# *NEWS FROM MOSCOW*

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## HIGHLIGHTS



## IN BRIEF

### New Defence Minister

President Boris Yeltsin fired Defence Minister Igor Rodionov on Thursday, May 22, blasting him for failing to start reforms in Russia's army during his 10 months at the head of the country's military.
At the meeting of Russia's Defence Council shown on evening news broadcasts, Yeltsin ridiculed Rodionov and saddled him with the blame for the corruption and poverty plaguing the Russian military.
Immediately after the meeting attended by senior commanders of all branches of the armed forces and fleet, as well as members of the government and presidential administration, Yeltsin signed decrees sacking Rodionov and the chief of general staff, Viktor Samsonov.
In their places, he appointed Igor Sergeyev, 59, the commander of Russia's Strategic Rocket Forces, as acting defense minister, and the commander of the Far East Military District, Viktor Chechevatov, as chief of general staff.
On Friday, May 23, Boris Yeltsin confirmed Igor Sergeyev as defence minister charged with the difficult task of turning Russia's cumbersome, cash-strapped military into a leaner, professional force.
The new minister has headed the Strategic Rocket Forces since 1992, responsible for 756 inter-continental missiles with 3,535 nuclear warheads which make up Russia's strategic arsenal.
A Kremlin spokesman said Yeltsin had also named General Anatoly Kvashnin as acting head of the

general staff, number two in the armed forces after the defense minister.

*(From The Moscow Times, May 23 & The Moscow Tribune, May 24)*

The dominant Communist faction in the State Duma plans to propose a draft law calling for printing 300 trillion rubles ($51.7 billion) to close the government's yawning budget gap, a leading Communist legislator said May 12.
Viktor Ilushin said the proposal is an answer to the 108 trillion rubles in spending cuts the government has proposed for parliamentary approval as part of an emergency budget-stabilization package.
Ilushin noted that money printing would be targeted at specific projects, limiting its inflationary effect.
Government officials, including President Boris Yeltsin, consistently have rejected printing money as a way to resolve the budget problems, arguing that such step would restart hyperinflation.

*(From The Moscow Times, May 14, 1997)*

Russian gross domestic product was flat during the first four months of 1997, showing no growth from the same period last year, Russia's state statistics committee said. April GDP was down one percent on a year-on-year basis, the committee said. GDP for the first quarter had risen 0.3 percent in comparison to a year ago.

*(From the Moscow Tribune, May 21, 1997)*

Prime Minister Viktor Chernomyrdin plans to visit China in June to sign several major agreements, including plans to build a nuclear power plant and a natural gas pipeline, officials said on May 20.
During his trip, Chernomyrdin is to meet with Chinese President Jiang Zemin and Premier Minister Li Peng.
The Foreign Ministry said Chernomyrdin is expected to sign about 10 economic agreements.
An important agreement to be signed involves feasibility studies for a trans-Asian gas pipeline from Irkutsk, Russia, to China - a project discussed during talks between Jiang Zimin and President Boris Yeltsin in April.

*(From the Moscow Tribune, May 21, 1996)*
*Note of the Editor: Yu. Koptev was present at previous talks which took place at Moscow*

Russian Ilyushin-96T cargo aircraft powered by American engines and controlled by American avionics made its maiden test flight Friday, May 16.
The 70-million, wide-body freighter, with engines from Pratt&Whitney and parts from 10 other U.S. firms, took off from Voronezh 550 kilometres south of Moscow and flew for 21 minutes, an Aeroflot airline spokesman said.
The aircraft , which can carry 50 tons over 11,000 kilometres or 92 tons over 5,000 kilometres, was rolled out in April, several months late due to funding problems. Aeroflot ordered 20 of the planes, both cargo and passenger versions, for delivery by 2001.
Al. Luchaninov said by phone from Voronezh that Aeroflot hoped to have the plane operating on regular cargo routes this September.

(From The Moscow Times, May 17, 1997)

**President's decree: stop providing state guarantees for commercial credits**

RF President signed a decree on May 12, which would stop providing commercial credits under the state guarantee. See the full text below.

In order to implement the RF President's address to the Federal Council "Order in the executive - order in the country. (About the state in the country and major priorities in the Russian Federation's policy)" and to better manage state's debt, is decreed :
1. To stop providing guarantees for credits of commercial banks, given to the Subjects of the Russian Federation and to other recipients of the federal budget means, for financing expenditures, foreseen in the Federal budget.
The government of the RF is to:
2. reconsider its decisions on providing state guarantees taking into consideration the paragraph 1 of the decree, excluding those decisions, according to which the Finance Ministry is already providing guarantees for commercial credits, and to decrease credit amounts;
consider possibility to finance federal budget expenditures, which were foreseen to attract commercial credits under state guarantees, by means of searching resources within the frame of unified management system of servicing state debt of the RF;
the ruling documents must be brought in compliance with this decree within one month.
3 The decree is enforced on signature.

May 12, 1997
Signed by President B. Yeltsin

*(Translated from Rossiyiskaya Gazeta, May 15, 1997)*
*Note of the Editor: Financing of the international space station for an amount of 1.5 trillion rubles is foreseen by means of commercial credit. We remind you that the governmental decision allowing to attract 800 billion under the guarantee of the 98 budget was made. Its second part regarding 700 billion is still missing. This decree might cause some difficulties to adopt a decision concerning the rest of the money (700 billion rubles).*
*Nevertheless, it is not clear whether the space station financing is covered by the decree.*

By a vote of 256 to 16, with 4 abstentions, the Russian Duma in mid-April passed the first reading of a law titled " On commercial activities in outer space". Duma representative Yevgeny Bushenkov, deputy chairman of the Committee on Geopolitics stressed to Duma observers that the widely held view within the Duma was that maintenance of Russia's space infrastructure and technology based solely on government funding was impossible and that commercial revenues were a vital necessity. A draft of the law has not been released, however, it reportedly provides a legal regulatory framework for future Russian commercial space activities including those undertaken by both government-controlled organisations and privately held companies. Also reportedly included in the draft law is a government organisational structure of responsibilities and authorities to promote investment of commercial funding into Russian space programs.

*(From the Anser's report, No 233, May 2, 1997)*

From May 19 to May 23, the international exhibition "Svyaz-Expocomm-97" has taken place in Moscow. Its scope covered all the contemporary means of telecommunications. The whole list includes more than 200 participants. Leading world companies such as Deutche telecom, Siemens, Motorola, Ericsson presented their products and services.
AO Gazkom, formed by Gazprom and Energiya, presented its latest Yamal project showing a Yamal

dynamic model. *(See News from Moscow No 32, 36&44, 1996 and No 7, 1997)*
The Russian Satellite Communications Company, a national space communications operator, took part in the exhibition presenting its technical facilities. The company operates 8 Gorizont satellites, 2 Express satellites and one Ekran -2 satellite. It has six Space communications centres ( two centres in Moscow, two - in Moscow region, one in St. - Petersburg and one in Gus-Khrustalny ).
A number of russian companies ("Belka corporation" incorporates group of companies, among them are "Sputnikovye sistemy" (satellite systems),"Belka Ltd" , "Belsatkom" and others), Lans company, Supral group, General satellite corporation) presented equipment for satellite TV.
A wide range of receiving stations for satellites communications system. Among them Izhevsk Radio plant gave a big presentation of its products. IRZ produces communication equipment for satellites, eg: onboard telemetry devices, small size radio stations, devices for trajectory measurements, navigation equipment. The plant is a direct supplier of various electronic devices of space and ground applications, which are used in all the russian spacecraft both manned and automatic ones. The plant presented its users stations for Bankir and Gonets satellite communications systems.
*(As it has been often mentioned by Russian space officials, Gonets low orbit satellite system has an undeveloped users' segment and due to this fact is not fully used.)*

## SPACE NEWS

### ALPHA: CONSTRUCTION WILL BEGIN IN JUNE 1998

Construction of the international space station will begin in June 1998, seven months late but with full Russian support as originally planned, NASA said.
Some members of Congress had argued for a reduced Russian role following the country's inability to fund a critical station component, which in turn delayed station construction.
Brinkley said, the Russians will launch the first station component in June 1998. This US-financed but Russia-built tug, which should have been launched in November, will be modified to increase its motion control and allow it to be refuelled in orbit - a safeguard against further Russian trouble.
After months of stalling, the Russian government has finally resumed paying for the service module and even more money is forthcoming, Brinkley said.
"That does not mean that the risk has been completely eliminated," he said. "But ... I'm very encouraged about what we saw and what we heard, which includes the sharing of all their financial documents as well as looking at the components and looking at the hardware".

*(Abridged from The Moscow Tribune, May 16, 1997)*

**Russian space officials said Monday May 19, they have completed the first module for the Alpha station and said they hoped the funding crisis threatened to derail Russia's involvement in the project had been resolved.**
The cargo module is one of 36 making up Alpha. The multifunctional cargo module, which weighs 23.5 metric tones and costs NASA $215 million, was constructed at Moscow's Khrunichev Space Centre. It will control the orientation and direction of the space station and will act as a base for assembling Alpha in orbit. Sergey Shaevich, the cargo module program director, told a press conference at the Khrunichev Space Centre that the decree pertaining to Russia's financing of the service module has so far been fulfilled.
"Most of the problems have been resolved," he said. "We are presently going through the procedure of transferring money."

*(Abridged from The Moscow Times, May 20, 1997)*

The launch of an American satellite from Russia's Far East rocket base at Svobodny has been postponed until the end of June, an official said Thursday May 22.

The Early Bird remote Earth probing satellite was scheduled to take off on June 18, but the American owners asked to postpone the launch at least until July, Space Military Forces spokesman V. Mikhailichenko said.

"The exact date has not been scheduled so far and may be postponed even further," Mikhailichenko said.

He said the Russian rocket was ready for the launch and postponement of the launch "had nothing in the common" with the crash of Zenit rocket at Russia's Baikonur launching facility earlier this week.

*(From The Moscow Times, May 23, 1997)*

PROTON LAUNCHES HAVE RESUMED

Military Space Service press service informed, the american satellite Telstar 5 was launched saturday, May 24, from Baikonur at 9:00 p.m. (Moscow time) with the Proton K launcher. The satellite was put into geotransfer orbit with the DM series upper stage. The parameters of the orbit are as follows:
altitude: apogee 35779 km, perigee 6716 km
inclination 17.5 °.
orbit pass - 12 h 42 min

*According to Russia's largest manufacturer, revenues from commercial launches will raise to between $500 million and $600 million this year.*
*Khrunichev said its booster rockets accounted for 60 percent of the $470 million earned by Russia from commercial space in 1996, the ITAR-TASS news agency reported.*
*Khrunichev executives said the company has seven more commercial launches scheduled for this year under contracts with foreign companies to put 19 satellites in space.*
*Khrunichev has 20 contracts, worth $1 billion, the report said.*
*Also contributing to Russia's space revenues in 1996 were the Russian Space Agency, which brought in 25 percent of money and the Defence Ministry, with 15 percent, Khrunichev said. (From The Moscow Tribune, May 27, 1997)*

## DETAILS

ZENIT-2 FAILURE

The 460-ton Zenit-2 rocket carrying a Russian military satellite exploded less than a minute after launch May 20.

It crashed on the steppe in a powerful blast as its first stage engine failed 48 seconds after it was launched from Baikonur cosmodrome at 11:07 a.m. local time, said Russia's military space force spokesman Ivan Safronov.

There is no casualties, as local residents were evacuated from nearby villages as a regular precaution.

Helicopters spotted fragments of the two stage of the two-stage, 57-meter long booster and the Kosmos series military satellite some 13 kilometres from the launch pad.

A commission has begun an investigation into the reasons for the failure, the spokesman said. Officials put the damage at 100 billion ($17.2 million).

The launch failed as workers in Baikonur were making final preparation for the launch of a U.S. communication satellite scheduled for May 17.

The Telestar 5 satellite, built by the U.S. Space Systems Loral company and intended for television broadcasts, is to put into orbit by a Proton-K launcher.
Tuesday's accident was the Zenit-2's 28th launch and seventh failure since 1985. It came as a blow not only to Russia, but also for Ukraine, which provides about 40 percent of components for the launcher.
Engines for the launcher are built in Russia, but the final assembly is conducted at Ukraine's Yuzhnoe construction plant in Dnepropetrovsk.
Space industry officials in both Russia and Ukraine have ambitious plans for Zenit, using it to place foreign satellites in orbit.
The U.S mobile-telephone company GlobalStar LP has signed agreements to loft 36 of its low orbit satellites on three Zenit rockets.
Yuzhnoe also is part of Sea Launch, which plans to launch satellites from a floating platform in the Pacific beginning in 1998.

*(From the Moscow Times, May 21, 1997)*
*See News from Moscow No 33&41, 1996 and No 2, 1997 for Sea launch*

## DESCRIPTION OF ZENIT-2 FAILURES AND THEIR REASONS

**1. First launch of the "Zenit-2" launcher.**
April 13, 1985 (N-1L) - because of wrong adjustment of the fuel flow rate regulator of the second stage engine, the fuel was fully spent on the 415th second of flight. The payload did not reach orbit.

**2. Second launch.**
June 21, 1985 (N-2L) - the turbo-pump of the second stage steering engine exploded on the 511th second of flight because the oxygen pipeline was not pressurized. The payload did not reach orbit.

**3. 4th launch.**
December 28, 1985 (N-5L) - the fairing did not open because the opening system was in contact with the body. As a consequence, the turbo-pump of the second stage steering engine exploded on the 1009th second of flight.

**4. 15th launch.**
December 28,1990 (N-15L) - 2.44 sec after the "off" command, at an altitude of about 11 meters, a high temperature pipe of the first stage engine broke into one of four chambers.
Reason: burn out of the bellow due to organic impurities.
The rocket fell down on the launch table, got into the table aperture, and then, exploded under the table. The launch table (weight 660 t) rose up in the air, then fell down destroying two of six levels of the launch structure. People were not injured. Fragments flew about 900 meters away.

**5. 16th launch.**
August 30, 1991 (N-16L) - intensive burning in the oxidizer pipeline of the turbo-pump of the second stage main engine started on the 157.84th sec of flight. The burning process was accompanied with a dramatic output pressure increase and resulted in opening oxidizer pipeline. Decrease or interruption of the oxidizer flow to the gas-generator resulted in increase of generator gas temperature and in ignition of both the turbine and the gas pipe-line.
Judging on analysis results of the available telemetry, the location of ignition and its reasons could not be defined. Possible reasons could be the following:
- organic impurities or some other particles in the oxidizer pipeline;
- touching or collision between seals or between parts of the automatic loading system ("ALS") of the oxidizer ("Ox") pump.

**6. 17th launch.**
February 5, 1992 (N-17L)
In order to control operation of the automatic loading systems of the "Ox" pump, the second stage main engine was additionally equipped with sensors, which measured the following parameters:

- axial displacements of the pump "Ox" shaft, mm
- "Ox" pressures in the "Ox" transfer pipeline from the automatic load system to the booster pump
- temperature of the "Ox" pump collector surface in the area of the transfer pipe-line.

The engine exploded on the 158.59th sec.
Up to the time t=1.76 sec (since the command "to switch on the second stage main engine") the temperature T=-176 °C.
Starting t=1.76 sec, the axial displacement of the "Ox" pump shaft changed sharply from 2.55 mm to 0.28 mm as of t=1.81 sec, proving that the "Ox" pump shaft moved to the side of the fuel ("F") pump shaft.
During that, the pressure in the "Ox" transfer *[from the automatic loading system to the booster pump]* pipe-line spasmodically increased from 1.4 N/cm$^2$, as of t=1.77 sec, to 40.5 N/cm$^2$, as of t=1.78 sec. This significant increase of "ALS" output pressure could be explained by ignition in the area, which is limited by the disk of the automatic load system and the floating seal located on the back side of the "Ox" pump blading.
At the time t=1.81 sec the pressure in the "Ox" booster pump increased from 7.4 N/cm$^2$ to 51.0 N/cm$^2$, while the input booster pump pressure increased from 3.6 to 12.8 N/cm$^2$. In this way the wave of increased pressure propagated along the transfer pipe-line from the automatic load system to the booster pump output, and then, to the engine.
Ignition process resulted in destruction of the engine body and in its operational slump during 0.02-0.04 sec starting t=1.87 sec. It is confirmed by the dramatic decrease in fuel nozzle input pressure, "Ox" output pump pressure, gas generator input "Ox" pressure, first and second engine stage output "F" pressure, as well as by dramatic decrease of rotation frequency of the turbo pump rotor.
Explosive nature of the engine destruction was also confirmed by sharp pressure increase in between tanks and rear

compartments of the second stage.
In the end of April 1992, a meeting of the interdisciplinary commission on 17-L and 16-L launchers failure took place at Energomash. It was defined, that the failures were caused by the disk of the automatic loading system. During the development phase, in particular technological tests, this disk had scores. The disk was made of a copper-graphite alloy. It was decided to replace it with a nickel-vanadium one. The testing showed its good performances (only one explosion). When performing further tests, the second stage main engine worked once nominally, but then it exploded twice.
Firing tests were performed on a horizontal table in Dnepropetrovsk, and the vertical mode was not simulated during testing. Perhaps, as the nickel alloy has worse heat rejection performances than the copper-graphite one, its heating could result in "Ox" pump ignition.
After that, money for additional development and 15 firing tests on the vertical facilities in Zagorsk were appropriated.
Rebuilding the launch pad No 2, destroyed by the explosion, started in 1991, but this work was cancelled in 1992 due to lack of funds.

Zenit-2 performances

| | |
|---|---|
| Launching weigh, t | 459 |
| Max payload mass in low orbit, t | 15.7 |
| Length , m | 57 |
| First and second stages diameter, m | 3.9 |
| Engines thrust t : | |
| first stage (atm/vacuum) | 740/806 (RD-170) |
| second stage (main (RD-120)/steering) | 85/8 |
| Operational time, s: | |
| first stage | 140-150 sec |
| second stage (main/steering) | 200-315/300-1100 |

## ABOUT THE DEVELOPMENT OF RD-170

In the opinion of designers, successful application of Zenit launchers should be guaranteed by a number of factors. First of all, it is high exploitation reliability of all its components, and non toxic fuel. But reliability performances of the launcher were put in doubt after the first three failures in a row occurred one after another during 1990-1992. These failures were caused by malfunction of the propulsion system. Actually, we speak here about reliable engines of RD-170 (first stage) and RD-120 series (second stage).
The Oxygen-Kerosene engine RD-170 was

designed in 1974-1986 under the lead of V.P. Radovskiyi, Designer General of NPO Energomash.
It was designed for the first stage boosters of the heavy space transport system "Energia-Buran". In order to decrease development expenditures of the boosters, the engine design was highly unified with the first stage of the Zenit -2 carrier, designed at Yuzhnoe under the lead of Utkin, who is now Director General of TsNIIMASh.
RD-170 is a high pressure four chamber - combustion liquid rocket engine with turbo pump fuel supply system.
Operational time of RD-170, when launching Energia-Buran system, is 140-150 sec, including transition modes to "full" and to "zero" thrust.
The thrust curve is smoothly decreasing from 100 percent to 70 percent during 30 second, and then drops to 50 percent in 2 seconds. The 50 percent level is kept during 10 seconds, then during 0.5 sec the thrust is cut off.
According to specialists, the design of a liquid rocket engine, which can be switched on several times, is a complicated task. An adjustment of the liquid fuel components flow is required in order to provide smooth transition to "full" and to "zero" thrust level.

< RD-120 is a single - chamber engine with a turbo pump propellant feed system.It was developed using the staged combustion scheme. The propellant components ignition is performed by starting fuel.
This engine is used for the second stage of Zenit-2.

The engine successfully passed full testing, both ground and flight. Ground fire testing was performed with fully assembled engines.
When developing the engine, the designers had to resolve a number of serious problems. Among them are fuel pipe fires, destructions of turbo pump bearings and high frequency vibrations in combustion chambers.
It took a long time to resolve these problems.
Ignitions in fuel pipes occurred due to impurities. Difficulties with turbo pump operation were also finally overcome, but high frequency vibrations, which could cause destruction of the nozzle head parts, took place till the exploitation phase.
During combustion chamber development, 300 fire tests were performed with a total time of 23000 seconds. During these tests, six different cooling schemes and over 20 designs of mixer part with different nozzles performances were tested.
The RD-171 engine- is a modification of RD-170. It is used for the first stage of Zenit -2. It has four swinging chambers, compared to RD-170,used for "Energiya Buran", two chambers of which were swinging.
Both engines have regulation system for both the thrust and fuel components ratio.

**Four chamber RD-170**

*(Abridged from the document " Information on the Zenit launcher", I. Afanasyev, A. Vladimirov, © 1995.*
*Pictures are from NPO Energomash documentation )*

***For your information:***

Energomash is a developer and manufacturer of rocket engines.

Energomash's testing complex *(in Omsk)* is headed by Alexander Vergun, who is also the deputy director and chief designer of Energomash.

The complex is located in the Omsk region, not far from the workers' settlement Krutaya Gorka.

No country possesses installations for the vertical testing of heavy-duty rocket engines like those of Energomash. The Omsk complex is worldwide renowned for its uniqueness. The Americans, for example, would agree to any terms if they were allowed to test their engines there.

Unfortunately, the testing complex is falling apart after remaining idle for three years, and unless it is put into full operation over the next 18 months, its unique equipment will become useless.

From recent history.

A secret resolution issued by the Central Committee of the Communist Party of the Soviet Union in 1956 on the development of rocket construction necessitated the testing of new rocket engines.

Accordingly, in 1958 the then Minister of Defence Ministry D. Ustinov personally offered that a proving ground to test rocket and aviation engines should be built in the centre of the West Siberian plain. Only 37 months later, in October 1962, the first tests were carried out.

In 1979, the Omsk aerospace group Polyot received a state order to manufacture around 60 superpowerful engines designed by the V.P.Glushko Energiya Design Bureau. A year later, under a new large-scale space exploration program, started the construction of the only complex in the world for testing such engines.

However, the roar of engines have not been heard in the test area for a long time.

In 1994 the government resolved to terminate the Energiya-Buran program, and stopped funding engine tests. In 1996 the Russian Space Agency allocated only 1.7 billion rubles out of the 30 billion rubles needed just to maintain the viability of the Energomash enterprise.

Energomash now sells liquefied oxygen and nitrogen. Its electronic engineers designers, and testers of rocket engines are carrying out a conversion program. They are making window frames and door apertures, and moulding slag blocks on equipment of their own construction. They are raising mushrooms for sale in the former Energomash shops, and hoping to find buyers for mini-breweries which they have designed and put together themselves.

Vergun has great hopes in the only project of this kind in Russia - the construction of a

rubbish-processing plant that will use the defense technology of plasma incineration. Unlike traditional rubbish burning plants, which swallow up enormous quantities of fuel and energy, this one will provide electricity, heat, metals, gravel, and around 50,000 tons of carbonic acid (which is in short supply) annually, one ton today costs five million rubles.

*( abridged from Moscow News No 19, May 1997)*
*Note of the Editor: According to leaders of Energomash, the enterprise can fully utilize its facilities owing to the cooperation with Pratt&Whitney. This cooperation is backed by the Russian Space Agency. Russian Space Agency's official say, that in today's situation, the cooperation with the americans allows to keep the production and science level of the enterprise, whose technologies are not needed within the country.*
*See also News from Moscow No 42, 1996.*

**SPECIAL REPORT: Interplanetary missions**

*As the spacecraft mission planned under the Mars-96 Program failed, a demand arose to review the Planetary Research Program. The Russian Academy of Sciences decided, that a new Mars mission is to be performed. Since the national space program is in a critical financial situation, it would not be possible to restart such a big mission as Mars -96.*
*The decision of the Academy of Scinces defines the necessity to develop a new generation spacecraft, which will be launched with Soyuz series rockets.*
*The next national Mars mission is planned now for 2001.*
*The Moon program is a milestone in the new concept of the Solar system exploration program.*
*Besides exploration of Mars, Moon and Fobos it is recommended to perform asteroids studies, as well as missions to Pluto, Mercury, and comets.*

The following Program Implementation schedule is proposed in the frame of the decision of the Russian Academy of sciences.

| Year | Project of National Program | Participation in other programs |
|---|---|---|
| 1998 | | MSP-98 (NASA)<br>Participation in experiments |
| 1999 | Luna-Geochemist - 1<br>Penetrators | |
| 2001 | Mars-2001<br>Rover+Penetrators * | Rosetta (ESA)<br>Participation in experiments |
| 2002 | | Pluto (NASA)<br>Approaching probe |
| 2003 | Fobos-Soil *<br>Return of matter from Fobos | |

| | | |
|---|---|---|
| 2004 | Luna-Geologist-1<br>Return of matter from Moon | 2005Return of matter from Mars (NASA)<br>Participation in the project |
| 2006 | Luna-Geologist -2<br>Rover | |
| 2007 | | INTERMARSNET (ESA)<br>Participation in the project |
| 2008 | Asteroid<br>Return of matter from asteroid | |

** Both projects could be also implemented with one single launch mission in 2001 (if possible)*

Technical policy: versatile spacecraft and electrical rocket engine

A peculiar feature of technical policy applied to the aforesaid projects *(see the table)* is that the projects are based on the new-generation spacecraft to be launched on the middle class launch vehicles.

The spacecraft should incorporate advanced technologies to offer the highest efficiency.

The spacecraft should be designed and modified in parallel with its modification and usage in scheduled space programs.

The first option of new-generation spacecraft has to be developed by 1999 and used for the lunar mission. Experiments being planned for Mars and Fobos will be based on modifications of the same versatile spacecraft.

By now, the space technology offers rather verified (including flight tests) new capabilities enabling a qualitatively higher level of experiments to explore the Solar System. We can now implement both technical solutions made in designing spacecraft and new hardware and systems among which are electrical rocket engines (ERE) designed within the last decade (ion and plasma) and light solar power units. The output velocity provided by ERE is an order of magnitude higher compared to traditional jets using chemical propellant. Thus, the EREs offer the possibility to improve sufficiently the mass balance of spacecraft with respect to payload.

This allows a new approach to the implementations of missions to the Solar System and, first of all, to its small bodies - satellites of planets, asteroids, comets.

The preliminary investigations proved the possibility of solving a rather wide spectrum of tasks by using the versatile spacecraft with ERE. Besides, several other goals are considered, such as the Mercury exploration, asteroid monitoring (to assure asteroid safety), sun observation, development of towing lines to the Moon and the Geostationary Orbit.

The development of new-generation versatile spacecraft using ERE will help Russia to avoid lagging behind in the Solar System exploration. The international cooperation could contribute greatly to the implementation of space exploration projects and evidence the growth of technical and political authority of Russia in the world.

The preliminary analysis showed that proceeding from scientific, experimental experience the new-generation, versatile spacecraft using ERE can be developed in the nearest two years and subjected to flight tests. The final version of this spacecraft can be developed within 4.5 years.

*As a Moon mission is also planned by ESA at the turn of the century, find below more detailed description of the Russian Moon mission, proposed for implementation. The Moon mission would be the earliest russian interplanetary mission around the same period.*

LUNA MISSION

*It was mentioned, that after the intensive period of Moon studies in 60s-70s, a long break took place. But today we are in front of a new wave of interest for the Moon.*
*There are a few reasons for a new interest for the Moon. First of all, all the obtained data have been processed. Secondly, new technologies and tools today are available allowing to receive new information with details and precision, unreachable before. And finally, new projects propose to create on the Moon stations in order to use its resources.*
*In connection with this, all major space agencies are planning programs of Moon exploration, which could be of great importance for the Earth.*
*The next Russian Moon mission is planned for 1999. Find below its description, given by the resolution of the Academy of Sciences, approved Jan. 31 by the Section of planets and small bodies of the Solar system. This document is signed by A. Galeev, academician, Chairman of section, Director of Institute for Space Research and by E. Galimov, academician, Director of Institute for Geochemistry and Analytical Chemistry. Among the participants to this program proposal NPO Lavochkin (S. Kulikov, Director General) and MAI (G. Popov, Director of the Institute for Applied Mechanics)*

Moon Exploration Programm Implementation plan

The Moon exploration program can be implemented stepwise.
For **Phase 1** launch of spacecraft carrying a block of penetrators for sensing classic properties and thermal field of the Moon is planned. In this Phase problems dealing with the Moon origin, presence of Volatile, global mapping will be solved.
Besides, elements of the new spacecraft will be verified.
The first launch is planned for early 1999. The follow-on launches will be accomplished by 2001. By 2001, a spacecraft for a mission for taking soil samples on Fobos will be completely tested and prepared.
In **Phase 2** the Moon Rover will be delivered to the lunar surface to take samples and return them to the Earth.
This Phase is planned for the period from 2001 till 2010.
During **Phase 3** it is suggested to build the lunar station, verify mining activities on the lunar surface. A human presence is likely to be required in this Phase.

Space System for Luna-25 Experiment Implementation for the LUNA Program

*System components:*

The rocket - space system consists of:
- serial Molniya LV with Upper stage and PL fairing;
- spacecraft consisting of a transfer module and three penetrators, and scientific hardware.

This system is shown in the chart next page.

The mission to the Moon suggests the flight to the Moon, then three penetrators will be released, while an orbiting module will remain in lunar orbit. ***(Penetrators are to be released in three points: visible and invisible sides of the Moon, and the region of the South pole)***

The primary scientific objectives are:
- multipurpose exploration of the Moon by remote techniques from the orbiter including the lunar surface relief, composition of rocks, mapping;
-direct physical-chemical exploration of lunar regolith in the specified region by means of penetrators.

To accomplish these tasks the Luna spacecraft will be equipped with a set of scientific hardware and three penetrators.

The scientific hardware will include :
- TV set;
-IR and Visible Range Spectrometer;
-Radar - Altimeter;
- Plasma set;
-Gamma - Burst Analyzer
- Magnetometer

## Mission scenario

The Luna-25 spacecraft will be inserted into the Earth-Moon trajectory on the Molniya LV to be launched from the Plesetsk Launch Site.
The flight to the Moon will take 3 days.
In the Earth-Moon trajectory, on the 2d day of flight, the required correction is made so that to direct the trajectory through one of the penetrator landing points.
Early on the third day, based on the trajectory measurements, the second correction is made that is followed by the spacecraft orientation to point the first landing penetrator axis vertically to the surface at the moment of intrusion in the lunar soil.
The landing points of three penetrators should form approximately an equilateral triangle required for seismic experiments.
About 20 hours prior to the rendezvous with the Moon, a spin about the longitudinal axis of the first penetrator and its separation from the spacecraft are performed.
After the first penetrator is separated the spacecraft manoeuvres are performed to transfer the trajectory to pass through the second target point, and to separate the second penetrator. Thereupon, the same procedure is repeated to land the third penetrator. The entire process should be accomplished within 3 hours.
After the third penetrator separation the spacecraft trajectory is changed for fly-by. In the assumed perigee the SC is braking and transfers to the Moon Artificial Satellite (MAS) polar orbit required for subsequent downlink of data from the penetrators. For the convenience of communication the MAS orbit period is selected equal to the Earth day.

## Landing Scenario

Having separated from the SC, the penetrator, stabilised by spinning about its longitudinal axis, continues to approach the lunar surface. Approximately 10 km above the surface, on a signal from the penetrator laser altimeter, the solid propellant engines are fired so that, at an altitude of 2 km, the penetrator velocity is cancelled to zero relative to the Moon.

Then, a command is generated to separate the solid propellant engines that, under action of centrifugal forces, are separated and the penetrator, under gravity, gains a vertical velocity of 8 + lO m/s to penetrate the lunar surface. Here, the lateral velocity component can reach +15 m/s. The acceptable surface inclination (or the total angle of attack) during penetration should be up to 20°.

**SC Mass Budget**

| **Systems, Assemblies, Units** | **Mass, kg** |
|---|---|
| Transfer vehicle including: | 320 |
| Propulsion Unit | 98 |
| Power Supply System | 56 |
| Control System | 14 |
| Thermal Control system | 4 |
| Radio system | 15 |
| Structure elements, pyrotechnics, multi-layer insulation | 40 |
| Separation system | 3 |
| Cable system | 30 |
| Reserve | 60 |
| Fuelling (propellants, gases) | 300 |
| Scientific Equipment on Transfer vehicle | 130 |
| Lunar penetrators, 3 x 250 kg | 750 |
| **Total** | **1500** |

*(Abridged from the document "Scientific-technical predictions for future exploration of planets, Moon, and small bodies of Solar System", proposals for national programm till 2010, Space Board at the Russian Academy of Sciences)*