quasiperpendicular shock wave with large Mach and  $\beta$  numbers for three intersections of the circumterrestrial shock wave registered on the "Prognoz-10" satellite on 8 October

1985. The directions of the vectors and polarization modes of these waves, observed in the spacecraft reference system in the frequency range 0.2-10 Hz, were determined. Figures 5; references 8: 4 Russian, 4 Western.

UDC 551.521.8

**Low-Frequency Noise on 'Intercosmos' Satellites Under Different Solar Activity Conditions**

917Q0022M Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 15 Nov 89) pp 760-764

[Article by V. I. Larkina]

[Abstract] Variations in the intensity of low-frequency electromagnetic radiations were investigated at the altitudes of the upper ionosphere during different levels of solar activity. An analysis of data from low-frequency wave measurements carried out on the "Intercosmos" satellites during different phases of the solar activity cycle revealed that the amplitude of the radiations at the solar activity maximum is greater than at the minimum. There is also a difference in the rates of increase in the amplitude of radiations with the development of geomagnetic disturbances in different phases of the solar activity cycle. These findings make it possible to judge changes in the flux density and energy of particles penetrating into the Earth's plasmasphere during years of maximum and minimum solar activity and to draw conclusions on changes in magnetospheric plasma associated with a solar activity increase or decrease. In other words, electromagnetic low-frequency noise can serve as a special indicator of solar activity and state of the magnetosphere. Figures 5; references 8: 5 Russian, 3 Western.

UDC 523.037:525.7

**Increases in Streams of High-Energy Charged Particles in Region of Brazilian Magnetic Anomaly and Earth's Seismicity**

917Q0022N Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 4 Apr 89) pp 789-791

[Article by S. A. Voronov, A. M. Galper, S. V. Koldashov, L. V. Maslennikov, V. V. Mikhaylov, N. V. Nikitina and A. V. Popov]

[Abstract] In 1985 the "Mariya" magnetic spectrometer aboard the "Salyut-7" was used in investigating electron and positron fluxes in the energy range 20-200 MeV. An unexpected result was observation of sharp increases in the counting rate of particles on 10 September 1985. This phenomenon was registered in the neighborhood of the Brazilian magnetic anomaly. On this basis it was postulated that there is a possible correlation between changes in particle fluxes and the Earth's seismicity. The

experiment was continued in 1987 on the "Mir" complex with the "Mariya-2" complex. A table lists the pertinent events observed in both experiments. In a number of satellite experiments electromagnetic radiation was registered over the foci of impending earthquakes. It is believed that this radiation leads to the formation of processes exerting an influence on the motion of particles trapped by the geomagnetic field and that this is manifested in changes in their pitch angle distribution. With longitudinal drift of the particles these changes are registered in the Brazilian magnetic anomaly region where the trajectory of orbital stations intersects the corresponding drift shells. It is possible that the observed interrelationship between the change in particle fluxes in the magnetosphere and seismicity is determined by processes in interplanetary space which exert an influence on the final stage of earthquake preparation and which are manifested in such magnetospheric phenomena as the current sheet and particle leakage. Figure 1; references 6: 5 Russian, 1 Western.

UDC 551.521.8

**Dependence of Streams of Charged Particles Measured on 'Salyut-7' Orbital Station on Altitude**

917Q0022O Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 30 Sep 89) pp 791-792

[Article by V. I. Lyagushin, M. A. Sarayeva, O. A. Starovoytova and P. I. Shavrin]

[Abstract] In 1986 the "Salyut-7" orbital station was transferred from a circular orbit at an altitude 350 km to a circular orbit at 500 km while maintaining an unchanged inclination to the equatorial plane. This made it possible to estimate the scale of the dependence of fluxes of charged particles registered aboard the station using the "Ryabina" instrument on altitude. The measurements were made in the middle and low geomagnetic latitudes and under quiet geophysical conditions. The "Ryabina" instrument registers charged particles capable of penetrating a layer of matter  $3 \text{ g x cm}^{-2}$ . The intensity of the primary particles should increase with an increase in altitude as a result of decrease of the shadow cone. The intensity of the albedo particles should decrease with altitude. The observed absence of an appreciable dependence is at least partially attributable to a reciprocal compensation of these tendencies. Within the limits of changes in altitude typical for the trajectories of the "Salyut" and "Mir" stations the dependence on altitude can be neglected in an analysis of variations in cosmic ray intensity if the intensity variations do not exceed five-10 percent. Figure 1; references; 1 Russian.

UDC 550.383

**Nonstationary Streams of Electrons With Energy Greater Than 15 MeV in Earth's Magnetosphere***917Q0022P Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 7 Sept 89) pp 792-795*

[Article by K. G. Afanasyev, Ye. V. Gorchakov, V. A. Iozenas and M. V. Ternovskaya]

[Abstract] Electrons accelerated to 15 or even 30 MeV were detected in the magnetosphere from the "Cosmos-900" satellite during magnetic storms with a sudden commencement (SC). An analysis revealed that the acceleration of electrons to energies of tens of MeV does not occur in any magnetic storm but only when the velocity of the solar wind in a corpuscular stream is adequately high. An event was registered on 18-19 July 1977 which differed considerably from earlier events in that it was associated with a recurrent stream of the solar wind, not with SC magnetic storms. At the time of this event the Earth intersected the boundary of the magnetic sector. Electrons with an energy greater than 15 MeV were registered. This phenomenon was compared with events which were registered in April, September and November 1977 and in January and October 1978. The parameters of all these events are listed in a table. The energy spectra of electrons in all cases were very similar. The event of 18-19 July 1977 was associated with a high-velocity recurrent stream, but the other five events were related to shock waves from solar flares. The high-energy electrons in the event of 18-19 July 1977 are evidently of magnetospheric origin. It is possible that under the influence of high-velocity recurrent streams of the solar wind the magnetosphere can become an effective accelerator of electrons. Figures 2; references 3: 1 Russian, 2 Western.

UDC 681.3.016

**Influence of Angular Distributions of High-Energy Electrons on Lessening of Doses Behind Thin Shieldings***917Q0022Q Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 12 May 89) pp 795-797*

[Article by A. I. Martynov, L. I. Ryzhova and V. A. Shurshakov]

[Abstract] The absorbed doses created by cosmic radiation behind thin layers of matter was investigated. Measurements were made using passive dosimeters of the thermoluminescent type which were mounted on the outer skin of "Salyut" and "Cosmos" vehicles. It was found that the maximal contribution to the dose behind a shielding less than 0.1 g/cm<sup>2</sup> is from high-energy electrons of the Earth's radiation belts. An estimate was made of the influence of the angular distributions of

high-energy electrons on absorbed doses behind thin shields on the basis of data from the "Intercosmos-17" satellite on electron fluxes with an energy greater than 10 keV in a circular orbit with an altitude 500 km and an inclination 83°. The instrumentation and methods used are described. Aluminum was used as the shielding and silicon was used as the absorber. Computations of attenuation curves for absorbed doses from high-energy electrons were made for a case when the shielding was an oriented plane, the normal to which was directed to the zenith. Measurement data were processed for about 200 revolutions. The Monte-Carlo method was used in computing the absorbed doses from electrons. The surface doses in the orbit of the "Intercosmos-17" orbit were about 1 krad/day. The slope of the attenuation curves for shieldings of less than 0.1 g/cm<sup>2</sup> is slightly dependent on the form of the angular distribution of incident electrons. With an identical intensity of electrons the absorbed doses in the case of isotropic incidence are less by a factor of three-four than in the case of normal incidence (other possible cases are also examined). Figures 2; references 12: 10 Russian, 2 Western.

UDC 524.3-13

**Ultraviolet Scanning of Individual Sectors of Sky With 'Glazar' Space Telescope***917Q0028A Moscow ASTRONOMICHESKIY  
ZHURNAL in Russian Vol 67 No 5, Sep-Oct 90  
(manuscript received 20 Nov 89) pp 966-971*

[Article by G. M. Tovmasyan, R. Kh. Oganessian, R. A. Yepremyan, D. Yugenon, M. A. Mkrtchyan, M. N. Krmoyan, A. L. Kashin, V. V. Butov and S. I. Serova, Byurakan Astrophysical Observatory, Armenian Academy of Sciences; Granit Special Design Bureau, Armenian Academy of Sciences; Geneva Observatory (Switzerland); Flight Control Center]

[Abstract] Observations were made with the "Glazar" orbital telescope carried in the "Kvant" module of the "Mir" station. This instrument has a Ricchi-Chretien optical system, field of view 1°.3, diameter of main mirror 40 cm and focal length 1.7 m. It has automatic, semiautomatic and manual operating modes. Some additional details concerning the telescope are given and the different operating modes are individually discussed. The article gives the results of observations made during the period 20 October-12 November 1987 using a single film. During this period 18 sky regions were photographed in an automatic mode with 85-second exposures and seven sky regions were scanned in a semiautomatic mode with four-minute exposures at high galactic latitudes. A table gives a list of these regions with the coordinates of their centers with an accuracy to two-three minutes of angle. The total area of the observed regions is about 28 square degrees. The images of 15 stars were identified on these photographs; these are listed in Table 2 with their star magnitudes at 1640 Å. Figures 4; references 2: 1 Russian, 1 Western.

UDC 520.87:530.12:531.51

**Optimization of Antenna Network in Problem of Search for Gravity Waves**

917QOO28B Moscow *ASTRONOMICHSKIY ZHURNAL in Russian Vol 67 No 5, Sep-Oct 90* (manuscript received 14 Dec 89) pp 1074-1081

[Article by Ye. K. Kuchik and V. N. Rudenko, State Astronomical Institute imeni P. K. Shternberg]

[Abstract] A widely spaced global network of gravity wave observatories is needed for detecting cosmic gravity wave radiation. A network of cryogenic solid-state resonance antennas already exists in its initial variant and the possibility of establishing a network of laser-interferometer observatories is being discussed. Two possible cases of network optimization are discussed: on the assumption of isotropically distributed sources and on the assumption of sources in Virgo cluster. Optimization in the case of expansion of the network is also considered. One possible variant provides for a maximal increase in the zones of sky coverage by the antenna network, minimizing the probability of missing a gravity wave event. The choice of the network optimization strategy must be based on a detailed analysis of the relation of the probabilities of missing and detecting gravity wave events. So much work would be required in reorienting massive cryogenic antennas, much less long-base interferometer systems, that it is essential to carry out accurate preliminary computation of network geometry and have a rigorous mathematical formulation and solution of the problem of optimization of orientation of the world network of gravity wave detectors. Figure 1; references 12: 3 Russian, 9 Western.

UDC 520.87:530.12:531.51

**Configuration of Zones of Sky Coverage for Global Network of Gravity Wave Antennas**

917QOO28C Moscow *ASTRONOMICHSKIY ZHURNAL in Russian Vol 67 No 5, Sep-Oct 90* (manuscript received 14 Dec 89) pp 1082-1094

[Article by Ye. K. Kuchik and V. N. Rudenko, State Astronomical Institute imeni P. K. Shternberg]

[Abstract] The present-day network of cryogenic solid-state gravity wave detectors consists of observatories at San Francisco, Baton Rouge, Perth and Rome. This network is being supplemented under the gravity wave program of the State Astronomical Institute, which calls for putting into operation at Moscow several solid-state detectors operating at room temperature and a cryogenic resonance antenna. There are a number of possible

configurations for the existing and supplemented networks. The relative merits of these configurations are discussed. The choice is in part governed by different hypotheses on the distribution of gravity wave sources: an isotropic distribution, or sources in Virgo cluster. In the initial stage of network operation preference should be given to a strategy of increasing the efficiency of the double coincidences scheme and emphasis must be on a model of an isotropic distribution of sources because although gravity wave events in Virgo cluster are considerably more frequent, their amplitude is too small for reliable detection. It is probably desirable that investigation of sources in Virgo cluster await introduction of more sensitive laser-interferometer detectors. Meanwhile, the Moscow antenna with any azimuthal positioning will give an additional coincidence for a considerable part of the sky. If the orientation of the four cryogenic detectors elsewhere in the world is not changed, the Moscow antenna must be oriented along an E-W line, but if these four detectors are given their planned configuration it is better that the Moscow antenna have a N-S orientation. Figures 5; references 11: 3 Russian, 8 Western.

UDC 629.783:520.82

**Determining Light Pressure Vector From Photometric Observations of Geostationary Satellites**

917QOO28D Moscow *ASTRONOMICHSKIY ZHURNAL in Russian Vol 67 No 5, Sep-Oct 90* (manuscript received 23 Nov 89) pp 1095-1108

[Article by A. M. Mikisha and M. A. Smirnov, Astronomical Council, USSR Academy of Sciences]

[Abstract] The light pressure vector was determined using specific observational data for two geostationary satellites. The radial component of light pressure  $F_1$  (direct pressure of sunlight) and the component  $F_2$  (pressure of light reflected by satellite) have a periodic character with a diurnal period. On the assumption of smallness of eccentricity and orbital inclination there is no secular variation. The transversal and binormal components of these same forces have a secular character on which is superposed a periodic change with diurnal, semidiurnal and eight-hour periods. Two tables give relative estimates of the contribution of different light pressure components. Specific calculations revealed that the component of the total vector of solar pressure  $F_2$  caused by light reflected from such a satellite constitutes a value about 20 percent of the  $F_1$  value attributable to the direct pressure of solar radiation on the satellite. Allowance for this effect is therefore necessary when using geostationary satellites for geodynamic purposes. Figure 1; references 25: 5 Russian, 20 Western.

UDC 551.521

**Research on Optical Properties of Venusian Atmosphere**

907Q0166 Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 26 No 8, Aug 90 (manuscript received 26 Jun 89) pp 837-840

[Article by I. N. Minin and I. M. Tarabukhina, Leningrad State University]

[Abstract] In greater detail than before, the measurement data from the Pioneer-Venus and Venera spacecraft are analyzed for clarification of the optical properties of the Venusian atmosphere. The values of the optical parameters (volumetric coefficients of true light absorption and scattering) are thoroughly analyzed for confirming or refuting their validity. Data are given on those parameters as a function of altitude above the planetary surface. The results clearly demonstrate the predominant role of molecular light scattering in the layer beneath the clouds (below 45 km) and confirm predictions made earlier relative to light polarization of the Venusian sky. There is no confirmation for the presence postulated by Dlugach and Yanovitskiy of fine aerosol that makes a substantial contribution to Rayleigh scattering, nor for a supposed role of Raman scattering, proposed by other authors. However, there is evidence of an aerosol layer at about 20 km. At about 50 km there is a maximum of both true light absorption and scattering. At altitudes above 45 km, both parameters change consistently, indicating that droplets in clouds fully determine their optical properties, refuting the published hypothesis that the absorbing agents are not directly related to the main aerosol component. The critical examination of the literature continues, with some findings refuted, others supported and still others recommended for further study. Figures 2; references 12: 8 Russian, 4 Western.

UDC 520.6;523.42

**Measurements of Dynamics of Air Mass Movement in Venusian Atmosphere With Balloon Probes (VEGA Project)**

917Q0008 Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 9, Sep 90 (manuscript received 24 May 90) pp 832-843

[Article by R. Z. Sagdeyev, V. V. Kerzhanovich, L. R. Kogan, V. I. Kostenko, V. M. Linkin, L. I. Matveyenko, R. R. Nazirov, S. V. Pogrebenko and I. A. Strukov, Space Research Institute, USSR Academy of Sciences; R. Preston, J. Purcel and C. Hildebrand, California Institute of Technology, Jet Propulsion Laboratory; J. Blamont, L. Boloh and G. Laurans, French Space Research Council; R. E. Spencer, Jodrell Bank; J. Golt, Canadian Radio Observatory; V. A. Grishmanovskiy, A. N. Kozlov and Ye. P. Molotov, USSR Space Instrument Making Scientific Research Institute; Ya. S. Yatskiv, Main Astronomical Observatory, Ukrainian Academy of Sciences; R. M.

Martirosyan, Radio Physics and Electronics Institute, Armenian Academy of Sciences; I. G. Moiseyev, Crimean Astrophysical Observatory; A. E. E. Rogers, Haystack Observatory; F. Biro, F. Biraud and P. Kaufmann, Meudon Observatory, France; P. Metzger and R. Shwartz, Max Planck Radio Astronomy Institute, West Germany; B. O. Ronang, Space Observatory, Uppsala, Sweden; G. Nicolson, Radio Observatory, South Africa]

[Abstract] This article gives the results of measurement of the dynamics of air mass movement in the upper layers of the Venusian atmosphere based on the drift of balloon probes launched from flyby vehicles in June 1985 into the northern and southern hemispheres in the Soviet project VEGA. Each of the balloons carried a transmitter operating in the 18-cm wavelength range. The power radiated in the direction of the Earth did not exceed 5 W. After filling with helium, the balloon probes freely floated at an altitude of about 53 km, making it possible to study the dynamics of movement of these layers. Measurements of the coordinates and velocity of movement of the probes was by the differential radio interferometry method. The reference source was a flyby vehicle which carried a similar transmitter. The probe operating in the southern hemisphere revealed air mass movements with a velocity 65.3 m/s in a latitudinal direction and 3.4 m/s in a longitudinal direction. The probe in the northern hemisphere revealed movement in a latitudinal direction at 68.7 m/s, but failed to detect a longitudinal component. In many sessions, periodic motions of the balloon gondola with a period 7 s were detected. In the southern hemisphere, the number of such sessions was greater by a factor of 10 than in the northern hemisphere. Figures 5; references 15: 11 Russian, 4 Western.

UDC 521.1

**Possibility of More Precise Determination of Orbit of Phobos Using Inexact Models of Motion of Mars and Earth**

917Q0023A Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90 (manuscript received 25 May 89) pp 715-720

[Article by S. N. Vashkovyay and N. V. Yemelyanov]

[Abstract] If the coordinates of Mars and the Earth are known with an accuracy to only tens of kilometers it is impossible to determine the position of Phobos on the basis of measurements of range and radial velocity in a 400-day observation interval more accurately than several kilometers. An approach is therefore proposed for attaining a more acceptable result despite use of the inexact orbital elements of the Earth and Mars now available. Corrections are introduced which compensate for this inexact knowledge. When using range measurements, as well as joint measurements of range and radial velocity, the error in determining the position of Phobos and the errors in determining key coefficients in the pertinent equations is the lesser the length of

the subinterval of the mentioned 400-day observation interval. When there is an inexact knowledge of the coordinates of Mars and the Earth it is better to use Doppler measurements: determination of a single correction to radial velocity reduces the error in the position of Phobos to 20 m. The proposed method will be useful in processing surface and space observations of Martian satellites. Figure 2; references 3: 2 Russian, 1 Western.

UDC 535.72:523.42

**Region of Main and Lower Maxima of Venusian Dayside Ionosphere Determined From Radiooccultation Experiments With 'Venera' Satellites**

*917Q0023B Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 5, Sep-Oct 90  
(manuscript received 21 Mar 89) pp 765-775*

[Article by L. N. Samoznayev]

[Abstract] This article gives the most thorough analysis yet published on the results of radio occultation obser-

vations of the region of the main and lower maxima of the Venusian dayside atmosphere obtained using the "Venera-15" and "Venera-16" satellites. Numerical computations were made of the vertical distributions of electron concentration for different solar activity levels and different solar zenith angles. These computations are compared with experimental N(h) profiles. This comparison not only makes it possible to explain the observed variations in the profiles with the phase of the 11-year cycle, but also to some degree confirms the correctness of the planetary model of the thermosphere constructed using the results of Pioneer-Venus observations for periods of low and moderate solar activity. The comparison revealed that the observed variations in vertical profiles in the region of photochemical equilibrium are attributable to changes in the flux of UV radiation and the parameters of the model of the thermosphere during the course of the solar activity cycle. Figures 4; references 19: 6 Russian, 13 Western.

**'Vympel' Automatic Landing System**

907Q0159A Moscow *TEKHNIKA - MOLODEZHI*  
in Russian No 4, Apr 90 pp 28-31

[Article by special correspondent Igor Lebedev, under the rubric "TEKHNIKA-MOLODEZHI Inquiry: "'Vympel,' or 'Platsdarm'?"]

[Text] The article on the microwave landing system (MLS) for civil aircraft was nearly complete. It began with bombastic (as I thought at the time), but effective phrases about the last minutes of flight of the Buran orbital craft: "Its precise, accurate landing was a kind of baptism by fire of our microwave system ..." And I then talked about the system itself, its working principle, its full compliance with international requirements, and how it should be adopted without delay by civilian aviation.

Deciding, however, to have one last talk with the experts, I showed the manuscript to one of them. The technical side of it turned out to have no major problems.

"But as for this 'baptism by fire,'" he hesitated to add. "That's not quite right. And if you really want to be precise, it's not at all right."

"Excuse me. Isn't there a mistake here? After all, this is not my idea. I used reputable publications—essentially, the official point of view. For example, here is what the chief designer of Buran, Yu. P. Semenov, says: 'Adoption of the landing system by aviation is extremely promising. It would make airplanes totally independent of the weather'" ("On the Launch Pad," *LENINSKOYE ZNAMYA*, 16 Feb 1989).

"I think he was misinformed about that," responded my conversation partner.

"But there's more." Leafing through my dossier, I produced a quotation (from the West German *FLUG REVUE*, No 4, 1989): "Such a microwave landing system meets the requirements of the International Civil Aviation Organization (ICAO). It should be adopted worldwide in the nineties."

"I don't know where the West German reporter got his information, but the Buran landing system is not like that."

"How can this be?" And I read a paragraph from an article by Doctor of Technical Sciences G. Gromov, general designer of the ATC, navigation, and landing electronic systems, and A. Reutov, corresponding member of the USSR Academy of Sciences, "Radio Path From Space" (*PRAVDA*, 6 Dec 1988): "The Buran landing took just a few minutes, but what a tremendous labor for the scientists, engineers, workers, and test pilots...."

"This labor, manifested by the jeweller's precision attending the operation of all systems of the landing complex, demonstrated the high potential capabilities

for enabling all-weather and, later, automatic landing of various classes of airplanes. The work experience gained in the development of the Vympel complex will help in the creation of a mass-produced, high-precision electronic system for landing aircraft."

"Those, apparently, are the sources of your 'official point of view,'" said the person I was talking with. "You see, it's plain from the last quotation that Buran landed by the Vympel system. But your article concerns a different system."

"Which one?"

"The one that meets the requirements of the ICAO—the Platsdarm MLS."

"What about Vympel?"

"Well, talk to People's Deputy A. Shchelkanov."

**The Dossier Grows**

From the inquiry of Deputy A. A. Shchelkanov:

*To Comrade V. Ye. Kurtashin, chairman of the USSR Supreme Soviet Commission of the Union Soviet on matters of the growth of industry, power, engineering and technology.*

*Dear Vladimir Yegorovich:*

*Being occupied with the search for means of improving the standard of living of our indigent, I was very troubled by the telegram (enclosed) of Dr. Tech. Sci. V. V. Kashinov of Leningrad, addressed to the Congress of People's Deputies of the USSR, about, specifically, the needless waste of tens of millions of rubles. In view of the absence of a response to the telegram, I ask you to examine impartially whether there is any truth to the statement of the author, presented in the enclosed 'historical report' that says that:*

*—the Vympel landing system for the Buran orbital craft, as emerges from the enclosed conclusion of the commission of the Ministry of the Radio Industry, is not compatible with the Platsdarm aviation landing system;*

*—both systems, essentially solving the same problem, were developed at the same time in the same institute of the Ministry of the Radio Industry (the VNIIRA [All-Union Scientific Research Institute of Radio Apparatus], and if so, why?;*

*—Buran could have used for its landing the Platsdarm system, which meets to the requirements of the International Civil Aviation Organization (ICAO), and a special system need not have been developed for Buran.*

*If, as this alarming telegram to the Congress says, the answers to those questions are in the affirmative, then who personally bears responsibility for the ill-advised duplication resulting in the creation of incompatible systems costing several tens of millions of rubles? Or who, finally, will be able to clearly prove that these claims are untrue?"*



The inquiry mentions a telegram from V. V. Kashinov and some kind of "historical report." Perhaps the answers lie there?

From the historical report "Development of Radio-Navigational and Landing Equipment for Aircraft in the Soviet Union," written by Dr. Tech. Sci. V. V. Kashinov:

*The newspaper LENINGRADSKAYA PRAVDA of 1 Dec 1988 produces photographs of the antennas of the radio beacons for the landing system for Buran. They are dish antennas, which precludes the possibility of the use of advanced technology—phased-array radars (PAR), which are used in the international MLS. Thus, the system for Buran is not compatible with the MLS and will not help accelerate the introduction of automatic landing in aviation, as is asserted in the article "Radio Path From Space." On the contrary, the work on the system for Buran diverted specialists from work on aviation systems and delayed the adoption of those systems. Furthermore, there is direct evidence that the expenditure of funds on the system for Buran, which is not a bit better than the aviation MLS systems, was entirely unjustified.*

It turns out that the principles of operation of the systems are completely different. Dish antennas perform a mechanical scanning of the radio beam; PARs, an electronic scanning. Thus, Platsdarm could not have grown out of Vympel. What's more, it is mentioned that Vympel is not a bit better than Platsdarm. Does that mean that the latter could have been used for the landing of Buran?

From the reply of V. Kurtashin to Deputy Shchelkanov:

*The extremely tight timeframe for the creation of the unique complex and the strict demands in terms of reliability and trouble-free operation of the systems preordained the direction of development and the choice of prototypes of electronic landing systems for the orbital craft that had the most to offer in terms of technological-design and engineering solutions when the project began, especially since the American orbital craft in the Space Shuttle program were outfitted with a similar landing system...The fact that the VNIIRA was able to carry on the development of a microwave landing system for the 6-cm range on a par with international standards and at the same time conduct successful testing of a prototype of the Platsdarm MLS in 1983 demonstrates the high scientific and production potential of that group.*

*In connection with the above, I feel that the 'Conclusion as to the letter of Kashinov, V. V., of 16 Jan 89, to the Attorney General of the USSR, Comrade Sukharev, A. Ya.,' sent by letter of the deputy minister of the radio industry of the USSR, Comrade Reutov, A. P. (originally AR-108 of 30 Mar 89), is sufficiently authoritative, and I recommend ceasing further correspondence on this matter.*

The idea is clear. The good background of the Vympel system and the "equating" with the Americans were the main arguments against Platsdarm. One document advances others. In the above excerpt, there is mention

of a 'Conclusion as to the letter of Kashinov.' Let us concentrate on the matters of interest here and have a look at the "Conclusion," signed by commission of the USSR Ministry of the Radio Industry, which will clarify somewhat the previous excerpt.

*Development of the electronic landing system itself, the Vympel complex, for the Buran orbital craft, was begun in 1979. The dates of delivery of the first prototypes and models of that landing system for a complex of tests with the prototype-aircraft and flying laboratories in 1981-1983 and subsequent years were set by government-level directive documents.*

*In 1979, the USSR had no models of a microwave landing system of 6-cm range (Platsdarm system) suitable for use in the development of a landing system for the orbital craft within the stated timeframe. Furthermore, the standard format of the MLS signal was adopted by the International Civil Aviation Organization (ICAO) only in December 1982 and was revised repeatedly up until 1987.*

A "Refutation by V. Kashinov of the 'Conclusion as to the Letter...'" was not long in coming.

*In April 1978, the ICAO had chosen the 6-cm range, the operating principle of the international system, and the signal format. Thus, the corresponding development of the electronic landing system of the Vympel complex for the Buran orbital craft was begun one year after the international community of scientists and specialists had chosen the best version of landing system for all types and purposes of aviation.*

*Design work on the landing system of the Buran orbiter was begun roughly at the time state testing of the Platsdarm system was being completed. I do not think that G. N. Gromov (general designer at the VNIIRA) had any doubts at that time about the feasibility of a landing system with electronic scanning.*

*As emerges from the 'Conclusion,' five years were spent on the DEVELOPMENT of the MLS (i.e., Platsdarm) from scratch to category 2. It also took five years for the MODIFICATION from category 2 to 3. Why?*

Here, I believe, an explanation is in order: category 2 of Platsdarm is essentially the finished system, able to be used for landing. But at an altitudes above the ground of roughly 30 m and lower, its 2° pencil beam can't provide accurate information to the crew. The category 3 MLS has a 1° beam and serves the airplane all the way down to touchdown on the concrete. To produce that system requires only increasing the width of the phased-array radar roughly twofold, using the identical standard modules of which it is built. Furthermore, in light of the high international requirements for system reliability, the system must be backed up with additional equipment of the same type. As we can see, nothing had to be invented to move from category 2 to category 3—the component base merely had to be enlarged. In the opinion of the specialists with whom I spoke, that would have taken the

institute a year, assuming it took a serious approach to the problem. But not five years!

We continue to quote from the "Refutation."

*I believe that a concentration of efforts would have enabled the creation of the category 3 MLS much earlier and would have 'enabled the world's first automatic glide landing of the Buran orbiter, equipped with an onboard control system, on 15 Nov 1988,' without the needless expenditure of tens of millions for the creation of a shorter-wave, mechanical-scanning system and without any confusion of the scientific-technical policy of the nation in the area of landing equipment.*

*...It should be noted that the United States did not develop a special landing system for the Space Shuttle, but used a system already developed for aviation. The Americans spent nothing to develop a landing system for the Space Shuttle!*

I think citing the two opposing letter-writing parties is enough—the main arguments have been presented. Incidentally, I learned from other documents that, as early as 1976, specialists of the VNIIRA had shown American colleagues prototypes of Platsdarm.

But Deputy Shchelkanov hasn't gotten any clear answers to his questions. Are the two systems compatible? That is, can an aircraft with onboard equipment for the specific Vympel land at an airport equipped with the universal Platsdarm, and vice versa? Just how wealthy was the department to be able to afford the development of two expensive systems at the same time? As for the third question—Was Vympel necessary and could Platsdarm have landed Buran?—the answers are contradictory. Furthermore, logic leads to one more question. With two systems on hand that are able to perform the same functions, we should decide this for the future: Would it be too expensive to develop both? And if we choose one, then which one?

The scientific-technical council (NTS) of the Ministry of General (read: Space) Machine Construction (MOM) should have dotted all the i's and crossed all the t's.

#### A Debate That Was Never Held

About three dozen people from various cities gather in the small conference room of the MOM: general and chief designers, representatives of the Academy of Sciences, prominent specialists—the people who in charge of our space programs.

A few months back, the presence of a journalist at the MOM NTS during the discussion of the tactical characteristics and specifications of our operational space technology was in the realm of fantasy. The space department must be given credit: it has lifted itself one rung higher on the ladder of glasnost.

The speaker, general designer G. N. Gromov, was given 15 minutes for his report. It was recommended that we not use dictaphones, and so I will relate only the essential

points of his remarks. The Vympel complex had checked out completely. According to the tactical characteristics and specifications, the landing system had to be able to determine the coordinates of an aircraft flying at great altitudes. (I am not able to give certain figures for the same reason that no dictaphone was used.) None of the systems in existence at the time the problem was posed was suitable. Furthermore, it was known that the Americans had selected a 2-cm system with mechanical scanning for the landing of the Space Shuttle.

As for the Platsdarm MLS, its format, or in other words, its signal standard, wasn't adopted by the ICAO until 1982. (However, Gromov's monograph "The Differential-Geometry Navigation," published in 1986, alludes to April 1978—*Editor*.) Incidentally, there are at present some countries who advocate not converting to the MLS. With respect to certain characteristics of the two systems: they are identical in terms of precision, but the number of radio frequency channels in Platsdarm is higher by an order of magnitude. On the other hand, Vympel works for higher altitudes. And in general, when the latter is compared with the Shuttle landing system, it may be said that the Shuttle system does not enable landing at low angles. Which means that our system has solutions that are more progressive.

Several times, the speaker placed special emphasis on the fact that the installation date for the MLS (i.e., Platsdarm)—as recommended by the ICAO—is 1998. I understood that to mean there is no need to hurry with Platsdarm.

Which of the deputy's questions did Gromov answer? Nothing was said of the incompatibility of the systems. Why they were being developed at the same time in the VNIIRA was also unclear. To the third question—Why not simply use Platsdarm?—the answer boiled down to the statement that Vympel was the only true solution of the problem presented to the institute.

Eight individuals spoke after Gromov. They supported his conclusions with remarkable uniformity. The general idea was roughly as follows: Vympel, and that's final! The developers were working under deadlines, the goal had to be achieved within the stated time at whatever the cost, and it was in fact achieved (read: success is not criticized).

It was said that Vympel was the bird in hand, Platsdarm the bird in the bush. After that, for some reason the thought occurred to me that in the 1950s the book-keeping abacus was also a bird in the hand, faithfully performing arithmetic operations, while the computer was a distant, if also ideologically noxious bird in the bush (even though we were on virtually equal footing with the Americans in theoretical and experimental projects during those years). But after two decades, the bird in the bush became the bird in the hand for the developed countries, while we are annoyed at our failure. One of the speakers openly admitted that Platsdarm is technology of the 21st century, but—and here's where

the logic of the speaker seemed strange to me—he would not risk using it for Buran today. He also said we were not behind the foreign countries, and moreover Vympel was cheaper than Platsdarm (here again, the thought occurred to me that the abacus was also cheaper than the computer).

After the close-ranked unanimity in favor of Vympel, the time came for the person to speak who had stirred up all the trouble, who had boiled up all this kasha—V. V. Kashinov (sorry about the pun).

Stubbornly repeating his arguments, he said that the development of Vympel was superfluous, that money and years of work had been wasted on the creation of a system that had no future, while Platsdarm languished in idleness. Furthermore, the features of Vympel (mechanical scanning and its low frequency) create the preconditions for an air incident (read: an accident).

"I have made the forecasting calculations and I stand behind what I am saying."

But what was Kashinov saying now? The Burans won't be around long, and equipment for the future system must be installed aboard the new orbiters. For that, we need to quickly develop a program for converting the landing of the Burans to the Platsdarm system.

Interestingly, at the end of the discussion, a paradoxical response was uttered by one of the members of the institute in charge of the scientific-technical policy of the Ministry of the Radio Industry: "It is not necessary to enter this in the resolution of the NTS, since such a program is already under preparation." How could that be? The department that for three hours had been arguing that Platsdarm was unnecessary and premature had already begun working out a program for conversion to that system?!

But in my view, the i's still were not dotted, because, although Kashinov was directly involved in development of the MLS and was a specialist of high stature (nonetheless, in 1986 he had to leave the VNIIRA as a result of staff cutbacks, although there were only three (!) doctors of sciences there, counting him; I mention this without comment), his view was controversial and had thus far stood alone. Therefore, the following remarks aroused the greatest interest in me.

V. M. Benin, former deputy chief designer for landing systems (retired since 1987) had worked on both Vympel and Platsdarm.

Vympel and Platsdarm, in his opinion, were incompatible systems, and therefore, if both were to operate in the country, aircraft would have to have two different sets of landing equipment on board. As for the operational altitude, in which Platsdarm was allegedly inferior to Vympel, such demands had simply not been required of the former system (they are unnecessary for conventional aircraft), and it was no trouble to satisfy them for the landing of Buran.

When in 1978 the ICAO selected one of the three best systems (they had been chosen from among dozens that had been submitted and analyzed since the early 1970s, and they had been worked on by the best specialists in the world, including our own), the Vympel-type system, with a shorter wave range than that of Platsdarm, did not even figure among them. Why not? Because during rain, snow, and fog, waves of such length are attenuated much more strongly than are 6-cm waves.

The scanning frequency and, thus, the information update of Vympel is an order of magnitude lower (!) than that of Platsdarm. Furthermore, the scanning itself in Vympel is a mechanical process, which leads to wear on the system and lowers its reliability, while the scanning in Platsdarm is electronic.

As for the scientific-technical level, this depends on the underlying principles of the project and the parameters of the manufactured equipment. Thus, Vympel is based on the principles of radio beacon equipment, which were developed in the mid-1950s. In the 1960s, the United States used them to build the Flarescan equipment and other systems. Those principles also served as the foundation for the Shuttle landing system (but let us remember, the Americans made that choice in the mid-1970s). At that time, we has also used those same principles to develop landing equipment that subsequently found no application, since it was resolved to provide the aviation of all departments with the standard Platsdarm MLS equipment. Thus, the principle of design of the Vympel system was already obsolete in 1979, when the projects got under way.

It emerges from a comparison of the parameters of Vympel and Platsdarm that the latter has advantages in range, working sector, rate of information update, and potential reliability, i.e., its scientific-technical level is higher than that of Vympel. And the last question—Could the landing of Buran have been accomplished with the Platsdarm system? Here are the facts that corroborate the possibility. The development of a new standard system of the Platsdarm type was ordered by the government as far back as 1974. The MLS equipment, category 2, went through factory testing in 1983. Thus, the use of Platsdarm for the landing of the orbital craft was entirely feasible. Yet, the leadership of the VNIIRA chose a different path. Benin's conclusion: it would be far more advisable to use Platsdarm for the landing of Buran. Realistically, that could even be done in the near future. The tight time schedules as a justification of Vympel are not convincing. If manpower and money had been concentrated on Platsdarm, it would have been ready on time. Vympel is a dead end.

A. I. Dunayev, head of the USSR Glavkosmos, summarized it all. The scientific-technical level of the Vympel system was state-of-the-art, but at the same time, its production and design aspects would have to be improved. With that, the three-hour meeting of the MOM NTS came to an end.

I do not know if Deputy Shchelkanov was satisfied with the resolution of the NTS. But as for me, piecing together the facts I had heard, I came to a sad thought. First, the main argument of the advocates of Vympel, i.e., practically the entire NTS, was the time frame hanging over the heads of the project workers. Second, Platsdarm was the latest word in electronic landing equipment, recognized by the world community and also by our specialists. Third, we often hear these days that the space programs are the cutting edge of science and technology, suppliers, as it were, of progressive technologies to the economy.

And so, by any estimation, the development of Vympel (one would like to think that it is an exception in our space programs) is an end in itself. The flight of Buran had been set for the 15th: work like mad, make the deadline, and then sit back and wait for the commendations and prizes. Why take a risk if the problem can be solved with yesterday's methods?

Here, I feel, we come to a question that no one has given a clear answer to—why on Earth did the VNIIRA pursue the two projects at the same time?

Let us think about it. In the late 1970s, the institute received its assignment to support the landing of Buran. Work is already under way on Platsdarm, but the leaders of the VNIIRA understand that it's possible to land the craft by a different system, and at the same time open up a new source of funding. The scientific problems connected with Vympel had been solved in previous decades, there was nothing in particular to wrestle with, and no one would "begrudge" the money for outer space. As for Platsdarm, let its supporters work on it, and when the time comes, we will also skim the profit there.

Thus, everything went according to plan. Vympel was ready, Buran was landed, time to collect the awards. But bad luck—here comes the indefatigable Kashinov and his protests. What's worse, glasnost and democracy in the form of the inquiry of the people's deputy have gotten mixed up in it. In my opinion, the matter was not so much discussed impartially, as covered up by the efforts of one group of specialists, who today hold the bastions of the MOM. Against them, what are the voices of a few individuals retired by staff reduction? "Eggs are expensive at Christmas time," said one of the participants of the NTS in reference to Vympel. But which is more important—Vympel today, or Platsdarm in the 21st century?

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### 'Platsdarm' Microwave Landing System

907Q0159B Moscow TEKNIKA - MOLODEZHI  
in Russian No 4, Apr 90 pp 31-34

[Article by Yevgeniy Nikonov and candidate of technical sciences Yuriy Belyatskiy, scientific associates at the Scientific Experimental Center of Air Traffic Control

Automation, USSR Ministry of Civil Aviation: "Land Anytime, Anywhere!": first paragraph is source introduction]

[Text] Yevgeniy Nikonov and candidate of technical sciences Yuriy Belyatskiy, scientific associates at the Scientific Experimental Center of Air Traffic Control Automation, USSR Ministry of Civil Aviation, talk about Platsdarm.

Today, the so-called ILS glide-slope and localizer is used for precision landing of aircraft. It came to be used as much as half a century ago in some countries, but it was adopted internationally in 1948. Even though the system has evolved with each decade, its reliability and other characteristics improved, it is no longer able to meet the demands of tomorrow.

The instrument landing system has narrow coverage. That allows the airplane to make a landing approach along a single trajectory only, from great distance. Because of that, not only is the traffic capacity of the airports low, but there are also hardships for a population center's residents who live beneath the air landing corridor—the roar of the engines is overhead round the clock. The old system, for example, cannot handle airplanes with vertical and shortened takeoff—it simply loses sight of them for the very same reason of very limited space monitored. The signal of the glide-slope antenna of the ILS is heavily dependent on the condition of the ground surface in front of it; preliminary preparation of the locality is required—e.g., trees must be cut, snow cleared—but on occasion, installing the equipment is still not at all possible. The system has only 40 radio channels, which means that if there are other airfields or radio broadcasting stations nearby working in the same frequency range, the resultant interference is unacceptable and the addition of each new ILS is a problem.

We shall not enumerate all the shortcomings. It must be said that a replacement for the ILS has long been sought. Even before 1970, there were almost fifty proposals. An undesirable situation arose when different systems could be adopted in different countries. Therefore, after careful discussion, the ICAO decided that an international system, based on the centimeter range, should replace the ILS, which operates in the meter wave range. Its format was finally approved in 1978.

Unlike the ILS, which tracks a rigidly specified flight trajectory over radio beacons, the MLS encodes the air space in three coordinates within broad landing approach and takeoff sectors. Furthermore, it has a rangefinding channel that enables continuous measurement of the distances to the landing strip. Neither rain, nor snow, nor fog is a problem to the MLS—civil aviation comes close to being all-weather.

The ground equipment of the new system includes azimuth and elevation radio beacons, the signals of which are picked up by onboard receivers and enable the pilot to determine the azimuth and elevation of the airplane at any given time during the landing approach.

The principle of angle measurement—electronic scanning of a beam with reference time, implemented by phased-array radars—is shown in the figure in the text. The centerfold of the magazine shows the coverages of the azimuth and elevation radio beacons (Fig. A) and the general layout of the scan sectors of the MLS (Fig. B).

How, for example, does the azimuth subsystem work? At any given moment of time, the pencil beam (1-3°) scanning at a frequency of 13 Hz begins to move "to" from its extreme left position (-40°). After moving through a certain angle, the beam at time  $T_1$  hits the airplane, and the onboard instruments register the signal. After reaching the extreme right position, the beam returns "fro" and again encounters the airplane at time  $T_2$ . If we know the scanning rate of the beam, the time it takes to span between the extreme positions, and also the difference between  $T_2$  and  $T_1$ , we can easily find the azimuth. The elevation is computed in similar way, with the exception that the scanning beam frequency is 39 Hz. The total update period for the angle measurement information is 615 ms, i.e., the pilot has exact data on the airplane's position almost constantly.

The system also includes a go-around radio beacon. It is used to determine the azimuth of an airplane during takeoff. The ILS does not have such capabilities.

The ground transponder of the MLS radar rangefinder receives the signals of the onboard interrogator and sends replies. That equipment continuously informs the crew as to the distance to the landing strip, working efficiently even when there is a great deal of interference from re-reflected signals at an airport with heavy air traffic. (As for the ILS, the airplane only registers passage over checkpoints—the marker beacons.)

The MLS has one other advantage—easy installation at the airport. Its apparatus and antennas are much smaller than those of the ILS. Furthermore, the azimuth beacon of the MLS can be offset 500 meters from the axis of the takeoff and landing strip, which is important for airports with complex terrain.

It should be added that the MLS provides the crew with data on the condition of the landing strip, the wind strength and direction, weather conditions, and other information that makes it easier for the pilot to land the airplane.

[Photo caption, p 34] Starting in 1992, our country will equip its airports with the new landing system. The work is being done in cooperation with the ICAO. If we do not want to become isolated from the world community, the installation of the MLS at our main international airports should be completed by 1998. Such is the opinion of the director of the Scientific Experimental Center of Air Traffic Control Automation, Doctor of Technical Sciences Tatyana Grigoryevna Anodina. [photo not reproduced]

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UDC 629

### Synthesis of Control of Spacecraft Rendezvous by Free Trajectories Method on Basis of Algorithm With Predictive Model

907Q0161A Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 25 Oct 88) pp 506-512

[Article by N. Ye. Zubov]

[Abstract] It is proposed that rendezvous by the free trajectories method be regarded as a problem involving the search for optimal control with the use of an algorithm with a predictive model. Simple analytical formulas are derived for computing the controls. The range of initial rendezvous conditions for which the algorithm is effective is determined. A method is proposed for determining the dependence of the parameters of the generalized operation functional on initial rendezvous conditions. Procedures are given for adjusting the functional coefficients which make it possible for the selected region of initial conditions to obtain accuracy characteristics for such indices as the mean values of the components of the vector of final state of the spacecraft and the standard deviations for these components. It is possible to execute a rendezvous with these accuracy characteristics from any other region of initial conditions different from that considered in this study. In such cases definite limitations must be satisfied: the maximal duration of engine operation in any of the control channels must not exceed 30 percent of the rendezvous time and the programmed impulses (with an impulse character of thrust) must ensure an accuracy in spacecraft guidance to a stipulated point with an error not exceeding 2000 m in each of the three coordinates. References 6 (Russian).

UDC 629.198.3

### Application of Recurrent Method of Parabolic Approximation of Extremals in Problem of Optimal Spacecraft Behavior

907Q0161B Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 20 Dec 89) pp 513-520

[Article by A. L. Vorobyev]

[Abstract] A recurrent method for the approximation of extremals determining the behavior of a dynamic system with rapid transition from a stipulated initial phase state to a final state was developed with allowance for limitations on the characteristics of motion of the system. A solution of the problem of rendezvous of a spacecraft with a satellite was obtained on the basis of a modification of a one-dimensional Pontryagin regulator for a two-dimensional system. Application of the method for parabolic approximation of extremals to specific examples is illustrated, such as for a system with an extremal in the form of arcs of circles and a nonlinear regulator.

These examples show the effectiveness of synthesis of phase extremals from parabolic arcs for solving nonclassical boundary value variational problems. Figures 4; references 6 (Russian).

UDC 629.78

**Experimental Check of a Mathematical Model of a Spacecraft With Intratank Damping Devices That Allows for Liquid Vorticity**

907Q0161C Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 25 Aug 88) pp 521-530

[Article by V. G. Lebedev, A. I. Mytarev, B. I. Rab-  
inovich and G. A. Churilov]

[Abstract] In studying the disturbed motion of a spacecraft and in solving stabilization problems, one must take into account the presence of the considerable masses of liquid that are aboard the craft. The spacecraft must be regarded as a solid body with cavities partially filled with liquid. Mathematical models of varying complexity that describe rotation of spacecraft with intratank damping devices about the longitudinal axis of symmetry are investigated on the basis of the eddy motions of the liquid contained in the tanks. The assumption that wave movements of the liquid are absent enables the researchers precisely isolate the specific effects associated with the eddy motion of the liquid only. A kinematic diagram of the experimental apparatus is presented and discussed. The influence of effects associated with intensive eddy formation in the liquid on the dynamics and stability of controllable motion of the spacecraft is analyzed. The adequacy of the proposed mathematical models is confirmed on the basis of processing of data from an in situ experiment, and the limits of applicability of each of these models are determined. Figures 5; references 9: 7 Russian, 2 Western.

UDC 629.785

**Dynamics of Soft Landing of Spherical Descent Modules**

907Q0161D Moscow KOSMICHESKIYE  
ISSLEDOVANIYA in Russian Vol 28 No 4, Jul-Aug 90  
(manuscript received 7 Aug 89) pp 539-544

[Article by V. G. Perminov]

[Abstract] The dynamics are examined for the soft landing of spherical descent modules that have good aerodynamics, which thereby ensure aerodynamic stabilization relative to the oncoming flow in the segment of ballistic drag in a planetary atmosphere. Requirements are imposed on each of two landing stages: the damping of the landing velocity component normal to the surface, and movement of the module on the planetary surface. In the first, the longitudinal and lateral accelerative forces must not exceed the accelerative forces at entry into the planetary atmosphere; and in the second, after damping, the module must stop in a position that enables the conduct of scientific research and data transmission. Analysis of the first stage assumes the following: (1) a flat, hard landing site; (2) the surface of the module is covered with inelastic, collapsible, honeycomb-structured shock-absorption; (3) impact upon landing is brief and orientation does not change over the period of damping of the velocity component normal to the surface; (4) the mass of the vehicle is constant. The nature of change in the parameters of lander movement as a function of surface slope and time is analyzed. The method was used in choosing the optimal variants for the landing of the Venera-7 and Venera-8 descent modules. The findings are not applicable only to strictly spherical probes, but also to those whose frontal surface is a spherical segment. Formulas are derived which can be used in an analysis of the dynamics of a vehicle in the sector of contact between a spherical part of its surface and the planetary surface. Figures 5; references 3 (Russian).

**'Molniya-1' Communications Satellite Launched  
23 Nov**

*LD2311155290 Moscow TASS in English 1540 GMT  
23 Nov 90*

[Text] Moscow November 23 TASS—The Soviet Union launched another communications satellite today to provide long-distance telephone and telegraph links and broadcast Soviet Television for the Orbita network.

The Molniya-1 blasted into space atop the Molniya booster. It was deployed in a highly elliptical orbit with the apogee of 40,593 kilometers in the Northern Hemisphere and the perigee of 654 kilometers in the Southern Hemisphere.

The revolution period is 12 hours 15 minutes and orbital inclination is 62.9 degrees.

**Three 'Cosmos' Navigation Satellites Launched 8  
Dec**

*LD1012104490 Moscow TASS in English 1037 GMT  
10 Dec 90*

[Text] Moscow December 10 TASS—The USSR launched last Saturday [8 December] the Cosmos-2109, Cosmos-2110 and Cosmos-2111 satellites into space. They were put into orbit by a Proton booster rocket. The satellites are assigned to tune up elements and equipment of a space navigational system to determine whereabouts of Soviet civil planes and sea-going ships.

The satellites were put into close to circular orbit with the following parameters:

Initial period of revolution—11 hours, 16 minutes,  
Distance from the earth—19,142 kilometers,  
Orbital inclination—64.8 degrees.

Onboard equipment is operating smoothly.

**'Raduga' Communications Satellite Launched 20  
Dec**

*LD2112090890 Moscow TASS International Service  
in Russian 0827 GMT 21 Dec 90*

[Text] Moscow, 21 Dec (TASS)—Another "Raduga" communications satellite, with retransmitting equipment on board to ensure telephone and telegraph radio communications and transmission of television programs, was launched by a "Proton" carrier rocket in the Soviet Union on 20 December. The "Raduga" satellite has been put into a near-stationary orbit with the initial parameters as follows: Distance from the earth's surface—35,937 km; period of revolution around the Earth—24 hours three minutes; inclination of orbit—1.3 degrees. The equipment installed on board the satellite is functioning normally. The command and measuring complex is guiding the satellite. The operation of the communications and television equipment of the satellite will be in accordance with a pre-set program.

**'Raduga-1' Communications Satellite Launched 27  
Dec**

*LD2812083490 Moscow TASS International Service  
in Russian 0806 GMT 28 Dec 90*

[Text] Moscow, 28 Dec (TASS)—A "Raduga-1" communications satellite was launched in the USSR by a "Proton" booster rocket on Thursday [27 December]. The satellite carries multichannel relay equipment providing for the further expansion of telephone and telegraph radiocommunication on USSR territory.

The satellite was placed in a near-stationary orbit with the following parameters:

- Distance from the earth's surface—36,535 kilometers;  
- period of revolution—24 hours 34 minutes;  
- orbital inclination—1.4 degrees.

The satellite equipment is functioning normally.

**'Almaz-1' Satellite To Launch in December**

*LD2411192390 Moscow Domestic Service  
in Russian 0430 GMT 24 Nov 90*

[Text] Preparations for the launch of a new automatic station are now close at hand. It will be engaged in studying earth from space.

Our special correspondent Leonid Lazarevich interviewed Gerbert Aleksandrovich Yefremov, general designer of the machine-building scientific and production association, where the station is being created.

[Begin recording] [Lazarevich] The launch of the new space vehicle Almaz-1 is being prepared for December. It is a large platform which, as far as I know, weighs about 20 tonnes in all, including a payload of four tonnes. What is the aim of this launch?

[Yefremov] This is not the first platform to be launched. It is the second launch, but on the first occasion, as Cosmos-1870, it was an experimental launch. The platform will be able to receive a large stream of information, because it is an automatic one. It is designed to function permanently for a long period, and will have on board equipment for all-weather observations. Its equipment will enable it to receive fairly detailed information on ecology, the earth's natural resources, sectors of the economy, hydrology, and so forth. [end recording]

UDC 528.873.044.1

**Experience in Operational Mapping of Degree of  
Moisture of Exposed Soils and Snow Cover From  
Satellite Radar Images**

*907Q0141A Moscow ISSLEDOVANIYE ZEMLI IZ  
KOSMOSA in Russian No 3, May-Jun 90 (manuscript  
received 25 Jun 88) pp 26-34*

[Article by M. Nazirov, USSR Hydrometeorological Scientific Research Center, Moscow]



[Abstract] The physical prerequisites and an algorithm for visual-instrumental mapping of the degree of moisture of soils and snow cover in flatland and hilly territories in the European USSR and Kazakhstan are analyzed using satellite radar images obtained in an experiment in April-May 1987. It was determined that in early spring, before the vegetation is extensive, radar contrasts can be used to distinguish areas with types of soil and snow cover that differ in terms of quantity and moisture phase state. Using a number of images as examples, the procedures for analyzing the radar images are given in detail. From altitudes of about 650 km, to which satellites with side-looking radars are now launched, the scanning zones provide much information on the agricultural zone of the European USSR and Kazakhstan, but the daily radar charts leave broad sectors which are not scanned. This problem could be solved by launching satellites to altitudes of about 730 km. As a result, from one such satellite a single reception point could receive four radar images covering virtually the entire southern part of the European USSR with a width of about 2000 km. This would require two-directional lateral scanning from the satellite. With respect to currently operating satellites, adequately complete radar charts of the state of soils and the snow cover can be compiled only once every three days, but even this information is highly effective for the adoption of practical decisions in the organization of spring agricultural work. Figures 3; references 4 (Russian).

UDC 528.77:550.814+629.78:551.24

#### **Study of Boundaries and Prospects for Finding Oil and Gas in Tectonic Zones of Tajik Depression Using Space Images**

907Q0141B Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 90 (manuscript received 16 Nov 88) pp 50-56

[Article by M. Kh. Ishanov and A. K. Gayazova, Tadzhikaerokosmogeodeziya Scientific-Production Association, Dushanbe]

[Abstract] The interpretation of space images of the Tajik depression makes it possible to detect the position of regional faults (lineaments), determine the boundaries of tectonic zones more precisely, ascertain the location of buried structures that are promising in terms of oil and gas deposits, and identify tectonic fracture zones within which hydrocarbon traps have been destroyed. The research was based on small-scale images in the visible part of the spectrum and in the near-IR and IR ranges, as well as on medium-scale black-and-white, color and multiband images obtained from a number of satellites. The images, at scales 1:200 000-1:1 000 000, with a 50-60 percent overlap, were characterized by a maximal clarity of the photoimage and minimal natural interference, such as clouds, snow cover, haze and shadows due to relief. The most effective spectral range was 600-700 nm. Additional work was done on the ground and from

aircraft. The geology, geological history and geomorphology of the work region are described and tectonic zones are delineated on a photomap of the studied area. On the basis of the images and analysis it was possible to define the specific structures in the Tajik depression most suited for reconnaissance and exploration for oil and gas. Figures 2; references: 7 Russian.

UDC 629.783:778.39

#### **Systems of Minimal Number of Satellites for Repeated Scanning of Earth**

917Q0027A Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 90 (manuscript received 2 Mar 89) pp 102-108

[Article by Sh. I. Galiyev and V. I. Zabotin, Kazan Aviation Institute imeni A. I. Tupolev]

[Abstract] The problems involved in the choice of orbits of satellite systems for the remote sensing of the Earth are examined. The Earth's surface is assumed to be a sphere of the radius  $R$  and is assumed to have a uniform gravity field. Referenced to the Earth is an absolute coordinate system in which a system of  $N$  unperturbed satellites, regarded as material points, is examined. In this general formulation it is shown that for ensuring total coverage of the Earth's surface the number of satellites in the system must be greater than or equal to  $2k+2$  and that when  $k = 2, 3, 4$  this number of satellites is adequate for construction of such a system. The merits and shortcomings of a series of variants of systems are analyzed. Particular attention is given to the advantages of eight- and ten-satellite systems. It is shown that a change from circular to elliptical orbits would make it possible to reduce the number of satellites necessary for simultaneous multiple coverage of the Earth's surface. Figures 2; references 13: 6 Russian, 7 Western.

UDC 528.94(202)

#### **Methods for Determining Economic Efficiency in Using Space Survey Materials in Multisided Study and Mapping of Natural Resources**

917Q0027B Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 90 (manuscript received 30 Mar 89) pp 109-113

[Article by A. K. Gayazova and A. S. Zhezherun, Tadzhikaerokosmogeodeziya Scientific Production Association, Dushanbe]

[Abstract] The Tajik Affiliate of the Priroda State Center since the 1970's-1980's has inventoried and mapped the natural resources of Tajikistan on the basis of space surveys. A number of examples are cited showing that the use of such materials in thematic mapping affords the possibility for obtaining a considerable savings due to acceleration and cost reduction in the mapping process. There is an increase in the information content of the new maps and their practical use in the economy has



proven highly effective. Depending on the degree of reliability and the time frame considered the saving may be immediate, long-term, potential or predictive. In predicting dangerous natural phenomena the saving can be estimated as the sum of the prevented loss and in planning work as the profit due to the choice of more validated planning decisions. This is illustrated by specific applications of such natural resources mapping, for example, use of space surveys for aiding in oil and gas

exploration in which specific photo anomalies were later checked by drilling and seismic prospecting, bypassing much field work and thereby resulting in a significant cost reduction. A great number of maps were prepared (landslides, mudflows, pasture lands, forests, soils, soil erosion, reclamation, tectonics, soil salinization, etc.). The costs of compiling such maps from space photos and by traditional methods are compared. The formulas used in such cost calculations are presented.

### Defense Ministry Launches Communications Satellite for RSFSR

*LD2411033090 Moscow Television Service  
in Russian 1800 GMT 23 Nov 90*

[Video report by A. Gerasimov from Baykonur Cosmodrome on 23 November, incorporating remarks by M.A. Yelizarov, Russian Soviet Federated Socialist Republic deputy minister of communications, information technology and space, and V.S. Loboda, press spokesman for the USSR Ministry of Defense space management unit; from the "Vremya" program—recorded]

[Text] At the Baykonur cosmodrome today, a communications satellite in the Gorizont series was launched by means of a Proton carrier rocket. The Russian Federation is the first of the Union republics to have acquired its own satellite.

[Gerasimov] The excitement and delight of the military men watching the launch of this 1,000 ton package putting a Gorizont television satellite into space is understandable.

This is how it looks. [Video shows close-up of satellite] For the first time in the history of Soviet cosmonautics, the USSR Defense Ministry is fulfilling a commercial order. After delaying the planned launch of its own satellite, the military department has provided the RSFSR Ministry of Communications, Information Technology and Space with the opportunity to begin carrying out a large-scale space project. Three satellites, one of which went into orbit today, are due to ensure assured reception throughout the territory of almost the entire country of the Second Television Program. Next year, it will become the Russian Television Program.

[Yelizarov] Fifty million Russian-speaking members of the population reside in the territory of other republics. Therefore, how is one to cut off this population? Boris Nikolayevich Yeltsin recently came back from Kiev after concluding a treaty with the Ukraine, and it was clearly stated there that over 11,000,000 Russian-speaking members of the population reside in the Ukraine. Surely, they are interested in Russia's program. There is our implementation of our 500-days program. True, the press and other news sources are now saying that it has failed and that it is unrealistic, but we are doing things.

[Gerasimov] Russia's communication workers are also banking on the space program in tackling tasks connected with providing a telephone service for the republic. After all, at present over 60,000 populated localities in the Russian Soviet Federated Socialist Republic lack communication with the rayon centers. According to a leader of the Ministry of Communications, one out of every two inhabitants in Russia will have his own domestic telephone in the course of the present decade.

A further point is that, again for the first time in the history of our cosmonautics, both the carrier-rocket and

the satellite were insured in line with world practice. With the approval of the Russian parliament, the republican Ministry of Communications will pay the country's Ministry of Defense about R100 million for the whole project.

[Loboda] Frankly speaking, we have not notched up any special profit, something around 15 percent of the overall cost. Naturally, this is an act of goodwill on the Defense Ministry's part towards the citizens of Russia, first and foremost, and the Soviet Union as a whole.

### RSFSR Minister of Space and Communications Interviewed

*907Q0146 IZVESTIYA in Russian 23 Jul 90 Evening edition p 2]*

[Interview with Vladimir Borisovich Bulgak by S. Leskov, under the rubric "Appointments": "First Space Minister"; first paragraph is source introduction]

[Text] *In the RSFSR government, V. Bulgak, a 49-year old member of the board of the USSR Ministry of Communications, has been confirmed to a post unusual for our administrative structures—Minister of Communications, Information Science, and Space.*

**Leskov:** Vladimir Borisovich [Bulgak], the word "space" in the title of your ministry—is it a tribute to the times, or a reflection of some real plans?

**Bulgak:** The ministry has the job of setting up a unified space-based communications system that belongs to Russia. The draw to space-based communications is natural for Russia, because of its immense, inaccessible areas. Hence the need for combining space-based and ground-based facilities under one roof.

What are our plans? We need to launch three more Gorizont satellites; that will then cover all of Russia not only with the first all-Union programing, but also with the second. And if we modernize existing satellites, the Moscow programing also will be received throughout the entire republic within five-six years. Plans call for two television programs to be transmitted to Russian television.

In my view, we need to determine the proportion of Russia's contribution to Union and international space programs. Russia's money should support Russia's interests. We are thinking of joining the international INTELSAT system, to which the USSR has been repeatedly invited. On a technical level, that is possible; after all, foreign systems aren't any better than Soviet systems.

**Leskov:** Television is a good thing. But the first communication need is the telephone. In terms of the availability of telephones, however, Russia is in 11th place in the country.

**Bulgak:** In Russia, there are 26-28 telephones for every 100 families. By the end of this year, every third family will have a telephone. And after five years, each second

family. But a new problem arises: 70 percent of the dial-office buildings today stand empty, because there is no equipment.

The weakest spot is the link-up between the rayon center and the oblast center. Take Krasnoyarsk Krai, for example—those link-ups span thousands of kilometers; here a "space bridge" is irreplaceable. At present, the percentage of space-based telephone communications is only four-five percent of the total. The world average is five-seven percent. In light of our geography, our percentage should be above the world average. We will also work in that direction.

**Leskov:** Such extensive plans require a great deal of money.

**Bulgak:** A communication satellite costs 8-12 million rubles (R); launching costs R7 million; operation, R2-2.5 million annually. Such fees have to be set for all who wish to use space vehicles, so that we can recover our costs. Through the fees, we will establish relationships with all the departments that cannot get by without communication satellites, including the State Committee for Television and Radio Broadcasting. I must emphasize that we pay the Ministry of General Machine Building for constructing the satellite and the Ministry of Defense for the launch.

Yet another possibility of earning money is in the sale, to any interested departments, of licenses to the right to build and operate space communication facilities situated in the territory of the RSFSR.

**Leskov:** How do you feel about the plan to solve the communications problems with a gigantic platform launched by the powerful Energiya rocket?

**Bulgak:** If right the ministry were to give the R6 billion it has right now over to the construction of a platform, then the development of the ground-based communications would come to a halt, and we would have to wait even longer for the end product. And the risk would be great: what if there were a failure, something the space program is not immune to? The platform is a good idea, it's attractive, and to abandon it would be to slow the growth of science. But today we don't have the money for it. Nevertheless, if the RSFSR Supreme Soviet were to consider the possibility of financing work with the platform, I would be very grateful.

**Leskov:** The era of industrialization is disappearing into the past. The era of a computerized society is approaching. That is also your bailiwick. Will we be able to approach the world level?

**Bulgak:** In discussions of a market economy, we talk about prices more often than not. But an indispensable element of the market infrastructure is information, and its routine exchange. We feel that in the program for a transition to a market economy, communications must become a priority.

### Soviet Cosmonautics: Achievements and Prospects 907Q0145 Moscow ZEMLYA I VSELENNAYA in Russian No 4, Jul-Aug 90 pp 8-16

[Article by V. S. Avduyevskiy, academician, Mechanical Engineering Institute imeni A. A. Blagonravov, USSR Academy of Sciences, and V. P. Senkevich, doctor of technical sciences, Flight Control Center; first paragraph is source introduction]

[Text] *Recently, discussion of the prospects for the development of cosmonautics program in our country has been vigorous. The many criticisms leveled at it have dealt with the excessive secrecy and the lack of information disseminated about the Soviet space program. This article describes the principal directions and trends in that program and the projects being developed within its framework.*

#### What Has Been Achieved

Since 4 October 1957, when the launch of the first artificial Earth satellite marked the onset of the space era, the Soviet space program has traveled a long and complex road.

Today, we have powerful rocket-space technology and ground support systems and facilities. Several types of launch vehicles have been developed in the USSR for solving the numerous problems associated with the mastery of space: from the Sputnik and the Vostok to the heavy-lift Proton and the superheavy-lift Energiya. Three first-class cosmodromes were constructed (Baykonur in Kazakhstan, Kapustin Yar in the Volga region, Plesetsk in the Arkhangelsk region). There are flight control centers for unmanned and manned space vehicles (the Flight Control Center at Kaliningrad, in the Moscow Oblast; the Deep-Space Communications Center near Yevpatoriya; and the numerous regional centers and points for the reception of economic and scientific information from space vehicles) and a complex network of surface and shipborne stations for communication and reception of space information in the structure of the command-telemetry and control systems. Dozens of types of unmanned and manned space vehicles, with varying purposes, have been launched into space.

The needs of the space program serve as an important stimulus for the development and improvement of electronics and computers, power engineering and machine building, chemistry, and many other sectors of industry. They are presented with exceptionally rigorous requirements with respect to the efficiency of apparatus, reliability and service life, and reduction of size and weight of the all component parts of a spacecraft. The space program has also posed a number of complex problems to applied science. The solution of those problems results in progress in materials science, in the technology for treating metals, in power engineering, in aerodynamics, in the creation of automatic control systems, and much more.

The designs, the technologies, and the experience gained in managing complex projects and research efforts in the space program are now also finding broad application in other sectors. The development of the reusable Buran craft and the superheavy-lift Energiya launch vehicle involved the creation of more than 240 new production processes, 130 types of equipment and more than 100 new materials, all of which have been transferred to enterprises and organizations of light industry and of the aviation, shipbuilding, nuclear-power, chemical, and electronics industries, as well as to medicine.

However, that is no longer adequate. The United States, for example, has a considerably greater economic return from the development of space technology than does the USSR. After spending some \$25 billion on the Apollo program, the American space industry is known to have received as much as \$300 billion (\$100 billion in 1970 prices) from the sale of patents.

The failure to inform the public on the work of the space sector and excessive departmental secretiveness have resulted in a distorted idea concerning its actual expenditures and also of its seemingly small contribution to solution of urgent problems of the national economy. It was not until the First USSR Congress of People's

Deputies was in session in June 1989 that the appropriations for the space program became public information. It was announced that in 1989 they amounted to 6.9 billion rubles (R).

According to predictions of sector specialists, the savings realized from the use of domestic space systems for national-economic purposes will be R19.2 billion in 1986-1990, R19.7-26.7 billion in 1991-1995, and as much as R32.3-52.1 billion in 1996-2000. It is expected that each ruble invested in the civilian space program will bring 12-17 rubles in profit.

Space research is enriching us with discoveries and new scientific findings. Thanks to that research, we have acquired extensive experimental data concerning near-Earth space, the Moon and the planets, processes that take place in the Earth's atmosphere and on the Sun, and the structure of matter. Those new facts are greatly refining our concepts of the world around us, sometimes changing those concepts radically.

After the missions of 10 unmanned vehicles in the Mars, Zond and Fobos series, our concepts of Mars changed radically; a great deal of new data was obtained for Venus as a result of research performed by the 16 Venera unmanned stations and the two Vega vehicles. The flights of 24 unmanned vehicles of the Luna series and several Zond vehicles enabled the study of circumlunar space and the lunar surface, as well as the travel of lunar rovers across its surface and the delivery of lunar soil to the Earth.

**Savings (in Billions of Rubles) From Use of Space Technology For Purposes of the National Economy (Based on Data From Board of Ministry of General Machine Building, August 1989)**

Field	1891-1985	Prediction for		
		1986-1990	1991-1995	1996-2000
Meteorology and ecology	2.8	3.9	5.8	9.6
Study of Earth's natural resources	0.3	2.2	4.8	5.8
Space communication, television, relaying	0.3	0.2	4.1	5.6
Space navigation	—	0.4	0.8	3.8
Space-based production, materials science, technology	4.9	12.5	4.2-11.2	7.5-27.3
Totals	8.8	19.2	19.7-26.7	32.3-52.1

It is difficult to overestimate the importance of space-based astrophysical and radiophysical research for solving many fundamental problems of modern science. Instead of just the two small "windows" of the spectrum of electromagnetic waves (optical and radio) that were previously accessible for ground-based observations, modern science is now able to perform research in space across the entire spectrum of wavelengths, from gamma radiation (with wavelengths of less than  $2 \times 10^{-8}$  cm) to radio waves (with wavelengths of greater than  $10^{-2}$  cm). For space physics and astrophysics, several types of standardized space vehicles have been developed, and work is also being done on orbital stations and manned spacecraft.

Manned missions occupy a special place in the Soviet space program. Since 12 April 1961, when Yu. A. Gagarin made the world's first orbital flight, more than 200 men and 13 courageous women from 20 countries have visited space—among them, 68 of our fellow countrymen. The crew of Soviet cosmonauts V. Titov and M. Manarov pushed the record for the longest stay in space to one year.

Orbital stations are now capable of functioning reliably in near-Earth space for many years and, in the process, successfully implementing a planned program of operations whose principal areas consist of the combined study and mapping of the Earth's natural resources (we

note that from orbit, in five minutes, with the required resolution, an image can be made of a territory whose survey from an aircraft would require one and a half-two years of flight operations); the study of the Earth's atmosphere; the investigation of various physical phenomena and processes in space; astronomical observations; biomedical research; development of new on-board systems and instruments; and experiments and quasi-industrial operations involving space-based technology and materials science.

How does the Soviet space program compare with the American program? If we look at the problems being addressed in them, then the methods and scales of their solution are, in many ways, similar. Nevertheless, it must be admitted that the United States has outpaced us in terms of manned expeditions to the Moon and its surface and in terms of the study of distant planets such as Jupiter, Saturn, Uranus, and Neptune with unmanned probes.

Over a somewhat longer period than in the United States, we developed a superheavy-lift launch vehicle, Energiya, the orbital craft Buran, launch facilities, and control and airport landing equipment.

It is no secret that the USSR is behind the United States, Japan and certain other countries with respect to the technical level of its computer component base, its data processing equipment, microminiaturization of apparatus and instruments, and certain other areas. That affects the performance characteristics of the electronic equipment used for space vehicles and orbital stations. That is why on-board systems are not reliable enough and must be backed up, which results in an increase in system weight. But even that does not always ensure adequate active lifetimes of space equipment (i.e., the time during which a satellite in operation and transmits information to the Earth). For example, our communication satellites operate for three-five years, which is less than half the lifetime of similar American vehicles.

The ballistic design of certain space systems (for communications and television broadcasting, for navigation, for meteorology) requires that a specific number of satellites be in orbit simultaneously. Often, because of the relatively short period of active operation, new satellites must be launched to replace malfunctioning satellites. And in light of the poor information density of certain types of Soviet-produced electronic receiving-transmitting equipment, it is easy to understand why the USSR annually launches 110-115 space vehicles, whereas, in recent years, the United States has launched less than one-fifth that number. And yet, today there are in orbit 180-220 American satellites that are transmitting information, and only 150-180 such Soviet satellites (the data, from the open foreign press, were obtained on basis of information from ground-based electronic receiving systems).

### Trends of Tomorrow

Let us examine the trends being predicted for the Soviet space program, which, incidentally, are also characteristic of the American space program.

There are many factors dictating the efforts to keep down the number and variety of development projects, despite the fact that the virtual avalanche of requests for space equipment is growing. Today there are dozens of types of special-purpose space vehicles, and if things were to continue to go as before, the number of such vehicles would exceed 300 by the year 2000. That means that we must seek new, progressive technical solutions. Exactly what would they be?

First, there must be a *changeover to the development of multipurpose orbital satellite-platforms*. That would make it possible, on the basis of a single base structure, to solve several different special problems at the same time. Extremely promising is the use of interproject standardization and a building-block, modular design for space vehicles and their component parts, plus easily interchangeable equipment.

A changeover to multipurpose satellite-platforms would make it possible to reduce the number of facilities launched into space and to use heavy-lift and super-heavy-lift launch vehicles more often. Such a strategy is difficult to effect—new design techniques have to be mastered (all the equipment on the platforms must be compatible), and organization of labor becomes more complex. The production areas of assembly shops must be expanded so that they can work with large-scale objects, and the production equipment and rigging must be replaced. Some of the assembly work will have to be performed in space. All this, to be sure, requires additional monies, which for the time being do not exist. Additional research is needed for an evaluation of the technical and economic efficiency of this area of work.

Second, *space equipment must be reusable*. That is not confined merely to reusable manned craft such as Buran or the Space Shuttle. It is possible, for example, to reuse ordinary launch vehicles with stages returnable by parachute. In certain cases, it is necessary to bring entire spacecraft back to Earth, or removable modules, assemblies, and apparatus, which, after repairs on the ground, can be sent back into space. If, for example, a large optical telescope with a 2.5-3-meter mirror whose fabrication is exceptionally labor-intensive and complex is launched into space, it must, after a given period of time in space, be returned to the Earth (on, say, Buran) to be renovated and then reused.

In the future, use may be made of aero-space systems operating on the principle of a jet aircraft and either an orbital airplane or a reusable winged rocket (ZEMLYA I VSELENNAYA, No 3, p 37, 1989—*Editor*).

Third, *an effective system for in-space transportation, servicing and maintenance, and repair must be developed*. In orbit, there needs to be hangars, warehouses, and

other structures for storing fuel, expended materials, apparatus, instruments, and tools. Automated robotic systems must be used to assist the cosmonauts. Such systems will see with television cameras and will be equipped with manipulator arms, mobile jet-powered cars for in-orbit transport, truss builders, and equipment for the assembly and repair of large structures and replacement of modules and instruments on multipurpose orbital platforms or orbital stations. The base unit for accommodating the facilities for transportation, servicing and maintenance, and repair in space could be the new-generation Soviet orbital station Mir-2 (which may be launched in 1997-1998) or the American Freedom station, both of which, when fully deployed, will be high-capacity, in-orbit assembly-and-operations space centers.

#### Areas of Development

The prospects for the development of individual areas in the space program are highly promising. To date, a number of Soviet and international projects involving space vehicles used for economic and scientific purposes have been developed. Let us examine some of them.

*Space-based systems for communications and television broadcasting.* These days, the need for communication channels is ever increasing, and the number of information consumers is growing. The Soviet space program is proposing to develop new communication satellites with high-power transmitters. The new STV-12 satellite television-broadcasting system will make it possible for TV signals to be picked up everywhere on collective- or individual-use antennas. The satellites will provide multiprogram broadcasting to the entire USSR and a number of foreign countries. The new vehicles, which will replace the present-day Gorizont satellites, will have a higher traffic capacity because of a larger number of relay trunks, an expanded signal passband, and onboard high-directional transceiving antennas that are more advanced.

Of interest is a project involving a superheavy geostationary satellite (launched by the Energiya vehicle) that will have a higher information density in the transmission of radiotelephonic information and that will be able to serve several million telephone subscribers. But that also requires the construction of an enormous number of ground-based receiving-and-transmitting facilities. That project has supporters as well as opponents, and it will require additional consideration.

Also possible is the use of space-based satellites for maintaining communication with individual subscribers (geologists and geodesists, for example) who are using portable equipment, including hand-held two-way radios.

*Space-based navigational and geodetic systems.* At present, as many as five satellites of the Tsikada system are always in operation for maritime shipping. They can determine ship coordinates every one-two hours within 100 meters. As a result, travel time is cut by eight-10

percent, which saves more than R100 billion annually. The GLONASS navigational satellite system is being developed for continuous global determination of the coordinates and speed of maritime vessels and aircraft (operation will begin in 1989-1990) (ZEMLYA I VSELENNAYA, No 3, p 13, 1990—*Editor*).

In conjunction with the GLONASS system and other satellite systems, the international COSPAS-SARSAT system (USSR, United States, France, Canada) will be able to perform dispatcher functions in the determination of the coordinates of ships and aircraft in distress, as well as in the transmission of timely information on imminent natural disasters to those who need it.

A new stage in space geodesy began with the launches of the GEO-IK satellites, which provide geodetic measurements—including construction of geodetic networks and determination of parameters of the Earth's gravity field—with a higher accuracy than that of the specialized satellites of the Kosmos series. The development of a new type of geodetic satellite, equipped with onboard geodetic instruments ensuring an accuracy of geodetic referencing of less than 1 meter, is possible by 1995-1997.

*Space-based facilities for the natural resources study, hydrometeorology, and environmental monitoring.* An important role belongs to artificial Earth satellites and orbital stations in the systematic observation of the ice cover of the northern seas, ocean currents, ice movements, and the temperature and salinity of the World Ocean; in the recording of plankton migration; in the monitoring of forested areas and regions of agricultural activity; and in the exploration for minerals. For solving many of those problems, scientists and practical workers will, in the near future, have unmanned multipurpose platform-complexes with apparatus designed to be in operation for many years.

Apparently as early as the end of this century, new systems of meteorological satellites will provide reliable weather predictions not for three-five days, as at present, but for 10 days—and in the more remote future, for a month. That will enable a more precise determination of the optimal times for operations involving, for example, agriculture and construction. It will provide early warning of deteriorating weather and will enable people to prepare for approaching natural disasters. A new generation of satellites are planned to go into operation for that in the second half of the 1990s. At that time, meteorological satellites will be not only in low and near-Earth orbits, but also in geostationary orbits. Via television (in the visible and IR ranges) and radar, information will be sent to Earth on the distribution of cloud cover and on the speed and direction of winds at various altitudes. Meteorological data arriving from unmanned ground and buoy stations will be collected and relayed by satellite. A standardized orbital platform supporting a permanently functioning system for the

day-to-day observation of land areas, the oceans, and the atmosphere may be in operation by the start of the next century.

The solution of ecological problems is impossible without the well-organized monitoring of state of the environment. International cooperation in that field is extremely promising. It is not by chance that our country's proposals concerning the creation of a UN center for emergency ecological assistance have been viewed with great interest. In the implementation of that concept, a key role belongs to remote sounding and monitoring facilities.

*Manned complexes.* In the future, the Buran orbiter will be used to solve a number of important economic and scientific problems on a Mir-type orbital station and on specialized modules. As for orbital stations, their flight duration, weight, crew size, and equipment will constantly grow. The total weight of the Mir complex may reach 140 tons. It will consist of five modules, each weighing as much as 19 tons, 4 tons of which will be scientific equipment. There will be six or more crew members, and power output will be 18 kW. Thus, the Mir station is being transformed into a permanently operating orbital assembly-and-operations, laboratory-research center.

Installations and robotic equipment will be developed for the in-orbit assembly and deployment of large structures. Those structures will primarily be trusswork structures dozens of meters in length and antennas with diameters of 50-300 meters; in the more distant future, the structures will be even larger. Power plants with an output of nearly 20 kW are also expected to be used in space, and in the early part of the 21st century, work will begin on construction of the first space-based electric power stations with outputs of as high as 500 kW or more.

*Scientific research in space.* The program for the space-based scientific research planned for the next 10-15 years is expected to be extremely intense. A considerable part of that program will be carried out within the framework of international cooperation on a mutually advantageous basis.

Fundamental problems in extra-atmospheric astronomy will be dealt with in the Spektr-Rentgen-Gamma project (ZEMLYA I VSELENNAYA, No 1, p 17, 1989—*Editor*). The study of relict radiation that was performed in the Relikt-1 experiment (Prognoz-9 spacecraft, 1983, from an apogee altitude of 700,000 km) (ZEMLYA I VSELENNAYA, No 4, p 5, 1984—*Editor*) will be continued in 1993 within the framework of the Relikt-2 project. The spacecraft will be sent to the vicinity of a libration point some 1.5 million km from Earth. The use of cooled transceivers will result in an instrument sensitivity three-four times greater than that of Prognoz-9. The space vehicle's being near a libration point will markedly decrease the influence of the radiothermal fields of the Sun, Earth and Moon.

Work is expected to begin in the mid-1990s, in the Aelita project, on spacecraft that will study "cold matter" (dust and molecular clouds) and inhomogeneities of the relict background. For such a study, the sensitivity of the instrumentation aboard those craft must be increased to  $10^{-5}$  K. The instruments will be cooled in a cryogenic system based on liquid neon and superfluid helium.

The study of complex processes in the Earth's magnetosphere that exert an influence on many terrestrial processes and phenomena will be continued.

Early in the 1990s, in accordance with the international Interbol project, two Prognoz-type vehicles will be used to perform simultaneous measurements of electrical and magnetic fields, plasma convection parameters and behavior, and processes associated with the acceleration of charged particles, as well as a study of the interaction between solar wind and the magnetosphere.

In the USSR, through the joint efforts of the European Space Agency (ESA), the Klaster [Cluster] system will be developed. That system will make it possible to study the three-dimensional patterns of the complex dynamic processes associated with plasma motion. The system will consist of at least five-six vehicles. In the more distant future, there will be the Roy [Swarm] system consisting of several dozen vehicles for studying the magnetosphere in various regions.

The Moon is a unique scientific-technical test range in which scientific research has been carried out in the past and will be carried out in the future and in which engineering solutions will be checked out for their correctness and space equipment—including that intended for flights to Mars and certain other celestial bodies—will be tested.

In the United States, the possibility of giving national status to three programs is being considered: development of a permanently operating orbital space station, the development of a new generation of launch systems, and finally, construction of a base on the Moon. Those programs have not yet been approved, because the monetary costs associated with them are quite high.

In the Soviet space program, because of economic difficulties, the problem of constructing a base on the moon has yet to be raised. Only the launch of a satellite into a polar orbit for a global photographic survey of the Moon in the 1990s is being considered. Planners intend to use the satellite make the lunar map more precise; specifically, images of its poles will be produced for the first time ever. Plans also call for the development of new vehicle for delivering soil back to Earth from the Moon's dark side.

There is a project for a permanently operating "unmanned lunar service" for performing prolonged systematic astronomical observations and measurements of cosmic radiation, corpuscular fluxes and other phenomena that are distorted near the Earth by its magnetic field (ZEMLYA I VSELENNAYA, No 3, p 57,

1989—*Editor*). From the Moon, it is also possible to study processes occurring in the upper layers of the Earth's atmosphere (synoptic processes, for example). In the more distant future, various stationary and mobile technical facilities, plants, and laboratories for performing production processes that are difficult or impossible on the Earth could be set up on the Moon. Scientists are interested in the Earth-Moon system libration points—the points at which the pull of the Earth and Moon is identical—because such points can be used as places for the storage of wastes or of satellites that have reached the end of their lifetime. They could also be used in setting up space communications and in performing scientific research (in the Relikt-2 project, for example). In the more distant future, they could be used for space settlements.

The study of solar system planets and other celestial bodies will remain an important area in the Soviet space program. The study of Mars and its satellites is continuing. The space odyssey of the Fobos-2 vehicle, which failed in its final stage, and the failure before it of Fobos-1 (ZEMLYA I VSELENNAYA, No 5, p 3, 1989—*Editor*) nevertheless produced a number of scientific findings and made it possible to debug certain equipment systems. That was the initial stage in a new, long-range space program for the study of Mars. The next stage should begin in a few years, when spacecraft will be sent to Mars (ZEMLYA I VSELENNAYA, No 1, p 19, 1989—*Editor*). Specifically, plans call for the 1994 launch of two unmanned interplanetary vehicles. One of the main jobs of these vehicles will be to study meteorological conditions on Mars and the structure of the planetary surface and crust. In the astronomical window that follows that (1996-1998), two other vehicles could deliver samples of the Martian soil back to the Earth.

In the first quarter of the 21st century one can expect the final development of the principal components of a Mars expeditionary complex, possibly with a manned flyby of Mars as the final preliminary stage of the expedition. But those things will cost many billions, which, under present-day conditions, is still beyond the means of the Soviet economy by itself. Cooperation with NASA and the ESA would be useful in handling the problem.

That also applies to the study of Venus, the comets, and the asteroid belt that is situated between the orbits of Mars and Jupiter. That asteroid belt can, in fact, be studied with available equipment, which explains the joint analyses being carried out in the Vesta project (USSR, France and ESA). Modules are being designed for landing on the asteroids, and scientific equipment is being developed jointly with other project participants.

It would also be of interest to study Jupiter, Saturn, and their satellites, but there are no plans for such work before 1998. Quite a few other space projects now being discussed by specialists could be cited here, but the analyses associated with them either are of a very preliminary nature or are extremely problematical and controversial.

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## Reevaluation of Space Program Costs, Priorities Urged

907Q0139 Moscow TRUD in Russian 2 Aug 90 p 3

[Article by V. Golovachev, political observer for TRUD; "Space—Not an End in Itself: Some Thoughts in Connection With the Launch of the Next Crew"]

[Text] Unexpectedly, I caught myself in a strange thought: the new crew flying into orbit evokes in me something similar to sympathy, but, unlike in the dozens of earlier launches, it's in no way an uplifted mood. Somehow it's absurd: it's a holiday for the cosmonauts, but I'm feeling sympathy. The commander, Gennadiy Manakov, and the flight engineer, Gennadiy Strekalov, calm and confident, left for a stint in space expected to last a little over four months (to be more precise, for 132 days). Their turn aboard the Mir complex will not be an easy one: EVAs, roughly 250 experiments consisting of production experiments on the Kristall, plus astrophysical, bioengineering, geophysical, and medical experiments—the usual stuff. So why this feeling of sympathy?

Both are well trained. The commander is an experienced test pilot, who has mastered nearly 40 types of aircraft, has flown modern fighters—and that includes during his training for the present space flight—and is a possible candidate as a future crew member on the Buran reusable craft. The flight engineer is a space ace and has been in orbit more than once. Together with V. Titov, he was the first (and God willing, the last) to test the emergency rescue system (ERS) on the ground, when, during a launch, the enormous rocket caught fire, and the special solid-fuel engines at its apex tore the cabin from the flames and lifted it into the sky off to one side, after which the cabin descended by parachute to the steppe.

They're cool-headed, strong, courageous people, who don't leave Earth for the sake of glory (the euphoria of the first launches passed long ago—G. Manakov is the 68th Soviet pilot-cosmonaut) or for the sake of money (the salary of a cosmonaut is 300-400 rubles; military personnel also get the usual pay supplement, and for a flight they're given a one-time premium of R2,000-15,000). They fly into space because they chose that difficult profession, because they love that attractive, risky business. Each flight is like a ticket to happiness for them: there are fewer flights than people who want to go up. I'm happy for the cosmonauts and am doing everything to drive away the stupid, out-of-place, untimely feeling of sympathy.

But it's not working very well, because I know that they will have to expend a great deal of effort not so much on research and experiments as on difficult work that involves fixing unexpected breakdowns and correcting somebody else's errors and miscalculations. "Many instruments," General V. A. Shatalov was forced to say with bitterness last year, "are 'undercooked'—half the



scientific equipment doesn't work. Crews spend an enormous amount of time on repairs and maintenance. Yes, of course, we're now convinced from experience that cosmonauts can be assigned any task and they will handle it. But, after all, that shouldn't be an end in itself...."

The efficiency in economic terms of manned flights under such conditions is giving rise to more and more questions. Initially, the cost of the mission of A. Solovyev and A. Balandin, who are now aboard Mir and who should be returning to Earth on 9 August, was estimated at R80 million, while the revenues (from unique crystals, biological preparations, etc., produced in space) was estimated at R105 million. I would like to know, however, what the actual costs and revenues turned out to be (the program was changed, the Kristall module arrived very late, and operation time in orbit was lengthened). Were we able to break even? And how are the revenues computed, how real are they, and is it possible to, so to speak, touch them? Would facts clearly refute those who assert that this is, by and large, a theoretical, "hypothetical" economic gain?

Let me say right off the bat: I am for the development of the space program. Only a short-sighted individual could call for a reduction of appropriations to that trail-blazing sector, which largely determines technical progress. But at the same time, after discussing the different variations from all angles in the USSR Supreme Soviet, we must openly choose clearly defined directions and take care that each ruble invested in the space program yields as much of a return as possible.

The manned space program is known to be about ten times more costly than unmanned space program if the cost is reckoned on a per-kilogram-payload basis. However, the lion's share of all the materials for scientific and practical needs (photographs of the Earth, clouds, etc.) comes from satellites. The most efficient, from a commercial standpoint, are communications satellites. In the United States, nearly 70 launches are planned for 1990-1995 for communications satellites. Indeed, their system of, say, telephone communications is incomparably better than ours. And it is especially incomprehensible that, for a year now, we have been discussing the problem of financing new communications satellites and an integrated program in the USSR Council of Ministers, the USSR State Planning Commission, and the USSR Ministry of Finance, and the problem still isn't resolved. Compare these figures: one five-month manned mission costs R80-100 million (this year, plans call for spending R220 million on manned flights), whereas the manufacture of a communications satellite costs only R8-12 million, and its operation costs R2-2.5 million. The comparison gives an extremely graphic picture, although I understand that the comparison here may not be not very appropriate. But I remind you: in Russia there are 26-28 telephones for every 100 families. More than 10 million people in the country are not reached by television...

Figures are always boring, but here, I think, is a special case. And that's because we're talking about money that is coming out of our pockets. For example, Buran cost us R14 billion. An end to its testing is still not in sight, nor is any clearly defined program for its use. And then there are the Fobos vehicles, which were lost in space, which cost the country about R300 million. The list could go on. Isn't it time that we focused close attention on the spending and revenues associated with this important sphere? Especially since there are interesting alternative projects? For example, in place of the construction of the new Mir-2 orbital station, specialists of the Salyut Design Bureau (an extremely prestigious space organization) propose the construction of a 100-ton in-orbit factory that would yield a thousand kilograms of product a year (each gram of which would cost, on the world market, many thousands of dollars). The factory would operate in a man-tended mode, with cosmonauts flying to it twice a year to stoke the furnaces, collect the finished product, and carry out the necessary repair and maintenance work. Total spending for the program would be R1.2 billion, while the value of the materials produced would be R3-8 billion. Interesting? At the very least, it's serious food for thought.

I will say in conclusion that the Americans want to build a large orbital station. And here's something that appeared in the NEW YORK TIMES not so long ago: "Government experts have belatedly discovered that the design of the Space Station Freedom, at a cost of \$300 billion (!), will have to be changed, because a large number of its components will begin to break down even before construction of the station is completed (which will take more than five years)... After assembling the station, astronauts will have to spend 2200 hours of EVA annually in maintenance work...." I doubt very much that we should follow the same path as the Americans. At any rate, the history of the development of the Mir complex gives considerable basis for such doubts. The assured lifetime of Mir, which has already been in orbit for four and a half years, runs out in 1992. And the in-orbit assembly of the entire system with modules launched from Earth is proceeding with enormous delays. The assembly will scarcely be completed by the indicated time (the project calls for the docking of two additional modules to Mir). Those and many other facts are prompting us to take a sober look at our space program, define our priorities more clearly, and, after doing so, appropriate funds, but without cutting them.

But for the time being, the two Gennadiys, Manakov and Strelakov, are steering a course for Mir. I know that it will not be easy for them. And from the bottom of my heart, I wish the crew success in their space mission.

#### U.S. Experience Cited To Urge Change in Space Program Management

907Q0155 Moscow SOVETSKAYA ROSSIYA  
in Russian 22 Aug 90 Second Edition p 2

[Article by Vladimir Terekhov, candidate of technical sciences, under the rubric "Points of View, Discussions, and Evaluations": "'Diverting Rivers' in Space"]

[Text] In searching for "black holes" in the economy, our politicized society is ever more frequently turning a suspicious eye toward the space program. And those suspicions are not unfounded. Discussions on "space" topics are being held not just in our country—they're being held in all the countries that are participating in space activities. And for now, unanimity is being displayed in at least one thing: today's space programs are at a crossroads. And so the lances are being broken over which of the two areas of today's space program should be given preference—manned or unmanned.

The similarity of the space destinies of the USSR and the United States and, at the same time, the abundance of reliable information about the American space program make it possible to draw certain well-founded conclusions that should be of interest to us as well. In the last few years, we have steadfastly created an idyllic image of the United States as a country without problems, where, of course, projects like the diversion of rivers are, of course, improbable. It is hard to say what's going on with their rivers, but in space, they are "diverting," and how! It would seem that we should be doing likewise...

Alas, the reflex factor does not play an ultimate role in our space program. Yet, in the history of the adoption of the expensive Energiya-Buran program, with its not very clear goals, the reflex factor probably was indeed among the determining factors. Distinctly visible on the body of today's space program are the birthmarks that appeared when it emerged in the late 1950s: ambitiousness, the playing on the imagination of the average person, the neglect of scientific-technical advisability, and cost of the space projects. Those marks are a reflection of the "Cold War," when, in the struggle for the minds of the people, diverse propagandistic symbols were used. Considered to be one of the symbols of progress is the successful realization of grandiose manned space projects. Our state, it would seem, must bear the dubious reputation of being the initiator of the pursuit of illusions in the field of the manned space program. The venture got under way. The launch of the first Soviet satellites and manned vehicles was perceived across the ocean as a political challenge that required an immediate response. The essence of that response was formulated in the early 1960s by President J. Kennedy: "...They are neither commercial nor scientific, but such projects as the lunar and planetary missions are a part of the battle on the unstable front of the 'Cold War.'" And so was born the Apollo Program, with the landing of humans on the Moon. In 1985 prices, some \$75 billion was spent on its realization.

Today, however, opinions are being heard from U.S. scientific circles that the Apollo Program is, of course, a triumph for the United States, but it is also an example of how things should not be done in space now. The fact is that various segments of American society invest different meaning into the constantly declared notion of "Leadership in Space." Judging by G. Bush's speech in honor of the 20th anniversary of the landing of the first astronaut on the Moon, the political and propaganda

factors in the American space program will continue to weigh heavily in the future as well. It is true that, in light of the public's mood, a declaration was made about the necessity of gearing the space program toward solving actual problems that exist here on Earth. But to a large extent, the support for such grandiose manned projects as Space Station Freedom, a manned base on the Moon, and a mission to Mars undercuts those declarations. Under congressional pressure, NASA conducted a three-month evaluation, and it turned out that it will be necessary to invest \$541 billion for those projects over 30 years. According to estimates made by American experts, the actual costs may be four- to fivefold higher.

Instructive for us, so it seems to me, is the opinion of the American scientists who view their country's leadership in space as tied to projects that serve to solve humanity's present-day social and economic problems. And that area of the space program is being realized basically through the use of unmanned vehicles, the cost of which is immeasurably lower than that of the grandiose manned systems. For example, two Voyager vehicles cost the American treasury half a billion dollars, which is incomparable to the \$30 billion already spent on the Space Shuttle. And during the flight of Voyager-2, which investigated the solar system's four outer planets, such a large volume of information was obtained that it will continue to be processed and interpreted even into the next century. The science-oriented and applied area of the space program has truly brought about a revolution. Through the use of satellites, national, regional and global communications systems are already in operation. For example, television broadcasts of the visits of our leaders to distant countries are being relayed, as a rule, via the Intelsat global space-based system. Communications satellites have joined together by invisible threads the several thousand islands of Indonesia by making it possible to set up the transmission of general education programs for children and illiterate adults. In Indonesia, the failure of the government programs for controlling the growth of the population, the country's most acute problem, was associated primarily with the lack of a nationwide communications system that could serve remote regions. Now, thanks to the Insat satellites, such a system has been set up. A revolution in the field of remote sensing was also brought about by the American Landsat satellite, which was developed in the early 1970s. Prediction of crop harvests and advance notice of the onset of diseases, observation of the condition of forests, the planning of territories, map-making, oil prospecting, timely notification about approaching hurricanes—those functions do not come near to representing a complete list of the Landsat satellite's "specialties." That satellite, by the way, is also used to make regular USSR grain harvest predictions that are used by the Soviet side to develop a strategy for talks on the subject of purchases of American wheat.

One of the best-known American astrophysicists, J. Van Allen, whose name is associated with the discovery of the radiation belts surrounding the Earth, in calling manned

spaced flights an "advertising component of today's entertainment industry," believes that the scientific and applied results that are produced in the course of such flights are not commensurate with the enormous expenditures for those flights. Similar views are also held by the U.S. Academy of Sciences' Space Research Administration, which has repeatedly come out in recent times against grandiose manned projects of any kind.

But this is the sad part: despite all the scientists' arguments, the manned space program is proving to be the constant favorite. Invariably, more than two-thirds of NASA's annual budget is spent on it; whereas difficulties with financing arise whenever the topic turns to satellites like Landsat. Only 20 percent of that budget goes for science in space. A paradox? The whole thing is that, in addition to the politicians and scientists, there is one other participant in the drawing of the space card—the country's aerospace complex, the private industrial companies to which as much as 80 percent of NASA's annual appropriations flows. Having come into being on Apollo-type projects, it cannot be content with a "triviality" like Voyager. There is something familiar-sounding, for example, in the tactics associated with pushing-through monster space programs like the Space Shuttle. In the process of forcing the program through Congress, the aerospace complex cited, in particular, the bewitchingly low cost of inserting a payload into orbit—a cost that was supposedly severalfold lower than that associated with using expendable launch vehicles. Somewhat later, when the operations at the companies were in full swing and it was too late to back out, reports flashed that the figure had been pulled out of thin air. And, at the present time, the cost is already 50 times higher than the promised figure, which makes it several times higher than that associated with the use of expendable launch vehicles. And in addition, in practice, the greatest number of Shuttle launches a year has turned out to be nine instead of the promised 36. Now it suddenly turns out that it is not even necessary to go into space that often.

The advocates of the manned space program have yet one more trump card, a distinctive heavy-caliber artillery—the magical incantation of "spin-off." That term refers to the incidental useful results from measures that were not directly intended to achieve such results. Say, for example, that a rocket is being developed for a flight to the Moon. It is clear that the goals of lunar exploration do not bear a direct relation to, for example, technological progress in "non-space" sectors of the economy. Nevertheless, it has an indirect effect. Thus, it is being alleged in our press, based on "American sources," that outright miracles are being produced with the dollars invested in the space program. For every dollar spent, the spin-off produces as much as \$24.

Where did those figures come from? Who gave birth to them? In the mid-1970s, NASA signed contracts with various companies who would provide an estimate of its contribution to the progress of the American economy. For NASA, those were not the best of times: the euphoria from the "victory over the Russians" had abated, and

public opinion polls indicated that the space program was nowhere near occupying first place among the problems on the mind of the ordinary American citizen. The companies, of course, understood what the customer wanted and gave him what he wanted to see. Not bad. Especially for NASA's money. For example, one company, Chase Econometrics Associates, figured the 1976 spin-off harvest to be \$24 billion for every \$1 billion "sown" into the space program. The main financial control agency of Congress—the GAO—was not enraptured for long, and, after a careful economic analysis, NASA was given strict instructions. And since then, NASA has regularly issued periodicals containing information on the specific technological achievements that have an effect on the various sectors of the economy. And NASA's claims to a messianic role in the economy are no longer encountered in those periodicals. In the United States, it seems, they have learned their lesson. That GAO cannot lay down the law for us, and, even to this very day, we continue to hear the speculations regarding the space profits from the money invested in the space program. Even though, sometimes, it doesn't hurt to learn from another's experience.

The space program and the national defense, I am certain, are also not lacking in supporting arguments of the spin-off type. Even without them, it is not difficult to explain to people why some of the gross national product that they produce by tilling the soil or descending into a mine goes for the building of rockets, tanks and satellites. They simply should clearly understand that we have exactly the amount of armaments as is necessary for their reliable protection. And that the space program exists to ultimately implement a statewide communications system and to provide the peasants on a constant and timely basis with all the information they need about the weather and crop conditions.

Here is where, logically, another question arises: Just who is it in our country who determines what we need to do or not to do in space? For the Americans, that is clear—it's the National Space Council, headed by the vice president. In our country, the general "lack of structure" shows up in space, too, and the most striking proof of that is the fate of the Energiya-Buran program. Sometimes one gets the impression that our space program is some kind of state within a state, which, in the process of its development, is pursuing its goals, which are known only to it. Space activities in the USSR are outside the law. In the United States, the space program, as a specific sphere of state activities, has been regulated by law for more than 30 years now. It is high time that we set up a commission for drafting such law, and it would be made up of specialists from departments that are directly or indirectly involved in the space program—namely, the ministries of general machine building, communications, defense, and agriculture; the academies of sciences, the KGB, and others. The space program needs a procedure for financing that would involve approval from the USSR Supreme Soviet, and it needs interdepartmental coordination, so that the crucial decisions would be made not on the basis of a desire of

questionable necessity to overtake and surpass, but rather, on clearly formulated national goals. Some basic order needs to be brought into the space program, so that its activities and plans would correspond to that encyclopedic definition of it, where it is "interpreted" as the "sum total of the sectors of science and technology that ensure the development of outer space and extraterrestrial facilities for the needs of humanity...."

### **RD-170 Rocket Engine To Be Marketed, Features Described**

*PM0412090190 Moscow Television Service  
in Russian 0630 GMT 1 Dec 90*

[From the "Man, Earth, Universe" program presented by USSR Pilot-Cosmonaut V.I. Sevastyanov]

[Excerpt] [Sevastyanov] I want to say that some of our achievements are unparalleled in the world. We have built the most powerful rocket, the "Energiya," which launched the "Buran." The engines of this rocket are the most powerful engines in the world today.

A new-generation main rocket engine [marshevyy raketnyy dvigatel] for the first stage of the launch vehicle was developed in the Soviet Union, at the "Energomash" science-and-production association.

The RD-170 engine has the world's biggest vacuum thrust—806 tonnes. The propellant components are kerosene and oxygen. It has the highest specific thrust impulse and most complete combustion, which makes it ecologically clean in operation.

The engine is designed for re-use and is characterized by high reliability, high accuracy and simplicity of operational mode control and thrust vector control.

A specific feature of the engine design is its compact layout based on four combustion chambers. Propellant components are delivered by a single turbopump located in the middle between the chambers. Thrust vector control is achieved solely by chamber manipulation. For this purpose (?bellows) units have been developed which are located in the gas oxydizer supply passages leading to the chambers.

Pressure in the combustion chambers totals 250 atmospheres. The caloric power released in the chambers totals 27 million kW, which is on a par with the capacity of a major hydroelectric power station.

The turbopump unit has a capacity of 180,000 kW, which is equal to the capacity of three nuclear power generators such as those used in the biggest nuclear-powered icebreakers.

The use of reliable sealed couplings as part of the design makes it possible to replace all the basic components.

One of the engine's qualities is the great economy and stability of the combustion process.

The engine's high level of reliability is largely due to the combination of the simplicity, originality, and technological effectiveness of the engine's layout with careful monitoring of all the stages of the manufacturing process. Specialized testing equipment, including hydraulic stands with a capacity from 1,000 to 50,000 kW, are used for this purpose.

Each engine that is produced undergoes technological and firing tests. In addition, selective engine tests are carried out to establish guaranteed service life in re-use. The design of the stands meets ecological stipulations for noise and light absorption, among others. All the operations of the test procedure carried out on the stands are fully automated.

During the tests the functional parameters of the main systems and assemblies are constantly monitored with the involvement of the accident-prevention system.

The interchangeability of components during engine tests and the reliable technology of interlaunch servicing make it possible to carry out multiple engine tests, including tests without dismantling the engine from the stand.

A range of progressive design and technological solutions and the large volume of research work which went into the engine—more than 700 firing tests—have assured the reliable and accident-free function of the engine and the possibility of its multiple re-use.

The RD-170 engine, mounted on the "Zenit" launcher—one of the most accomplished launchers built in the USSR of late—makes possible efficient launches into orbit of important space objects.

Vitaliy Petrovich [Radovskiy, director general and chief designer of the "Energomash" science-and-production association and corresponding member of the USSR Academy of Sciences], after watching this footage, I would very much like to congratulate your entire collective on the creation of this engine, which is truly a marvel of engineering. In my opinion, a more powerful engine is hardly necessary in this category. I don't know, but I think that this engine will be around for decades—I think it will be in use for fifty years. Naturally, I have a question. Do you intend to market it?

[Radovskiy] Yes, we believe that the time has come when we should meet not only domestic requirements and produce this engine for internal consumption, but also enter the international market with it.

[Sevastyanov] You have three minutes to promote this engine.

[Radovskiy] The first thing I would say is that it is an exceptionally reliable engine. That is to say, it has a very long service life and reserve service life. It can be re-used repeatedly. For ten flights as a minimum. And in addition it has a relatively long reserve service life. Furthermore, it has a whole series of other positive features. It is

a high-capacity engine—an engine with small dimensions and record thrust. An engine with an exceptionally high efficiency coefficient, that is to say its specific impulse is higher than the specific impulse of all existing engines in this class. It is technologically highly effective and easy to repair, thanks to the fact that virtually all its components are easily replaceable should tests reveal the need for any such replacement. It can be tested immediately prior to launch, on essentially the same lines as aircraft engines are tested prior to takeoff. This gives it enormous superiority over solid-fuel boosters used on the U.S. shuttle launcher, for instance.

[Sevastyanov] So what does this engine cost? I am aware that this is a commercial secret. But there must be similar engines abroad, even if they don't match the same standards.

[Radovskiy] Well, I could say that the 200-tonne lox engine used for the Shuttle, according to available information, costs up to \$50 million in the United States...

[Sevastyanov] I believe that this could be described as a true method of conversion—the utilization of high-tech developments from our defense complex, from our military-industrial complex, both by marketing specific models that have already been built and by applying new technological methods in other sectors of the national economy.

[Radovskiy] I entirely agree with you. At present two factors are hampering such a development—the lack of the necessary commercial know-how, especially in the international market. We are having to acquire it as we go along, so to speak. And second, insufficient trust among states, I would say. [passage omitted]

### **Commercial Deal Reported for American To Fly on Mir in 1992**

*LD1312131690 Moscow World Service in English 1200 GMT 13 Dec 90*

[Text] One of the Houston-based American companies has signed a multimillion [as heard] contract with the Soviet Union for a flight by its staff member aboard the Soviet space station Mir. This was said by the President of the Space Commerce Corporation, Art Dula, after negotiations on the matter with the Soviet side. According to Art Dula, the five-to-seven day flight is scheduled for the end of 1992.

### **Dunayev Confirms U.S. Citizen Flight in 1992**

*LD2512163190 Moscow TASS in English 1534 GMT 25 Dec 90*

[By TASS correspondent Rena Kuznetsova]

[Text] Moscow December 25 TASS—A British and an Austrian cosmonaut will be launched into space on a Soviet booster in 1991 and a German and French in 1992, Aleksander Dunayev, chief of the Soviet Glavkosmos space agency, told reporters today.

Dunayev was speaking at a press conference on the results of the latest space mission aboard the Mir space station by Gennadiy Manakov and Gennadiy Strekalov and Japanese reporter Toyehiro Akiyama.

A U.S. citizen will fly on a Soviet space craft late in 1992, Dunayev said.

“There are certain principles that should be honoured by partners. We knew about the proposed flight but could not disclose it until the U.S. side spoke out,” he said.

Hiroshi Ota of the TBS Japanese radio and TV company praised Soviet cosmonauts and space programme.

“It is very hard for an ordinary person, like myself to work in space. One has to be very well prepared to overcome the ‘surprises’ of weightlessness”, Akiyama told reporters.

Gennadiy Manakov spoke about difficulties in repairing a faulty hatch during a space walk.

The malfunction was different than what the mission control thought. “We couldn't repair it with our means. I hope the next crew—Viktor Afanasyev and Musa Manarov—will repair it after getting the necessary equipment from Earth,” Manakov said.

### **Lottery for U.S. Citizen Flight to Mir Station Confirmed**

*917Q0036A Moscow TRUD in Russian 20 Dec 90 p 4*

[Article by TRUD special correspondent V. Golovachev: “American Will Fly to the Soviet ‘Mir’ Station: A Sensational Plan”]

[Text] Yesterday American television companies reported that the Soviet space firm Energiya NPO [Scientific Production Association] had initially agreed to send a U.S. citizen into space. But then they reported that nobody in the USSR seems to know anything about such intentions on the part of the Soviet firm. So is it possible to do business with the Russians, are they stable partners? Today they agree to do business and tomorrow—they refuse?...

This sensational piece of news was one of the first to be broadcast. In order to clarify the mysterious situation I went to B.P. Nikitskiy, the leader of the Energiya NPO scientific research center, and asked him to comment on the report by the American television companies.

“It was simply a misunderstanding,” said B.P. Nikitskiy. “On 22 November the general designer of Energiya NPO, Yu.P. Semenov, signed an agreement with the American firm “Space Commerce Corporation” to the effect that by the end of 1992 we would be ready to send into space, to the Mir space station, a U.S. citizen who would be the winner of a contest. You know in the West they conduct both competitions and lotteries whose winners are given the right to take attractive trips—for example, to Hawaii, to the North Pole, and so forth. And here the organizers of the competitions got the idea of awarding as first prize a trip to the Soviet Mir space

station. In my view this is a very unusual and attractive project. They have to pay to participate in the competitions and lotteries. Plus there are the advertising revenues. So there is no special difficulty in raising the money required for financing such a project."

The Americans brought the idea of the flight of a U.S. citizen to our space station up to the Soviet organizations. We liked the idea. This is why the general designer of the Energiya NPO signed the agreement. It says that it would be a commercial flight and it would cost more than the flight of the Japanese astronaut."

"It is a shame, of course, that the Soviet people first learn about all of this from the foreign mass media. But that is not the ultimate issue here. What caused all the stir? Why were there reports that we were backing away from our intentions?"

"The journalists wanted more detailed comments and went to various organizations. The Main Space Administration correctly observed that they were not directly involved in this. In our Energiya NPO they were preparing rush materials and did not have time to comment in detail. So a report appeared which caused confusion among our partners.

And in this connection I wish to state quite definitely: The Soviet side does not and never did have any doubts about the agreement that was concluded. And yesterday, on 19 December, general designer Yu.P. Semenov sent the United States a telex with a confirmation that the agreement remains in effect. I am confident that the project will be carried out completely, symbolizing the spirit of international cooperation and contributing to the rapprochement of our nations."

And so B.P. Nikitskiy explained away the confusion. But one question still remains. In my view, the leadership of Energiya NPO has a share of the blame for the incident. If they had not concealed information from the press and from the Soviet public, this confusion would probably never have arisen.... On the whole we can only welcome the proposed project. Soviet-American cooperation in space, which was manifested clearly in 1975 with the joint flight under the Experimental Apollo-Soyuz Flight, will be continued in an unexpected and interesting way. This project will have not only commercial but also a great deal of humanitarian significance for it will serve the interests of peace and progress.

### **Apollo-Soyuz Project Recalled, Prospects for Future Space Cooperation**

*907Q0133 Moscow KRASNAYA ZVEZDA in Russian  
14 Jul 90 p 5*

[Article by M. Rebrov: "Project ASTP: Reminiscences of the Future: Peace and Space Research"]

[Text] In the early 1970s, the abbreviation ASTP—the Apollo-Soyuz Test Project—became part of the international space terminology. It referred to the joint flight of

manned craft belonging to the world's two leading space powers: the USSR and the United States. The idea got a mixed reception. Some considered it an original and tempting idea, seeing the prospects for consolidated technical projects carried out for the benefit of everyone on our planet. Others concluded skeptically that nothing of substance would come of the ill-conceived "political show."

A comparison of the opinions of the past solely for the sake of taking an excursion into history will hardly change the generally accepted assessment of what occurred in July of 1975. The scientific program for the flight of the Soyuz and Apollo craft looked more than modest by today's standards. Even more substantial are the engineering and design problems that were posed and solved by the specialists from both countries. And yet, one thing in particular must be said about the political result of the ASTP project. It became a symbol of how states with different social systems can, through joint efforts, solve global problems facing mankind on the eve of the 21st Century.

In that sense, a statement by THE WASHINGTON POST that resounded in that memorable month of July is curious: "The ASTP project has shown convincingly that different systems can dock not only in the narrow technical sense and not only in orbit. The result must be viewed in the broader scheme of things: rendezvous on a planetary scale, when states and governments set for themselves common humane goals." That idea was underscored in the commentaries of other newspapers, magazines, and information agencies.

The events of those years are memorable to me. First, there were the studies done by preparatory groups that included various specialists, and then an official agreement that indicated the time frame for the realization of what had been planned was signed. In 1973, we learned the names of the project directors on the Soviet and American sides, of the directors for the upcoming flight, and of the cosmonauts who had started training. In Zvezdnyy Gorodok [Star City], a special training facility was singled out for the joint operations and training (even now it is called the ASTP facility), and at the Houston center, there was Building No 4, or the Crews' Building. The cosmonauts and the specialists met periodically in these "residences." Technical questions, even extremely complicated ones, were solved quickly and with the understanding of the sides, and the greatest difficulties were created by the language barrier in the cosmonauts' exchanges. "Our discussions during the joint training," Aleksey Leonov said, "were beyond the capabilities of the most experienced translators—not to mention the technical staff, who were grabbing their heads in horror."

But a way out of the difficulty was found: it was decided that, during the flight, the Americans would speak Russian, and the Russians, English, and the cosmonauts

learned to understand one another splendidly in "Ruston." That is what they jokingly began to call the mixed English-Russian language. The word "Ruston" was formed from the two words *ruskiy* and *Houston*. Then two emblems were born, two badges of the upcoming flight. On one, against a red-and-blue background, within which was the Earth, were the silhouettes of the ships and the words "Soyuz" and "Apollo." That was the official emblem of the flight. On the other badge—it was a joke—atop the Apollo ship sat a funny little dog, Snoopy, a hero from the comics popular in the United States; opposite him, almost nose to nose, atop the Soyuz ship was a bear cub. "Let's get started!" exclaimed the dog in English. "Poyekhali!" [Let's go!] replied the bear cub in Russian.

On 15 July, at 1520 hours, Moscow time, the Soyuz-19 lifted off from Baykonur, and, at 2250 hours, the Saturn 1B launch vehicle departed from Cape Canaveral, rushing the Apollo craft into space. Then came rendezvous, contact, and mechanical capture. And on 17 July, at 1912 hours, the link-up of the docking assemblies was completed. All the joint operations were performed strictly according to schedule, minute for minute, second for second.

In greeting the cosmonauts and astronauts after their return from orbit, then-U.S. President Gerald Ford said, "I hope and believe that this flight is proof of the fact that we can cooperate not only in space, but also in other fields. This is just the beginning, but a very successful beginning..." The president's optimism was shared by many. The flight had been preceded by the signing by the Soviet and American parties (on 6 April, 1972) of an agreement on cooperation between the USSR Academy of Sciences and NASA. The very first article of that document indicated that the parties would develop cooperation in the field of space meteorology, the study of the environment, and research on near-Earth space, the Moon and the planets, and space biology and medicine.

The American scientists saw in this agreement an opportunity for engaging more actively in joint research, exchanging scientific data, and becoming part of the Interkosmos program.

Unfortunately, events did not follow that course. Soon afterward, the so-called Star Wars program was announced in the United States. A new round of militarization of space threatened to raise the arms race to an altogether new level—one that was dangerous from the standpoint of military instability and extremely wasteful in terms of expenditures. Nor were the attitudes of the "hawks" in the U.S. Congress conducive to the strengthening of cooperation in space. Nevertheless, the ice of the "Cold War" began to thaw under the warmth of the new thinking proclaimed by the USSR in foreign policy. The positive processes in the relations between the two countries began to gather strength.

In recent years, the plans of scientists from the USSR and the United States have been coordinated in a number of scientific and technical areas. And that is reassuring not only to the specialists of our two countries, but also to their colleagues from Western Europe, Japan, and Canada. The Soviet Buran and the American Shuttle, the Mir and Freedom orbital stations can serve as an excellent technical base for basic and applied research on an international scale. The call "Together to Mars!" is finding broad support in our countries at various levels—from scientists to the highest-ranking officials. Operations within the framework of the Soviet Mars-94 project and the American Mars-Observer program are being coordinated. The company Payload Systems and USSR Glavkosmos have signed a contract for conducting American biotechnology experiments aboard the Soviet Mir modular station (the experiments require a month's time, but the Shuttles can make only week-long trips).

In the spring of last year, talks took place with the company Comsat General about organizing joint work in the development and operation of linked systems in geostationary orbits. The heavy-lift Soviet Energiya rocket and the Zenit launch vehicles that are based on it are today among the most advanced and ecologically clean means for delivering payloads to orbits of varying altitudes.

The American company, Energetic Satellite Corporation, has displayed an interest in the use of our Proton launch vehicles for launching its Sat Track satellites. Similar talks have also been conducted with the Hughes aerospace company. However, the existing U.S. legislation regarding control of the export of new and complicated technologies, as it happens, is restraining the business contacts of the two countries' specialists. Meanwhile, as the foreign press is noting, that embargo is equally disadvantageous for both the Soviet Union and the United States.

What is behind it? Ambitions, the fear of commercial competition, or the inertia of the old thinking? All three. But life will not accept the stereotypes of the past. And the shortage of reliable launch vehicles is also holding back the development of peaceful cosmonautics. The Soviet Union, in developing the sphere of commercial space, could offer foreign customers a wide selection of services and, one must assume, there would be a demand for them. As for the barriers that are being erected, the optimists consider them to be temporary.

However, they, the optimists, are looking farther down the line and do not preclude the possibility of cooperation between the two great powers even in the field of military space. They believe that the exchange of reconnaissance information obtained from satellites could be of good use during any kind of conflict situations. And even another idea has surface in the foreign press: combine efforts in the development of a global system of space-based defense within the framework of SDI. Today, that idea no longer seems frivolous.



Yes, the times are changing and, it must be said, for the better. The process must not be hampered, and it certainly must not be blocked. A. Alyula [as published], the president of Space Commerce, has declared: "Now, when Soviet society has become more open, any obstacles on the path of space cooperation between the USSR and the United States seem simply inappropriate."

That is a sensible assessment of events on the eve of the 15th Anniversary of the ASTP program. This is why I called the story about the project "Reminiscences of the Future."

### **Soviet-Austrian Space Flight Set for Oct 91**

*LD1212134590 Moscow TASS in English 1319 GMT  
12 Dec 90*

[By TASS correspondent Vladimir Smelov]

[Text] Vienna December 12 TASS—The first Soviet-Austrian space expedition, the Avstromir project, is scheduled to blast off on October 2, 1991.

The spaceship will take an Austrian citizen to the Mir space station, where he will work with Soviet cosmonauts for several days, the APA news agency reports today.

### **Space Research Exchanged for PRC Consumer Goods**

*OW0612204090 Moscow International Service  
in Mandarin 1400 GMT 6 Dec 90*

[Text] Oleg Shishkin, Soviet minister of general machine building, announced: The Soviet Union has helped China in space research this year, and it will obtain consumer goods worth 110 million rubles from China in return. In addition, the Soviet Union and India have signed a huge contract for launching an Indian communications satellite into earth orbit with a Soviet-made rocket. At present, the Soviet Union and Australia are holding talks on launching the Soviet Union's new-type rocket—(?Soyuz IV)—for commercial purposes from an Australian launching site still under construction.

Shishkin pointed out: This indeed is a breakthrough in the world's rocket market.

### **Titov Denies Reports of Early Cosmonaut Deaths**

*PM0301165091 Moscow KRASNAYA ZVEZDA  
in Russian 3 Jan 91 First Edition p 4*

[Answer to reader's letter by Colonel General of Aviation G. Titov; first paragraph is reader's letter: "Canards in Space"]

[Text] In 1991 the whole world will be celebrating the 30th anniversary of the first manned space flight. I have heard that there were unsuccessful manned launches prior to 12 April 1961. Is this so?

Senior Lieutenant O. Leshchenko

[Titov] Speculation as to whether any Soviet cosmonauts flew before Yu. A. Gagarin is not new. Even in the sixties there were rumors about this and they have surfaced again today. It was said at that time that Vladimir Sergeyevich Ilyushin was allegedly involved in an accident in a "Vostok" spacecraft launch. In actual fact he was involved in a traffic incident and suffered a severe leg injury.

Also at that time, it was rumored that an unknown cosmonaut transmitted an international SOS distress signal from space, requesting help in Russian. There are even some publications which give the names of "unknown" cosmonauts who perished in catastrophes while in orbit. I have never heard of these people. Quite simply, they were never cosmonauts.

With regard to the "distress signals from space," radio amateurs were indeed able to intercept a voice in orbit shortly before Gagarin's space flight because human speech was recorded on tape and transmitted from a satellite to a ground tracking station as one of a series of checks on the ultrashort wave channel Yu. A. Gagarin communicated with Earth during his space flight on 12 April 1961. There was, however, absolutely no connection between this voice and any cosmonaut. I don't think it was speech; it was counting, recorded by one of the engineers who set up the "Zarya" communications system. We had to find out about the distortion which occurs in the intonation of the human voice during radio communication with Earth. But Western radio stations thought that these were coded distress signals.

Naturally, not all space flights and the preparations for them proceeded smoothly. The death of Valentin Vasilyevich Bondarenko in March 1961 left a scar on each member of the group of candidates for the first space flight. He died from burns sustained during a training session in an anechoic pressure chamber. Bondarenko was buried in his home town—Kharkov. It is possible that a rumor then sprang up that he had died during a space flight.

Six out of 20 future cosmonauts were then selected for immediate training for the first space flight. These first six were Yu.A. Gagarin, V.F. Bykovskiy, A.G. Nikolayev, P.R. Popovich, G.G. Nelyubov, and myself. In 1963 Grigoriy Nelyubov and comrades I.N. Anikeyev and V.I. Filatyev were excluded from the program for disobeying procedures. Nelyubov died in an accident after taking up a new post in the Far East. But again this was not a space or even an aviation accident.

In my opinion these rumors were started in the main by unqualified people trying to supply their own interpretation for the events connected with space exploration. And without bothering to check their facts, journalists on the lookout for sensational stories eagerly pass them on to their readers, who sometimes do not know what to believe.



### Call for End to Space 'Fall-Out' From Plesetsk Cosmodrome

*LD1412112590 Moscow Domestic Service  
in Russian 0430 GMT 14 Dec 90*

[Text] Officials from the USSR Ministry of Defense's Main Administration and from Arkhangelsk oblast's Plesetsk cosmodrome have gone to Uvatskiy rayon because a session of the local soviet has decided to ban space work over the territory of the rayon, and has demanded that an independent expert investigation is carried out. For about 15 years now, spent pieces of space equipment such as (Bion) and Molniya have been falling on the Yamal peninsula. A statement issued by (Yuriy Smolyakov), a spokesman for the Main Administration of the USSR Defense Ministry, the fall-out of the spent stages is virtually no danger to the population and there is no radiation. The local authorities are warned five days in advance. But is that good enough? We should note that a number of pipelines cross Uvatskiy rayon. On official maps one of these is designated the boundary of the so-called main fall-out zone.

### Possible Effect of Kazakhstan's Declaration of Sovereignty on Baykonur Cosmodrome

*LD1501101991 Moscow Central Television First  
Program Network in Russian 1800 GMT 14 Jan 91*

[Report by correspondent A. Gerasimov from Baykonur Cosmodrome; from the "Vremya" program]

[Text] [Announcer] About three hours ago a Progress spacecraft was launched. It will deliver essential cargo to Viktor Afanasyev and Musa Manarov to enable them to continue their tour of duty in space. A report from our correspondent:

[Gerasimov] If the fate of democracy in the country is at present being decided in the Baltic republics, the future of our space program is to a great extent being determined here at Baykonur today. Kazakhstan's adoption of a state sovereignty declaration came as a surprise to the whole space industry—Kazakhstan is where the huge cosmodrome enterprise is located. The arrival at Baykonur of President Nazarbayev of Kazakhstan which was timed to coincide with today's Progress launch—Progress is already in orbit, by the way—was motivated by quite specific reasons. In accordance with the sovereignty declaration, sovereign Kazakhstan henceforth enters into agreed relations with all departments located on its territory. From Nazarbayev's address at a news conference held in the town of Leninsk today, it emerged clearly that the time has come to repay the debts incurred a few decades ago. Rent for the more than half a million hectares of land occupied by the cosmodrome and the huge areas in the fall-out zone for used rocket stages could cost the Union space industry a tidy sum. The problems of alienation of the historic Kazakh lands themselves could also be high on the list. The republican leaders and the space department, however, seem to have found a common language.

[Begin Nazarbayev recording] We have already stepped up direct contacts, and the scientific and technical potential of the cosmodrome will work directly toward resolving some of Kazakhstan's problems, such as space communications, space television, the study of natural resources and the weather. These are all, I think, practical steps toward rapprochement and transfer to mutually beneficial bases. [end recording]

[Gerasimov] These are, of course, the first signs of future cooperation between the monster Union department and the republican authorities. Probably not everything has been taken into account; there are clear omissions; in particular, practically no account is taken of the interests of the military, yet they are in the majority here. Nevertheless, the groundwork for normal coexistence has been laid, and it could become an example of the constructive solution, with no excesses, of issues arising in our difficult times.

### General Ivanov Details Functions of Defense Ministry Space Units

*91UM0165A Moscow IZVESTIYA in Russian  
12 Dec 90 Union Edition p 6*

[Report on interview with Colonel General V. Ivanov by V. Litovkin; place and date not given: "Without the 'Secret' Stamp (For the First Time Colonel General V. Ivanov Describes the USSR Ministry of Defense Space Units)"]

[Text] All things are changing rapidly in our time. Several months ago we were preparing some materials for print that described the structure of the Soviet Armed Forces. A watchful censor's hand pasted pieces of white paper over the words "space units." No words to the effect that the existence of the units was no secret to anyone helped; the Law on Press did not exist then either.

Today we have the law and the unnatural stamp has been canceled...

[Litovkin] Vladimir Leontyevich, would you, the commander in charge of space units, tell us a few words about the history of your troops. When and for what purpose have they been created? What do they do?

[Ivanov] I want to make a correction right away. We are not troops, we are units. There is a basic difference in the names. Troops are armed with concrete weapon systems and their purpose is to accomplish combat assignments. But units is the name for the groups that facilitate that task.

We are military people but we do not have weapon systems. We deal with launches of space devices, we provide their operation in near-space and other orbits. Our satellites and spacecraft and stations may be used, in their turn, for a variety of other purposes—scientific, economic, or military. The launch sites in Baykonur and Plesetsk, with their testing grounds and launch preparation units, as well as the USSR Ministry of Defense Main

Space command, control and telemetry complex near Moscow, spacecraft tracking stations scattered from Brest to Kamchatka and the Kurils, and many other subsidiary services—they all come under our jurisdiction, if you will.

The history of our units started with the construction of launching sites, and with the creation of the Strategic Rocket Forces when our first domestically produced rocket, derived from the trophy V-2, was launched from the Kapustin Yar testing ground in October 1947.

Now we are launching Soyuzes, orbital stations, and other spacecraft. The system Energiya-Buran passed through our hands also. If you see people wearing shoulder-boards participate in space launches, you know that they are from the Ministry of Defense Space Units.

[Litovkin] That means that the crew that included a Japanese journalist was also launched by the military?

[Ivanov] Of course it was. The TBS [Tokyo Broadcasting System] TV company gave us, as a memento of the event, some of its equipment which will improve the performance of the Baykonur TV center considerably.

[Litovkin] If I understood you correctly, every machine sent to space by our country belongs to you primarily. That includes navigational systems, meteorological satellites, telecommunications satellites, systems for optical and electronics reconnaissance, and the ballistic missile early warning systems.

[Ivanov] No, that is not quite correct. It is true that no launch of any rocket, whatever equipment it might carry, can go without our participation. Moreover, we "keep track" of spacecraft in orbit and we process huge loads of working data. For that our units possess automated control systems, computerized complexes, high-speed computers capable of millions of operations a second and having a formidable memory; we have highly sensitive, very powerful electronics systems.

But we do not own everything that has been launched and put into orbit. For instance, ballistic missile early warning systems belong to the Air Defense Forces; we only lease several channels on the telecommunications satellites of which the USSR Ministry of Communications is in "charge".

[Litovkin] One more clarification, Vladimir Leontyevich. Can we say that your units are identical to SDI? And if not, can they be quickly transformed into such, if need be?

[Ivanov] At present, we and the SDI are two incompatible notions. I have already told you what our units are involved with. But SDI is primarily an all-government program of scientific and technological research, of design and experiments which aims to develop and test prospective weapon systems for anti-missile defense. Most of these systems are supposed to be deployed in space.

Our country has stated many times and at the highest levels that no placement of weapons in space can be allowed; we have stated our total disagreement with the expansion of SDI work. But the U.S. leaders and, primarily, their military-industrial complex did not give up the idea. The concept has already swallowed \$20 billion. Four hundred industrial firms and 28,000 leading scientists and experts are involved in this work, many of them are known to the whole world. If SDI work is expanded any further, our country will have to take certain countermeasures.

[Litovkin] Would it make sense to stop objecting to the SDI system but join the research instead? In this way we could end up with a world system of group security and control under the UN banner. I know that the United States suggested this idea to us.

[Ivanov] Yes, it did. But it wants to do it on a bilateral basis. The United States does not support the idea of creating a system of international security within the UN framework. The Americans think that it might become a political organization and that it would result in a transfer of the newest technologies in the area of space reconnaissance to our country and other countries. And this contradicts their interests.

But a "bilateral" cooperation would allow the United States to have an undisputable advantage in expanding their SDI work. The extent of our involvement in this work was not and is not as large as that of the United States. Therefore, we cannot talk to the Americans as equals, as the saying goes, in this respect; we would have to "disclose" to them a certain area of space to test the prospective ABM means. In other words, we would have to agree to a space missile and nuclear testing ground, to an international law basis which would help ignore the ABM agreement, to the possibility of testing and perfecting all the links of SDI in space. Such a step would undermine the security of our country and we could not agree to it.

The Americans have been able to determine the technical specifications of our ICBM's since 1987 anyway since we were conducting test launches to the Pacific Ocean areas. It would be unreasonable to give them such an advantage now.

[Litovkin] How much does our "military" space cost? Is it ready for the conversion?

[Ivanov] Last year we spent R3.9 billion on our space-related military programs. That is 55 percent of all the money our country spends on space research. This sum, as you know, is R7.9 billion. Our expenses, by the way, are covered by the Ministry of Defense budget.

On average it costs R8 to R12 million to build one spacecraft, depending on its type. It costs R7 million to launch it, to employ it in orbit costs some R2 to R2.5 million.

Is it much or is it little? It all depends on your point of view, on the way you compare it with something concrete. These are major expenditures, of course, especially now, given the present state of our economy. But let us make a comparison. The United States spends almost \$32 billion on space programs while 77 percent of that sum goes for military projects. Judge for yourself if we can afford to ignore this factor.

And here is another thing. The military space programs do not entail expenditures only, they also bring considerable profits to the national economy. The Ministry of Geology alone gets R50 million in profits with our help. We make it possible for 97 percent of our country's population to watch the First Program on TV, with our help 91 percent of the population can watch two of the all-Union programs. Reliable weather forecasts provided by just one satellite bring some 600 to 700 million in profits. Within the last five years we contributed around R2.6 billion to the state budget through the Ministry of Communications. We have a lot more possibilities than all this. According to calculations by our economists, our space meteorology, communications, and navigation alone can bring R25 billion in profits for our country within the next five years. But for that we need to design a comprehensive concept for the development of Soviet space programs.

I think that any conversion in a rule-of-law state should start with a law regulating it. We also need such a law and more than just this one. We also need a commercial plan; we need a financial framework specifying the rates for all the various "space services," including the interagency and international ones. This plan should provide allocations for the social protection related to military space programs. Maybe then our people will stop travelling from dormitory to dormitory or looking for a place to rent, they will have a roof over their heads.

We need a state program for our space work whether it concerns research, national economy, or the military. We are ready for it. It is the legislators turn now to say their word.

#### **Leningrad Military Space Institute Described**

*PM0801123991 Moscow KRASNAYA ZVEZDA  
in Russian 4 Jan 91 First Edition p 4*

[Report by A. Radionov under the rubric: "We Describe for the First Time": "Whom the 'Secret' Institute Trains"]

[Text] A real spacecraft will soon be installed in Leningrad, on the Zhdanov Embankment outside the walls of the main block of the Red Banner Military Engineering Institute named for A.F. Mozhayskiy. The students and teachers of this military-space institute now do not need, as was the case before, to conceal their association with space.

...I am walking with Major General V. Kalinin along the institute's long corridors, looking into offices and

"secret" laboratories and familiarizing myself with the study base. Of course, with the students—the future officers of the space units.

Vladimir Nikolayevich Kalinin is an interesting person to talk to. He is a doctor of technical sciences, a professor, and the institute's deputy chief for training and scientific work. He describes his institute with enthusiasm.

The institute's seven faculties and 55 departments train space command and engineering cadres in 26 science-intensive specialities. The graduates become mechanical engineers, electrical engineers, electronic engineers, radio engineers, mathematicians, geophysicists, systems engineers, and ballisticians.

Over the past 30 years the institute's scientific and teaching orientation has been closely linked with the development of knowledge of space, the improvement, operation, and application of space rocket technology, and the training of the relevant scientific and military engineering cadres.

"The higher educational establishment probably makes special demands on the selection of students?"

Vladimir Nikolayevich replies:

"We have a quite strict professional selection. Incidentally, it begins at the military commissariats and is pursued actively during entrance examinations at the institute's out of town study center in Lekhtusi settlement, Leningrad Oblast, where the candidates go."

Indeed, all this is entirely justified. After all, only someone who has strong physics and mathematical training and a high general standard of culture can cope with the Mozhayskiy institute.

A considerable proportion of the institute's graduates go to the Baykonur and Plesetsk cosmodromes. Their official duties include preparing spacecraft and launching them and putting them into orbit and also providing backup for launch vehicles like the "Energiya" and "Proton," for instance.

Another group of Mozhayskiy Institute students "master" virtually the entire territory of the Soviet Union—from the Western border to Kamchatka, from the tundra to the Pamir spurs in the south. They also serve at the measuring stations, ensuring the functioning in orbit of Soviet military and national economic spacecraft.

#### **Plans for Conversion of SS-20 Missiles to 'Start' Space Boosters Reported**

*PM1001124391 Moscow KRASNAYA ZVEZDA  
in Russian 10 Jan 91 First Edition p 4*

[Unattributed report: "Missiles Have Been Cut Back... and Sent into Space"; first paragraph is reader's letter]

[Text] It is well known that the missiles taken out of commission as part of reduction are being destroyed. Could they not be used for peaceful space purposes?  
[Signed] S. Sorokin, Barnaul

Of course, the use of military missiles for peaceful purposes is far more advantageous than their destruction. It is not surprising, therefore, that Soviet specialists, for instance, the "Tekhnopribor" association designers, are anxious to create on the basis of the SS-20 missile a three-stage solid-fuel "Start" booster rocket with a weight of 40-45 tonnes launched from a mobile launcher. "Start" uses all the units and materials not

subject to destruction within the framework of international treaties or not banned for use for peaceful purposes. In the opinion of specialists, within five years we will be able to produce about 300 booster rockets by this means.

This will assist conversion and help to preserve large material and financial assets. Thus, for instance, completed "Start" rockets can put into space scientific apparatus weighing about 200 kg in space orbits of up to 500 kilometers. This information was obtained at the USSR Defense Ministry space research press group.