(№.4　2001年2月28日号目次)

特集：航空宇宙関連研究開発機関（その2）

今号では、前号に引き続きロシアの航空宇宙関連の研究開発機関を特集します。
現在、宇宙船「ミール」落下しか一般では話題になりませんが、この分野でロシアに膨大な開発の努力と経験が蓄積されていることは間違いありません。
トピックとして、ロシアで発行されている技術雑誌をご紹介します。

トピック:

⑥ロケット宇宙研究所「プログレス」
（サマラ市）

I. Name of the Institute (Organization)

In Russian: Государственный научно-производственный ракетно-космический центр «Центральное специализированное конструкторское бюро «Прогресс»

In Russian abbreviation: ГНПРКЦ "ЦСКБ "Прогресс"

In English: State Research and Production Rocket Space Center "Central Specialized Design Bureau – Progress"

In English Abbreviation: TsSKB-Progress

II. Location

Official address: 18, Pskovskaya Str., Samara, 443009, Russia

Mail address: 18, Pskovskaya Str., Samara, 443009, Russia

Telephone number: (8462) 22-28, 27-13-61, 22-29-10

Fax number: (8462) 27-20-70, 27-12-14

E-mail for representative:

Website: http://www.samara.ru/~cosmos/tsskb/

Access (transportation, necessary time): The nearest international airport - Sheremetjevo-2 in Moscow. Than train (16 hours) or aircraft (2.5 hours) traveling time to Samara.

III. History

The history of the TsSKB-Progress goes back to July 23, 1959 when a special department No. 25 was established at the State Aircraft Plant No. 1 (now Samara Plant "Progress") as a subdivision of the Experimental Design Bureau No. 1 (EDB-1).

The department's main task was promoting the manufacture of R-7 intercontinental ballistic missiles. A year later, the department was transformed into branch No. 3 of EDB-1.

Since 1964, the organization was playing a prominent part in creating medium-duty carrier rockets R-7 and automatically controlled space vehicles for Earth remote sensing.

In 1967, branch No. 3 of EDB-1 was named the Kuibyshev Branch of the Central Design Bureau for Machine-Building, and since 1974 it is an independent enterprise – Central Specialized Design Bureau (TsSKB in the further text).

The Samara Plant "Progress" has been and remains the main manufacturer realizing TsSKB's developments. With the view of extending the production basis, in 1980 the manufacture of space vehicles for separate design trends was entrusted to the Leningrad Plant "Arsenal".

In 1996, TsSKB and Samara Plant "Progress" were combined into the State Research and Production Rocket Space Center "Central Specialized Design Bureau – Progress".

The TsSKB's permanent head is Dmitry I. Kozlov, Corresponding member of the Russian Academy of Sciences.

Type R-7 medium-duty rockets

August 1957 witnessed the first successful launch of the two-stage intercontinental ballistic rocket R-7 (8K71) designed at S.Korolev's design office (EDB-1). The perfect design allowed using the above rocket as a prototype for the R-7A (8K74) rocket and a family of carrier rockets.

In the late 1958, the EDB-1 specialists designed the three-stage carrier rocket "Vostok" (8K72) which was used for the first manned space flight. The first and second stages of the said rocket were manufactured at the Kuibyshev Aircraft Plant No. 1. For sending space stations to the Moon and planets of the solar system and as putting into orbit communication satellites, the EDB-1 specialists in 1958-60 elaborated the four-stage carrier rocket 8K78 later called "Molniya" which was updated in 1965. In that very year the "Molniya-M" (8K78M) carrier rocket with the "Luna-7 automatic interplanetary station was launched. Later the "Molniya-M" rocket was widely used for launching automatic interplanetary stations of the "Venera" series and "Molniya"-type communication satellites. Since the start of operation, over 250 launches of the above carrier rockets were performed.

In 1962, designers and engineers created the three-stage carrier rocket "Vostok-2" (8A92) which was developed in EDB-1 with direct participation of the Kuibyshev branch No. 3 which besides prepared the whole of the design documentation thereto.

In 1964, EDO-1 (branch No. 3) was charged with updating the said rocket for placing "Meteor" satellites (each up to 1250 kg) in high circular orbits. The first launch of the modernized rocket "Vostok-M" (8AM92) was performed in August 1964, and it was in use till 1991. In all, the "Vostok-M" carrier rockets made 94 launches for orbiting satellites "Meteor", "Meteor-2", "Meteor-Priroda", "Resource-O", space vehicles at orders of the Ministry of Defence, Bulgarian satellites "Intercosmos-Bulgaria", Indian satellites IRS-1A, IRS-1B.

The first independent development made by EDB-1 (branch No. 3) was the three-stage carrier rocket "Soyuz" (11A57) intended for placing automatic space vehicles, manned and transport spaceships in low circular orbits. Operation of that carrier rocket started in 1963. Later on specialists created such modifications of the "Soyuz" rocket as 11A511, 11A511L, 11A511M, and (in 1973) the unified carrier rocket 11A511U which became the basic one for launching satellites for Earth remote sensing and material studies, as well as biological satellites. The 11A511U rockets became the only means for transporting astronauts to the long-run space stations "Salyut" and "Mir" and launching transport spaceships of the "Progress" series. The said rockets helped perform 32 expeditions to the orbital station "Mir" including those with the participation of foreign astronauts.

During 40-year working period of the Design Bureau, it has created eight modifications of medium-duty carrier rockets of the "Vostok", "Molniya" and "Soyuz" types. The resources of carrier rockets of the "Soyuz" type are far from being exhausted. The 11A511U carrier rocket updating including fuel replacement for more efficient one helped increase its useful load.
The first launch of the 11A511U2 carrier rocket took place in December 1982.
At present, TsSKB is developing a three-stage medium-duty carrier rocket "Soyuz-2" ("Rus"). Improved power indicators, increased dimensions of useful load and a higher accuracy in orbits formation will enable to widely extend the range of space vehicles launched.
It is expected that the "Soyuz-2" carrier rocket will replace all types of carrier rockets manufactured by the "Progress" plant which shall optimize the production of new carrier rockets owing to their unification.
Automatic space vehicles
The year 1962 was noted for the launch of the "Zenit-2" observation satellite. It was the first launch made at the order of the Ministry of Defense. The lot production of the above satellites was entrusted to the "Progress" plant and its engineering support to branch No. 3 of EDB-1 which took part in the satellite manufacture, flight and acceptance tests. The "Zenit-2" development resulted in a new trend of the Ministry of Defense's activity – space orientation of objects. That satellite laid the basis for the "Zenit-4" satellite developed jointly by EDB-1 and branch No. 3. Starting from 1965, "Zenit-4" was used by the national Armed Forces.
In the period from 1965 to 1982, TsSKB developed seven "Zenit"-based modifications of satellites for space observations. Developments made touched upon active service period, characteristics of photographic equipment and film reserves, maneuverability, accuracy of orientation and stabilization, accuracy of landing and location of landing apparatuses. Photographic satellites served the basis for creating a principally novel satellite "Zenit-4MT". The wide-angle photographic equipment, exact affixment of a picture to the starry sky and satellite's orbital position made it possible to apply satellite-made images for making topographic maps.
Progress in science and engineering allowed TsSKB to start (1967) and finish the development of the new-generation satellite "Yantar-2K" noted for high-resolution images, multiple delivery of information, application of onboard computer ensuring flexible control, improved characteristics of onboard systems, use of solar cells as a power source greatly extending the satellite's service life. The said satellite service started in 1978.
The TsSKB specialists made use of the "Yantar-2K" satellites as a basis for development and putting into service several satellites for general-type and detailed surveillance featuring improved operating and engineering characteristics, as well as a cartographic satellite. Improvements touched upon photographic equipment, onboard supporting systems, etc. Besides, satellites service periods and efficiency were also enhanced. Efficacy in information delivery was increased due to installation of a great number of small-size capsules and high

accuracy of their landing in the specified area, as well as by transmitting information via a radio channel in a time duty close to real.

The "Yantar-2K" satellites facilitated creation of space vehicles having no world analogues and allowing to get high-resolution detailed and wide-angle images.

Defense-application satellites are a national means for supervising areas of political crises and procedures of disarmament effected under international treaties.

Fulfilling orders from the Ministry of Defense in 1965 to 1998, TsSKB created and put into service 17 types of earth satellites. The experience obtained helped in designing space vehicles for economic and scientific purposes.

IV. Management

Kind of organization: State Enterprise

Ownership: State Property of RF

Responsible Ministry: Russian Aviation and Space Agency

V. Executives

Dmitry I. Kozlov – Director General – Designer General, Manager of Central Specialized Design Bureau

Gennady P. Anshakov – First Deputy Director General-Designer General

Boris N. Melioransky – First Deputy Director General-Designer General for Economy

Alexander N. Kirilin – First Deputy Director General, Director of “Progress” Plant

Alexander V. Chechin – First Deputy Designer General

Vladimir D. Kozlov – Deputy Director General – Designer General for External Relations

Vadim V. Lamashkin – Deputy Director General – Designer General for Security Services

Georgy E. Fomin – Deputy Designer General

Konstantin V. Tarkhov – Deputy Designer General

Vladimir A. Kapitonov – Deputy Designer General

Yuri G. Antonov – Deputy Designer General

Aleksei C. Kvashin – Deputy Designer General

Alexander V. Cologub – Deputy Designer General

Vladimir I. Krainov – Deputy Designer General

Vladimir I. Klimov – Deputy Designer General

Alexander M. Soldatenkov – Deputy Designer General

Alexander A. Sochivko – Chief Engineer

VI. Current major activities

<u>Space complexes of economic application</u>

In 1977, specialists started elaboration of a spaceborne photographic observation subsystem "Resource-F" aimed at creation of "Resource-F1" and "Resource-F2" satellites on the basis of "Zenit-2N/Kh" and "Fram" satellites intended for various-scale multi-spectral photography of the Earth surface in the visible and infra-red ranges of electromagnetic spectra with high geometric and photometric characteristics. While creating the Resource-F! satellite, engineers and designers achieved a high degree of unification and application of previously developed and tested elements, materials, instruments.

"Resource-F2", the second stage in the above subsystem creation was outfitted with the principally novel photographic equipment MK-4 providing for 9-12 m ground resolution for a black-and-white film and 15-18 m for spectral-zonal film.

While in service, the "Resource-F1" and "Resource-F2" satellites passed through several modifications with the view of improving their characteristics. At present, "Resource-F1" is replaced with its updated version "Resource-F1M" with altered onboard equipment.

Alongside with space photography, of importance are space systems for on-line surveillance. For ensuring prompt delivery of information, TsSKB started development of satellites "Resource-DK" and Resource-DK3" for round-the-clock detailed and general supervision with a service period of up to three years instead of the currently used satellites "Resource-F1M" and "Resource-F2"

<u>Creation of space vehicles for research in the field of space technologies and zero-gravity physics</u>

The current task includes reduction of the total sum of all disturbing factors to the minimum. It is special-purpose satellites that meet the said requirement best of all. Among them is the "Foton" satellite designed by TsSKB and being successfully operated nowadays.

For enhancing satellites competitiveness in the given field, TsSKB is developing a new-generation satellite "NIKA-T" on the basis of the previously elaborated technologies.

<u>Creation of space vehicles for investigations in the field of space biology and medicine</u>

The TsSKB-developed satellite "Bion" is intended for fundamental and applied research in the field of space biology, as well as for holding experiments in such spheres as radiation physics and microbiology.

Starting from 1973, the "Bion" satellite was used for conducting versatile investigations with the use of rather unique equipment and instruments and various biological objects: from unicellular organisms to monkeys. In all, over 30 kinds of biological objects have been sent to space

<u>Creation of space vehicles for fundamental and applied research in the field of high energy particles</u>

Research of high-energy particles is related to fundamental one and includes investigation of charge compositions, energy of primary particles and their interaction with substance. For the said purpose, TsSKB developed satellites "Energiya" (1972, 1978) and "Efir" (1984, 1985).

For accounting high-energy particles, the landing apparatus of "Energiya" contained a big (1200 kg) photoemulsion units with. A service life of "Energiya" was not large – just six days, still specialists were of the opinion that it was quite sufficient for getting the required statistical data. The "Efir" satellite was developed on the basis of the "Bion"-type vehicle. The research equipment unit has the mass of 2450 kg and included charge detectors, energy detector and electronics.

Autonomous satellite "Nauka" and research containers

In 1968, the TsSKB specialists created a universal autonomous satellite "Nauka" bearing various equipment of research and applied character. That satellite made it possible to hold complex investigations and obtain unique (for that time) results. In the period from 1968 to 1979, 44 such satellites were manufactured and launched

International cooperation

September 26, 1996 gave birth to the STARSEM Russian-French joint venture (JV) for ensuring commercial operation of the "Soyuz" carrier rockets. The Russian side was represented by the "TsSKB-Progress" Centre and Russian Space Agency, the French side – by the "Aerospatiale" and "Arianespace" firms. The said JV expressed a new approach to the Russian-French cooperation in space. The JV's activity started with elaboration of the "Globalstar" project. Enhancing the "Soyuz" carrier rocket's abilities as concerns ascents and further operations with various useful loads in circular and elliptic orbits (altitude ranging from 250 to 1400 km) required development of the ascent unit.

VII. Number of employee

15000

VIII. Major facilities

The Centre is outfitted with:

- set of benches for strength static testing of structures (maximum axial force 10 kN, inner pressure up to 250 MPa; article parameters: up to 17 m height and up to 4 m diameter);
- set of benches for vibro-dynamic testing (exciting force up to 480 kN at 0-200 Hz frequencies and up to 200 kN at 3-200 Hz frequencies; article parameters: up to 17 m height and up to 4 m diameter, weight being up to 200 kN);
- two-chamber thermal-vacuum complex TVU-400-05 (volume 513 cu.m; article dimensions: 16 m length, 4.2 m diameter);
- set of climatic and thermal vacuum chambers, bench for many-factor impacts (vacuum, cyclically changing temperatures, vibrations, UV radiation);
- optical and mechanical complex OMK 1600 comprising as follows: optical bench with 250 m focal length, simulator of terrain running, Sun simulator, thermal pressure chamber;

- benches "Vector" and "Centaur" for simulation of an orbital flight, and for improvement of information and other channels of the motion control systems.

IX. Commercial proposals

The TsSKB is highly integrated into scientific and technology cooperation on bilateral, multilateral and international basis.

The TsSKB provides a board array of experimental and expert services. The test and experiment facilities are available for the coordinated research within agreed programs and are also subject to separate agreements.

For more details, please refer to i.i. VII “Current major activities and VIII “Major facilities’ of the above document.

⑦グルシュコ開発生産企業「エネルゴマシ」
（モスクワ州ヒムキ市）

I. Name of the Institute (Organization)

In Russian: Научно-производственное объединение энергетического машиностроения им. академика В.П.Глушко

In Russian abbreviation: НПО “Энергомаш”

In English: Glushko Research and Production Association for Power Engineering

In English Abbreviation: NPO Energomash

II. Location

Official address: 1, Burdenko St., Khimki 141140, Moscow Region, Russia

Mail address: 1, Burdenko St., Khimki 141140, Moscow Region, Russia

Telephone number: (095) 572-2200, 575-4000

Fax number: (095) 251-7504

Web-site:

E-mail for representative: energomash@glasnet.ru

Access (transportation, necessary time): Moscow international airport Sheremetjevo-2, half an hour by car

III. History

The Research and Production Association (NPO – Russian abbreviation) ENERGOMASH (joint stock company) is one of Russia's leading organizations engaged in the development of liquid rocket engines (LRE). NPO Energomash started its history since May 15, 1929 when a group for developing promising rocket engines headed by V.Glushko was arranged at the Gas Dynamics Lab (Leningrad). In the early 1930s, that group designed and demonstrated the operation of the first Russian LREs – experimental chambers ORM.

Since 1934, Glushko's team, as a subdivision of the newly established R&D Institute of Jet Engines, continued working at LREs in Moscow. In 1936, LRE ORM-65 was designed which operated on nitric acid – kerosene propellant, had up to 1.72 kN thrust and 2.5 MPa pressure in the chamber and was intended for application in rocket gliders and cruise missiles.

In 1940, LREs development continued in Kazan (at the Aviation Motor Works). In 1946, Glushko's team (which at that time acquired the status of an experimental design bureau – EDB) created the aviation LRE RD-1 which was produced in lots.

Since 1946, Glushko-headed EDB started the development of an LRE for long-range ballistic missiles. After several renamings, the EDB was given its present name – V.Glushko NPO Energomash. The many-year activity of this organization resulted in the creation of over 50 engines on various kinds of liquid propellants for Russian space rockets and missiles.

Engines RD-107 and RD-108 designed at NPO Energomash and using liquid oxygen – kerosene propellant were used on first and second stages of carrier rockets "Vostok", "Voskhod", "Molniya" and "Soyuz" including the launch of the Earth's first satellite and first manned space flight.

The four-chamber LRE RD-170 designed at NPO Energomash in the mid 1980s (for space systems "Energia", "Energia-Buran" and "Zenit") has no analogues in the national and world practice of rocket engine building.

During 50 years of its history NPO Energomash developed a large number of LREs for ballistic missiles and space launch vehicles, including open and closed cycle LREs, operating on hypergolic and cryogenic components. According to NPO Energomash officials, the company developed 53 types of engines, including modifications. Except of traditional components (oxygen-alcohol, oxygen-kerosene, HNO_3/N_2O_4-UDMH, oxygen-hydrogen) NPO Energomash tried such exotic propellants as fluorine with ammonia and high test peroxide with pentaboran. Identified engines, developed by NPO Energomash are listed in the Table 1.

IV. Management

Kind of organization: State Enterprise

Ownership: Joint Stock Company

Responsibly Ministry: Russian Aviation and Space Agency

V. Executives

Dr. Boris I. Katorgin – Director General and General Designer

Dr. Vladimir K. Chvanov – First Deputy Director General and General Designer

Dr. Gennady G. Derkach – First Deputy Director General and General Designer, Director of the Pilot Production Plant

Nikolay F. Korotkov - Deputy General Director for Economy:

A. A. Ganin - Chief and Chief Designer of Privolzhskiy Branch:

Vladimir S. Sudakov - Chief of Department of Information:

Eelena V. Sergeyeva - Press Secretary

VI. Current major activities

Energomash activity include:

- theoretical research in the field of liquid-fueled rocket engines;
- development of liquid-fueled rocket engines for first and second stages of launch vehicles using both hypergolic and cryogenic propellant components;
- development of tri-component liquid-fueled rocket engines;
- experimental work on liquid rocket engine designs, their components and subassemblies;
- expert evaluation of results from testing of units and subassemblies of LREs;

- development of new technologies for the production of liquid rocket engines.
Energomash participates in the following projects, included into the Federal space program:
Fakel - increasing reliability of liquid rocket engines and sustenance of the production of engines;
Baza - maintenance of testing base and tests of liquid rocket engines;
Soderzhaniye - works for increasing reliability and improving performances of liquid rocket engines of various types;
Raspushenka - increase of stability of working process in the chamber of 11D511 PF engine (latest modification of the RD-107);
Vzlet - increase of capability and improvement of ecological safety the Kosmos launcher;
Energia-M - development of a heavy launcher;
Rus' - modernization of the Soyuz launch vehicle (Soyuz-2);
AKS - development of an aerospace transport system;
Condor - development and testing of liquid rocket engines for perspective boosters;
Sapsan - development and testing of tri-component liquid rocket engine (RD-704);
Development-DU - creation of a technological backlog to ensure development of a new generation of propulsion units.
In addition to that, NPO Energomash is also a major drivier for the Riksha project, to use methane as a fuel in space launch vehicle. The Riksha project was authorised by the Government on July 18, 1996 with NPO Energomash appointed the lead developer of engines for it.

At present, NPO Energomash also is making use of experience gained in two directions. The first one consists in the development of a two-chamber engine RD-180 for US rocket "Atlas" and one-chamber engine for Russian rocket "Angara". The second direction includes designing an LRE on three-component liquid propellant.
In cooperation with Yuzhnoe Design Bureau (Ukraine) NPO Energomash works on modernization of the Zenit launcher.
Current development are given in Table 2.

VII. Number of employee

total employment - 3600 (2500 workers, 800 engineers and technicians, 300 of managing personnel)

VIII. Major facilities

NPO Energomash possesses a total of 83 test stands, 4 fire stands for comprehensive testing of rocket engines and engines components.
Testing facilities includes stands for complex fire tests of engines, as well as stands for autonomous testing of various engine elements, from injector units to the powerful gas turbines. There are

- two unique test stands for fire tests of engines with a thrust of up 1000 tons, equipped with automated systems of the engine control, automated control and measuring complex, capable of simultaneous recording and processing of about 1000 parameters of the engine and the test stand, and special storage tanks for propellant components. These stands are located just about 800 meters away from residential blocks of Khimki. This stand is visible for its 100 meters high, 16 meters dia dissipation tube, intended to dump noise and dilute exhaust plume with water.
- a group of the unique test stands for "cold flow" testing of centrifugal pumps and regulating units, using water or mineral oil. The automated system of recording and processing of testing results permits to obtain the information about characteristics of units immediately during the testing.

Partial list of testing facilities

- Pneumostands for static tests;
- Pneumostands for dynamic tests (blow-through) of control units with air (nitrogen);
- Stands for static and dynamic tests of units with liquid oxygen and nitrogen;
- Universal stands for static and dynamic tests of units and assemblies with hydrocarbons;
- Stands for hydrodynamic tests of the pumps, development and running-in of the multiplicators;
- Pneumostands for gas dynamic model tests of gas turbines;
- Stands for gas dynamic tests of units with modeling gas and for thermocyclic tests;
- Stands for hydrodynamic tests of regulators, hydraulic throttles, stabilizers, turbine flowmeters, injector (and other spraying devices), hydroturbines;
- Stands for tests of rolling bearings and shaft seals with simulation of axial and radial loads;
- Stands for static tests of seals and hermetics in simulators of connections;
- Stand for tests of lubricants, rubber products, hermetics for resistance to hydrocarbons and their vapours;
- Stands for materials friction tests;
- Stand for testing internal combustion engines engine power;
- Stand for heat exchange studies;
- Complex of vibration stands.

There is also the special metrological service of the test facilities, departments of which develop and certify methods of measurements, implement metrological control over the work of the test stands, carry out the maintenance, examination and repairs of the primary converters.

IX. Commercial proposals

The following themes are suitable for future cooperation:

- Independent or joint creation of novel LREs for foreign rockets at all development stages (designing, manufacture of prototype models, refinement, lot production).

- Development (probably joint) of LRE projects for foreign rockets.
- Critical analysis of separate design and engineering decisions concerning foreign LREs.
- Use of SPA ENERGOMASH production and experimental bases for manufacture and testing of assemblies and elements of foreign LREs.
- Development of separate assemblies and elements for foreign LREs.
- Participation in the selection of concepts of novel LREs for foreign launch vehicles operating on different propellants.
- Participation in the expert's analysis of emergency situations on foreign LREs with the issue of proposals concerning elimination of defects in design of assemblies and technology of their manufacture.

⑧イサーエフ化学エンジニアリング設計研究所
(モスクワ州コロリョフ市)

I. Name of the Institute (Organization)

In Russian: Конструкторское бюро химического машиностроения им. академика А.М.Исаева

In Russian abbreviation: КБ ХИММАШ

In English: Isaev Design Bureau for Chemical Engineering

In English Abbreviation: DBCE

II. Location

Official address: 2, Lesoparkoviy Tupik, Korolev 141070, Moscow Region, Russia

Mail address: 2, Lesoparkoviy Tupik, Korolev 141070, Moscow Region, Russia

Telephone number: (095) 513-4413

Fax number: (095) 516-8001

Web-site:

E-mail for representative:

Access (transportation, necessary time): Moscow international airport Sheremetjevo-2, one hour by car

III. History

The Isaev Design Bureau of Chemical Engineering is a leading Russian organization for developing and testing liquid rocket engines (LRE), propulsion systems and liquid rocket engines of small-thrust. DBCE is among the Russian Aviation and Space Agency enterprises.

DBCE has created over 120 kinds of LREs, propulsion systems and small-thrust LREs which have made great contribution in practically all spheres of rocket and space engineering: aviation; missiles of sea and land basing; airborne and antiaircraft missiles, meteorological rockets, space vehicles for outer space exploration, manned spaceships and orbital stations.

The DBCE history originates from February 4, 1943 when the Design Office headed by aircraft designer V.Bolkhovitinov founded a subdivision for developing LRE for a high-speed close combat interceptor BI. That subdivision with five staff members was headed by Alexei M. Isaev (1908-1971). Initially A.Isaev's team developed the above BI aircraft of L.Dushkin's design, and since December 1943 started developing LRE of own design with displacing feed of propellant "nitric acid – kerosene". December 1944 marked the start of official tests of that engine which was named RD-1.

The RD-1 modification – RD-1M – had an original construction. Contrary to the known engines of that period featuring a conical-shape injector head, in the RD-1M engine for the first time use was made of a flat head ensuring a more uniform propellant distribution over the combustion chamber section and a better mix formation of propellant components. That was facilitated by using (also for the first time) a rational scheme of injectors location on the head (checkerboard and honeycomb patterns). RD-1M had curtain cooling of the combustion chamber's firing wall with the help of a special peripheral row of injectors. Flight tests of RD-1M as part of the BI aircraft took place in January-March 1945.

A.Isaev's great contribution into the LRE development was solving the problem of durability and rigidity of shells of the combustion chamber and nozzle. Since the early 1945, A.Isaev' team working as part of the Research Institute of Jet Engines was engaged in the development of several new articles – LRE for aircraft accelerator SU-1500, flight model of a supersonic aircraft created at M.Bisnovat's design office, marine torpedo, "air-sea" missile and antiaircraft missiles. Engines U-1250 were first to use power communication between the firing wall and the outer jacket of the combustion chamber and nozzle. The first specimen of the above engine which initiated national developments of high-power LREs demonstrated in July – September 1946 remarkable (for that time) specific impulse and specific mass characteristics. Starting from that moment, in all constructions created by A.Isaev's office and by other engine-making designers primary attention was attached to improvement of the scheme with coupled shells.

In the late 1946, Isaev's team was entrusted to develop a 8-tf thrust LRE for the guided anti-aircraft missile of S.Lavochkin's design. The said engine development was accompanied with a number of problems concerning high-frequency instability in the combustion chamber bringing about explosions at starting and during first seconds of operation.

In 1948, Isaev' design bureau (DB) was attached to the generally established head institute of rocket engineering No 88 in Kaliningrad (near Moscow) where the work at the eight-ton engine continued and was successfully finished in September 1950. For ensuring the engine serviceability, Isaev suggested to part the combustion chamber head into several smaller sections by means of the so-called "cross" – partitions with 100-mm height welded to the injector bottom of the chamber. That decision was later grounded and recognized as an effective means for elimination of high-frequency pressure oscillations in the combustion chamber.

In 1950-52, Isaev supervised the creation of the USSR's first gas generators operating on a two-component propellant with large surplus of fuel or oxidizer which found wide application in displacing systems of propellant delivery, for actuation of turbines in turbine-pump assemblies (TPA) and pressurization of propellant tanks, as well as in closed-scheme LREs suggested by Isaev as long ago as 1947.

Successful work at the 8-t engine opened the way to more powerful LREs and made it possible to created the first ballistic rocket R-11 of S.Korolev's design on long-storage propellant components and its mobile version – R-11M transported in a filled state. The updated rocket R-11FM with the above engine was the starting point for creating submarinebased ballistic missiles equipped with engines and propulsion systems developed by Isaev' team.

In the first half of the 1950s, DBCE develops various LREs, among them being ones for anti-aircraft and ballistic rockets, as aircraft accelerators. In 1954 DBCE starts working at LRE with turbopump feed of propellant components. In 1957 Isaev made use of non-detachable (welded) connections of engine assemblies and thus completed the development of first all-welded LREs.

Since 1959, DBCE gets involved in the development of engines for space vehicles. In the 1960s, it gave birth to quite a family of LREs and propulsion systems for combat, rocket and space engineering including propulsion systems of all liquid anti-aircraft and cruise missiles designed by S.Lavochkin, P.Grushin, A.Berezniak, stages of marine ballistic missiles constructed in V.Makeev's DB and carrier rockets developed in M.Yangel's DB, braking and correcting propulsion systems of spaceships "Vostok", "Voskhod", "Soyuz" and orbital lunar vehicle of the rocket and space complex N-1/L-3 (S.Korolev's DB), propulsion systems for space vehicles "Luna", "Venera", "Mars", "Zond", "Molniya", "Polyot", "Cosmos", orbital stations "Salyut", etc.

The distinguishing feature of DBCE-designed LREs in that period was the turbopump system for feeding long-storage propellant components to the combustion chamber under high pressure. For low- and medium-thrust engines (propulsion systems of space vehicles) the open scheme was applied, for large-thrust LREs (propulsion systems of marine ballistic missiles) use was made of the closed scheme, with afterburning of the spent generator gas in the main combustion chamber. Besides, DBCE was developing low-thrust LREs as actuators of control systems of space vehicles.

Apart from the aforementioned, since the early 1960s DBCE worked at a high-efficient oxygen-hydrogen LRE for the upper stage of the rocket and space complex N1-L3M which became the prototype of the KVD-1 engine – the backbone for a methane LRE.

IV. Management

Kind of organization: State Enterprise

Responsibly Ministry: Russian Aviation and Space Agency

V. Executives

Dr. Nikolai I. Leontev – Director and Chief Designer

Yevgeniy P. Seleznyov – First Deputy Director and Chief Designer responsible for Foreign Relations

VI. Current major activities

Beginning from 1971, there were constructed 11 types of 0.6-225-kgf thrust engines for accurate orientation, stabilization and correction of spacecrafts' orbit operated on two-component self-igniting fuel, and 8 types of 0.5-5-kgf thrust engines operated on one-component fuel. These engines are widely applied in multipurpose spacecrafts, as well as in separation stages of BSMs' forebodies. Now, in order to improve their parameters, the said engines are being updated and standardized. In the DOT-5 and DOT-25 one-component fuel engines, there used the thermocatalytic decomposition of hydrazine on wire catalyst pre-heated by an electroheater up to min 350 °C. In the DOT-10 and DOT-50 engines, the catalytic decomposition of hydrazine is used. The applied iridium-based catalyst provides switching on without preliminary electric heating. In order to improve and stabilize dynamic and power parameters, the DOT-10 and DOT-50 engines are equipped with an electroheater which increase pre-operational catalyst temperature. Together with high thrust and power parameters, the one-component fuel engines have a transparent jet flame ensuring reliable operation of on-board astrophysical instruments.

Low-thrust two-component engines (DST-25, DST-100, DST-100A, DST-200, DST-200A, DMT-600) operate on conventional fuel components: nitrogen tetroxide and asymmetrical dimethylhydrazine. These engines are charactarized by stable parameters, efficiency, high-speed response, multiple switchings, their duration being from hundred parts of a second to hundred thousands seconds. Trouble-free operations and high parameters are provided by the radiation and internal film cooled combustion chamber made of niobium alloy with a protective layer. The DMT-600 engine with the ablation-cooling combustion chamber (as well as with internal cooling) has shown high power-to-weight parameters utilizing both a conventional fuel and monomethylhydrazine applied abroad.

The engine's specifications are given below.

Characteristics	DST-25	DST-100	DST-100A	DST-200	DST-200A	DOT-5	DOT-25	DOK-10	DOK-50
Nominal thrust, N	25	100	100	200	200	5	25	10	50
Fuel: Oxidizer Fuel	N_20_4 UDMH	N_20_4 UDMH	N_20_4 UDMH	N_20_4 UDMH	N_20_4 UDMH	hydrazine	hydrazine	hydrazine	hydrazine
Mixture ratio	1.85	1.85	1.85	1.85	1.85				
Specific impulse, N×s/kg	2790	2705	2980	2750	2940	2255	2300	2250	2250
Nozzle area ratio	45	43	100	43	100	60	55	46	42
Component inlet pressure, MPa	1.5	2.5	1.6	2.5	1.6	1.2	1.5	1.5	1.5
Combustion chamber pressure, Mpa	0.8	1.5	0.77	1.5	0.7	3.8	4.5	1.5	1.5

Duration of a single burn, s Minimum Maximum	0.03 4000	0.05 300	0.05 4000	0.05 300	0.05 4000	0.05 8000	0.05 6000	0.05 600	0.05 600
Total operation time, s	25000	10000	50000	5000	10000	120000	25000	1500	1500
Number of burns	300000	10000	450000	10000	100000	55000	6000	4000	4000
Electric power consumption of electric valves, W	15.8	10.8	34.2	21.6	34.2	15.8	7.9	7.9	16.2
Electric power consumption for heating of reactor before series of pulses, W						60	70	40	20
Mass, kg	0.9	1.1	1.5	1.3	1.7	0.9	1.3	0.6	1.1

Characteristics	DMT-400	DMT-500	DMT-600	DMT-600A	DMT-2200
Rated thrust, N	400	500	600	600	2200
Propellants Oxidizer Fuel	N_20_4 UDMH (MMH)	N_20_4 UDMH (MMH)	N_20_4 UDMH (MMH)	N_20_4 UDMH	N_20_4 UDMH
Mixture ratio	1.85 (1.65)	1.85 (1.65)	1.85 (1.65)	1.85	1.95
Specific impulse, N×s/kg	2825 (2865)	2776 (2815)	3090 (3139)	2894	2992
Nozzle expansion ratio	15.2	11.2	250	46	50
Propellant inlet Pressure,MPa	1.65 (1.6)	1.65 (1.6)	1.65 (1.6)	1.65	25
Combustion chamber Pressure, MPa	0.9	0.9	0.9	0.9	1.8
Duration of a single burn,s minimum/maximum	0.05/1500	0.05/1500	0.05/1500	0.05/1500	0.5/210
Total operation time,s	50000	50000	500000	5000	450
Number of burns	100000	1000000	100000	2000	750
Weight, kg	2.4	2.4	6.5	4.2	6.6
Dimension, mm	318x75x75	318x75x75	693x335x335	406x150x150	506x212x212

Cryo engine is used in oxygen-hydrogen booster stage (OHBS). The engine is one of the latest modification of cryo engines, that were developed since 1960. The engine includes one combustion chamber and turbopump supply system; the scheme of the engine provides afterburning fuel rich gas generator gas in combustion chamber. Combustion chamber and gas generators with regenerative cooling, one shaft turbopump (TP) with one stage oxygen and hydrogen centrifugal two-stages pump and one stage turbine are used in the engine. The thrust and mixture ratio control are provided by the throttles with electric actuators, that change the oxygen flow in combustion chamber and gas generator. Start-up/shut-down of the engine are

provided by control units, that are operated by helium from electro-pneumo valve assembly (EPVA) of OHBS. Pyrotechnic devices provide propellant's ignition in combustion chamber and gas generator. Cryo engine includes some units of precooling, OHBS tanks pressurization and conservation system.
Other modifications of this engine are planned to use in promising BB of the updated "Proton" CR, and heavy-category "Angara" CR that is under development.

In the period from 1994 to 1997 the design office was engaged in R&D relating to the closed-cycle LRE development, using liquid oxygen and liquefied natural gas as fuel components.

As a result of the activities an engine manufactured according to the scheme envisaging afterburning of generator gas (with fuel excess) installed downstream of the turbine has been developed. The engine was developed on the basis of the RD-56 oxygen-hydrogen engine available (with finishing off the oxidizer pump). The engine has been equipped with a system of multiple restarting. The natural gas and liquid oxygen piloting chamber with a small thrust has been developed, as well.

In August, 1997 the engine testing was realized (at Research Institute for Chemical Engineering in Sergiev Posad) - i.e. one actuation of the engine for 27 seconds occurred. The program of testing was successfully implemented and no defects in the engine after the testing was revealed. A series of the piloting chamber actuations was realized (5 actuations of 250 seconds total duration). The program of the tests was also successfully implemented.

VII. Number of employee

Number of employee: 2500

VIII. Major facilities

The Test Base is located in the territory of the DBCE in the town of Korolev, and its affiliate in the settlement of Faustovo, 70 km to the South of Moscow.

N	Purpose of benches and laboratories	Number
1.	Firing tests of LPEs, LTLPEs and their assemblies with altitude conditions simulation using actual units	27
2.	Firing tests of EPs using actual units	3
3.	Firing tests of solid-fuel units	3
4.	Pneumovacuum, hydraulic and gas-dynamic benches for blowdown firing tests of LPEs, LTLPEs, EPs and their assemblies on model units	48
5.	Vibration-dynamic tests of LPEs, LTLPEs, EPs and their assemblies	7

IX. Commercial proposals

The following priority areas and aspects should be defined to establish contacts between the foreign companies and the Design Bureau of Chemical Engineering to ensure peaceful space investigations:

- Efforts to design and to develop an engine or its separate elements running on ecologically safe cryogenic components on the basis of the available research and development studies including the positive results of the experimental efforts dealing with a closed-loop 6 ton thrust engine running on liquid oxygen-liquefied natural gas (methane) and equipped with a turbopump system to supply components to the combustion chamber;

- Efforts involving application of hydrazine as a fuel and of nitric tetroxide as an oxidizer for a 400 kg thrust engine and for up to 2000 kg thrust one to use hydrazine as a monofuel with monofuel catalyst decomposition;

- Efforts to design, to develop and to sale open-loop 2000 kg thrust engines and its elements (design and development of a turbopump, high-temperature insulation coating of combustion chamber) running on the ecologically safe components;

- Efforts to design, to develop and to sale high energy pulsed 0.5-600 kg thrust engines including the following:

- design and development of microengines running on ecologically safe components: oxygen-methane, oxygen-hydrogen;

- elaboration of procedures of high-temperature heat-resistant coating of combustion chamber;

- Efforts to design and to develop (and to sale) starting-cutting off and loading devices, reducers and other devices and elements to be installed on long-term stay space vehicles;

- All possible efforts to design and to develop liquid powered boosters including firing and cold try-out and research tests.

The Design Bureau of Chemical Engineering, for its part, is ready to take part in joint activities to develop oxygen-methane technologies. Besides, the DBCE has accumulated a vast experience in design and development activities including the initiative ones (for example, design and development of low thrust LRE for reaction control system for HERMES French designed small-capacity orbital aircraft) owing to its involvement in the essential Russian-Indian project to design and to develop 12KBR cryogenic powered boosting module for GSLV Indian booster and owing to the activities to ensure and to support operation of MKS international space station. DBCE may offer efficient cooperation covering wide range of the technologies of LREs and of their components and units.

⑨ フルニチェフ宇宙研究所
(モスクワ州)

I. Name of the Institute (Organization)

In Russian: Государственный космический научно-производственный центр им. М.В.Хруничева

In Russian abbreviation: ГКНПЦ им.М.В.Хруничева

In English: Khrunichev State Research and Production Space Center

In English Abbreviation: Khrunichev State Space Center

II. Location

Official address: 18, Novozavodskaya St., 121087, Russia

Mail address: 18, Novozavodskaya St., 121087, Russia

Telephone number: (095) 145-8535

Fax number: (095) 142-5900

Web-site: http://www.khrunichev.com

E-mail for representative: see on Web-site

Access (transportation, necessary time): Moscow international airport Sheremetjevo-2, two hours by car.

III. History

It is generally acknowledged that the Khrunichev State Research and Production Space Center was founded on April 30, 1916 when the Russo-Baltic Plant in Riga made the decision to build an automobile-making plant in Moscow. The basic shops were constructed in the period from 1916 and 1921. Attempts to start production process in the course of construction were a failure. In 1921, the plant was passed to the Armoury Department of the Russian Red Army for repair of tanks and armoured cars. However, in 1923 the Russian Government made the unexpected decision about liquidation of the plant and transfer it to the Junkers company (Germany) on concession terms. It seemed that invitation of such a renowned firm with its great experience, highly qualified personnel, advanced technologies and equipment should promote development of Russian aircraft industry. But it turned out that the Junkers firm, taking advantage of the cheap workforce in this country, just assembled four-seat aircraft J-20 and J-21, primarily from Germany-supplied parts. As a result, in 1926 the concession agreement was cancelled, and in the early 1927 the plant's capacities laid the basis for establishing the pioneer of the national aircraft industry – plant No. 22. From that time on, the enterprise was producing military and civil aircraft designed by A.Tupolev (ANT-3, ANT-5, TB-1, ANT-6, ANT-7, ANT-9, ANT-35, Tu-2, Tu-4, Tu-12, Tu-14), S.Ilyushin (Il-4), A.Arkhangelsky (high-speed bomber SB), V.Petliakov (Pe-2), V.Miasishchev (M-4, 3-M, M-50), as well as helicopters to M.Mil's design (Mi-6 and Mi-8)

In the period from 1955 to 1960, simultaneously with the construction of aircraft, the Plant fulfilled various governmental orders as concerns arrangement of lot production of rocket 205 and aerials for rockets flight control systems. In the 1960s, the Plant changed not only the profile (it started manufacture of rockets) but the name as well and since then it was called the Khrunichev Machine-Building Plant. The Plant's first article was the universal-type rocket R-200 designed under the supervision of Constructor-General V.Chelomei. Parallel to the manufacture of the UR-200 rocket, the Plant produced the launching device and the transport-and-mounting facility for the above rocket. In 1963-64, nine launches of the said rocket took place. However, further work at the UR-200 rocket was terminated, and the Plant was entrusted with the development of the fighting rocket complex known as RS-10 with a small-size rocket UR-100. The above complex was created in accordance with the single-start scheme and comprised ten separate launch positions with shaft launchers and the control center. For ensuring high readiness of rockets they were kept fuelled. Application of liquid fuels for the UR-100 rockets demanded solving the most complicated problem – long-term (from 7 to 10 years) keeping of fuelled rockets. The first launch of UR-100 took place on April 19, 1965. In July 1967, the RS-1-0 complex was placed in service. Batch production of the above rockets was arranged at the Khrunichev Plant. Later those rockets were also manufactured at the Orenburg Machine-Building Plant and Omsk Aircraft Plant. In total, over a hundred of RS-100 complexes were produced.

Improvement of the above complex characteristics never stopped. As a result, specialists made up designs for updated complexes RS-10 with UR-100M and UR-100K rockets noted for the separating head section. The period from August 1969 to March 1971 witnessed 30 launches of the UR-100K rockets which further became one of the most efficient specimens of the rocket weaponry.

In the early 1970s, the Plant started the work at the RS-10 complex with the UR-100U rocket. Within a short period the such a complex became an integral part of strategic armed forces.

For further enhancement of the national defense and because of necessity to pass over to the third-generation rockets with individual guidance fighting units, the Plant was entrusted with development and creation of the RS-18 complex with the UR-100N rocket. Flight testing of that complex carried out from April 1973 till December 1975 (25 launches) fully confirmed the rated tactical and engineering characteristics. Deployment of the said complex came along with creation of its more protected modification with the UR-100UTTKh rocket. The complex passed flight tests in the period from December 1977 to June 1979.

<u>Creation of the "Proton" launch vehicle (LV)</u>

Development of the heavy-duty launch vehicle UR-500 (later called "Proton") started in the second half of 1961. It should be noted that designing and manufacture of such rockets was carried out in this country for the first time, and some engineering solutions, e.g. layout of the 1st stage had no analogues the world over. While arranging the production process, specialists attached special attention to wide use of machine welding for ensuring the required quality of joints and air-tightness. Worth mentioning is the fact that during its first launch the UR-500 launch vehicle injected into orbit actual payload instead of prototype one. On July 16, 1965, the above rocket was used for placing in the near-earth orbit the research satellite "Proton" (later that name was also given to the LV). The launch of the "Proton-1" satellite was followed by respective launches of similar satellites: "Proton-2" (02.11.1965), "Proton-3" (06.07.1966), "Proton-4" (16.11.1966). Within the given period, the Plant developed and manufactured three first stages of the LV. The Korolev's Design Bureau made use of the 5th stage of the LV N-1 for developing the booster unit "D" as the 4th stage. During two years specialists created the three- and four-stage versions which are called "Proton-K". The rocket flights started in 1967 and by the present day over 250 launches of the LV "Proton" have been carried out. The Khrunichev Plant has all necessary equipment and facilities for producing rockets, provided it receives primary materials as sheets, profiles, forged pieces, etc., as well as engines and electronic units. The Plant also effects servicing of the "Proton" rockets during all periods of operation and maintenance. Nowadays, the Plant's capacities allowing to produce 20 carrier rockets annually are not used to the full. Annual number of launches from the Baikonur cosmodrome makes up 13 which is far from the admissible limit.

Creation of inhabited orbital stations

Since 1965, the Plant's specialists jointly with their colleagues from the Scientific and Production Association of Machine-Building (Reutov, Moscow Reg.) started development of an inhabited orbital station (IOS) "Almaz". In 1969, the Khrunichev Plant initiated the production of IOS sections. However, in 1970 the Government made the decision to create a long-term orbital station with rotary crews. For constructing such a station during a short period, it was suggested to make use of the ready-made sections and furnish them with units and systems intended for the "Soyuz" space vehicle. The manufacture of an orbital station called later "Salyut" began in February 1970. The station's basic elements (body, propulsion module, pneumatic equipment, electrical equipment, etc.) were manufactured in the shortest terms, and the station as a whole was assembled during 45 days. "Salyut" was launched on April 19, 1971 by means of the "Proton" carrier rocket. It was in orbit till October 11, 1971.

"Salyut-2" station was launched on July 27, 1972 but because of an accident with the "Proton" carrier rocket failed to orbit. The "Salyut-3" station had a modified construction. It was launched on March 11, 1973 but after orbiting the fuel reserves got exhausted and the decision on its submersion was taken.

Simultaneously with development of long-term orbital stations, the Khrunichev Plant was also engaged in assembly and testing of the first inhabited orbital station "Almaz" ("Salyut-2") developed by Chelomei's Design Bureau of machine-building. The station's testing was finished by the early 1973, and on April 3, 1973 it was placed in orbit. However, because of the body depressurization, soon the station's service life ended. The next inhabited orbital station "Almaz" ("Salyut-3") of enhanced reliability was launched on June 25, 1974. As it was planned. Its flight continued for seven months.

The "Salyut-4" station differing only slightly from "Salyut-3" by design was in orbit till February 3, 1977 and became the place of work for two expeditions.

The next station made at the Plant – "Salyut-5" – was launched on June 22, 1976.

Development of a new-generation orbital station was entrusted to the "Salyut" Design Bureau (Chief Designer D.Polukhin) and Khrunichev Machine-Building Plant (Director A.Kiselev). The novelty of the task included the necessity of installing one more docking unit which could make it possible to refuel the station, effect crew replacement in case of uninterrupted piloting, ensure simultaneous docking of the "Soyuz" and "Progress" spaceships, provide for an opportunity of exits into outer space for emergency repair operations. Actually it was necessary to design quite a novel station with new layout, transfer compartment and transfer chamber, fully changed interiors, etc. The "Salyut-6" station was launched on September 29, 1977. During all five years of its servicing, crews consisting of two to five astronauts worked there, replacing each other. On July 29, 1982, the station's flight program was fully implemented, and its life came to an end.

The next second-generation station manufactured at the Khrunichev Plant was "Salyut-7". It was launched on April 19, 1982 and stopped functioning on February 7, 1991.

The use of transport satellites of the "Kosmos" series became an important stage in maintaining the "Salyut-6" and "Salyut-7" stations in operative conditions. Four of them – "Kosmos-929", "Kosmos-1267", "Kosmos-1443" and "Kosmos-1686" – were made at the Khrunichev Plant. The flight of "Kosmos-929" lasted from July 17, 1977 to February 3, 1978. "Kosmos-929" was equipped with a recoverable vehicle which returned to Earth after a month's flight. In contrast to the above satellite, not envisaging docking with the orbital station, "Kosmos-1267" had such an opportunity but without inner transfer to the "Salyut-6" station. "Kosmos-1267" was also equipped with a recoverable vehicle which landed on Earth simultaneously with the "Salyut-6" station after 30 days of flight. "Kosmos-1443" operating jointly with "Salyut-7" with inner transfer to the station also had a recoverable vehicle which returned to Earth 5.5 months after the launch. The flight of "Kosmos-1686" which instead of a recoverable vehicle was equipped with a set of research instruments and had inner transfer to the "Salyut-7" station lasted from September 27, 1985 to February 7, 1991.

Transport satellites consisting of a cargo module and recoverable vehicle were launched by means of the LV "Proton". Transport satellites were outfitted with docking attachments allowing orbital docking of space vehicles of large mass and dimensions. Such a docking system ensured more than eight-year functioning of the "Salyut-7" orbital station in the near-earth orbit. Thus, transport satellites were not only space tugs and trucks but also served as additional working modules of the orbital complex.

Among vehicles developed and fabricated at the Khrunichev Plant are special apparatuses for the LV "Proton" being used for flight testing of recoverable vehicles. From July 5, 1977 to May 23, 1979, four launches were made, each injecting in orbit two recoverable vehicles. Recoverable vehicles inside the above special apparatus were located in a tandem order, the upper vehicle being outfitted with the emergency brake engine. Launches of those apparatuses helped greatly in improving designs of recoverable vehicles of the "Almaz" system. One of such vehicles was launched twice.

Creation of the "Mir" orbital station

In the summer of 1979, when the "Salyut-7" station was still in orbit, the Scientific-and-Production Association "Energiya" (now Rocket Space Corporation "Energiya") made the decision to initiate joint development of the third-generation orbital station "Mir". The "Energiya" Association was to act as a head organization. The "Mir" station together with the transfer compartment and five docking units was entrusted to the Khrunichev Plant. Up to April 1885, "Energiya", Khrunichev Plant and "Salyut" Design Bureau were engaged in the assembly of the "Mir" station and manufacture of its power-driven prototype.

It took almost a year to prepare the "Mir" station and LV "Proton" for flight. The station was launched on February 20, 1986.

In 1981, the decision was made on creating the experimental module "Kvant" for joint operation with the "Salyut-7" station. Later another decision was taken. According to it, instead of "Kvant" a transport satellite was launched to the "Salyut-7" station. As to the "Kvant" module, it was on March 7, 1987 sent to the "Mir" orbital station and docked to it.

Starting from 1983, specialists from the "Salyut" Design Bureau in association with their colleagues from the Khrunichev Plant were working at the "Kvant-2" module which was launched on November 26, 1989. It had motion control systems applying powered gyroscopes, power supply systems, novel air-producing and water-regenerating systems, and a great amount of research equipment including the controlled swinging platform, photometric and spectrometric equipment.

Development of the "Kristall" module was carried out simultaneously with the work at the "Kvant-2" module. "Kristall" was outfitted with a whole set of equipment for obtaining materials with new properties in space conditions. The draft plan and design documentation were prepared at the "Salyut" Design Bureau in the specified terms whereupon the Khrunichev Plant started the module fabrication. The "Kristall" module was launched on May 31, 1990 by means of the LV "Proton" and on June 10, 1991 it was docked with the "Mir" orbital station.

The "Spektr" module initially designed for the Ministry of Defense was manufactured at the M.Khrunichev Pant in 1991. However, because of the absence of the required equipment, it could not be used. In 1993, after talks with NASA, the decision was made to outfit the said module with additional solar cells and mount there US-made research equipment. After the operating and design documents had been prepared, the above equipment mounted and electrical and other tests conducted, the "Spektr" module was launched. It occurred on May 20, 1995, and six days alter it was docked with the "Mir" station.

The next module fabricated at the Khrunichev Plant was "Priroda" . Similar to "Spektr", the "Priroda" module passed through major alterations and renovations including replacement of solar cells. The module was launched on April 23, 1996, and its docking with the "Mir" station finished the assembly of the world's largest orbital complex.

The rich history of the Khrunichev Plant comprises almost unknown events, for example, creation of the world's biggest satellite "Polyus" (mass about 100 t) which was launched by the "Energiya" carrier rocket on May 15,1987 but not placed in orbit because of a failure of the propulsion system.

Creation of automatic non-piloted orbital stations "Almaz" was an important step in the progress of space vehicles. The first of them ("Kosmos-1870") was in orbit from July 25, 1987 to July 30, 1989. High-quality radar images of the Earth surface obtained were used for the needs of the national economy and defense. The "Almaz-1" station functioning in orbit from March 31, 1991 to October 17, 1992 was outfitted with the updated radar allowing to get high-resolution images of Earth.

In 1992, the Khrunichev Plant in association with the Daimler Benz Aerospace firm (then called ERNO) won the contest of the German Space Agency concerning creation (within the EXPRESS project) of a space vehicle with a recoverable capsule as the most important component part. The common German-Japanese project EXPRESS envisaged a number of experiments in orbit and in the course of the recoverable capsule's motion in dense atmospheric layers, as well as delivery of the experiments data to the Earth. The light-duty satellite "Express" developed and fabricated at the Khrunichev Plant is intended for the above experiments. It is made as a modular unit and consists of the recoverable capsule and the service module. The recoverable capsule is to locate research instruments and deliver them to Earth after finishing the exploration program and investigation of processes occurring during the capsule motion in the dense layers of the atmosphere. In January 1995, the EXPRESS satellite was launched at the Kagoshima Space Centre's polygon by means of the Japan-made carrier rocket M-3SII-8 but was not orbited because of the 2nd stage failure.

Khrunichev Plant's participation in creation of the international space station (ISS) seems quite natural. The Plant is the main manufacturer of the Russian segment of ISS. It developed and produced the ISS' first element – power module "Zaria". Though by its dimensions and basic structures it is similar to the already functioning modules "Kvant-2" and "Kristall", thanks to the composition of equipment, life-supporting and power-supply systems "Zaria" represents a new generation of such engineering systems.

The "Zaria" power module is responsible for receipt, storage and delivery of fuel within the common pneumohydraulic system including the service module and transport spaceships and can be used for installation of research, experimental and other special-purpose equipment and as a storage point for supplies and reserve equipment. The "Zaria" power module shall become the basis for creating heavy-duty transport modules for the ISS' Russian segment. The service module is to locate onboard systems ensuring flight program and functioning of research equipment and instruments. It also locates life-supporting systems for a three-person crew, systems of motion and spaceborne complex control, power supply system, means of communication via satellites-retransmitters. In 1997, the Khrunichev Plant started the work at the next Russian element of ISS – universal docking module. In the future the said module shall be used for linking research and life-supporting modules, as well as the docking and airlock module. The module's inner part will be used for placing gyro sensors for the station's orientation system, scientific equipment and instruments.

On July 12, 2000, the LV "Proton" delivered the service module "Zvezda" to ISS. The said module manufactured at the Khrunichev Plant and being the basic one in the Russian segment of ISS shall ensure the activity of a crew numbering from three to six persons, as well as control over the station with a regularly changing configuration. Within the ISS project, the "Proton" rocket will be used as the main transport system from the Russian side.

Because of the hard economic situation in Russia, in 1993 the Khrunichev Plant and "Salyut" Design Bureau united into the State Research and Production Space Center which was legalized by the special decree of the RF President. Such an action allowed the Khrunichev Center to participate more efficiently in international projects and start rendering services as concerns launch and ascent of foreign satellites (Astra-1F, Inmarsat, Loral, Panamsat, Ecostar, Asiasat, Garuda, Iridium).

IV. Management

Kind of organization: State Enterprise

Ownership: State Property of RF

V. Executives

Anatoly I. Kiselev – Director General

Alexander A. Medvedev – First Deputy Director General

Anatoly A. Kalinin – Deputy Director General, Director of the Space Rocket Plant

Anatoly K. Nedaivoda – Deputy Director General, General Designer of the DB ”Salyut”

Igor S. Dodin – Deputy Director General, Director of the Test and Operation of Rocket&Space Technique Plant

Yuri L. Arzumanov – Deputy Director General, General Designer of DB “Armatura”

Alexander V. Lebedev – Deputy Director General for External - Economy Relations
Vitali N. Popov – Deputy Director General for Economy
Eugeny M. Karachenkov – Deputy Director General for Personnel
Alexander P. Artemenko – Deputy Director General for Capital Investments
Alexei V. Emyushev – Deputy Director General for Social Matters
Alexander I. Eretichenko – Head of Security Services

VI. Current major activities

Main trends of activity

1. Using the LV "Proton" for launching foreign communication satellites

Starting from April 15, 1993, all contracts on using the "Proton" rockets are effected via the International Launch Services joint venture.

2. Participation in creation of the International Space Station.

Being one of the main partners in the ISS project, the Khrunichev Centre in association with the Boeing company has developed and manufactured the "Zaria" power module and the service module. The Center was responsible for design, development, fabrication, testing and delivery of the above modules to the Baikonur cosmodrome, as well as for supply of spare parts, simulators and equipment for ground training of personnel.

3. Updating of the LV "Proton-M"

The "Proton-M' updating shall not relate to overall dimensions, design of the body and engine characteristics. The main alteration consists in replacement of the obsolete control system with the one using onboard computer. Besides, it is planned to apply controlled descent of accelerators and increase the size of head fairings.

4. Creation of the LV "Angara"

Since efficiency is the basic criterion for new-generation carrier rockets, specialists from the Khrunichev State Space Center spare no efforts to follow it while developing the new Russian heavy-duty LV. The main condition is application of oxygen-hydrogen propellant in the 2nd stage and in the accelerating engine. Thanks to the fact that the cost of hydrogen makes up less than 1 % of the launch costs, this shall ensure stable gain (30-35 %) in the ascent costs per unit. For the 1st stage it is planned to use RD-174, one of the best and generally acknowledged engines (740 t thrust), for the 2nd stage, hydrogen-oxygen engine RD-0120. Besides, while developing the "Angara" rocket, specialists are going to make use of the universal welding equipment and experience gained during manufacture of large-size tank compartments for the "Proton" rockets and "Mir" station. At present, the draft design is ready, and the Centre's specialists started preproduction operations.

5. Oxygen/Hydrogen Upper Stage

The Khrunichev State Space Center is developing an oxygen/hydrogen upper stage for modernized launch vehicle “Proton M”. Creation of the oxygen/hydrogen upper stage is founded on the basis of the liquid-propellant engine KVD-1 developed in the Russian Design Bureau for Chemical Engineering. The construction of upper stage permits to effect a prolonged flight in outer space (up to 7.5 hours) and perform multiple starting of cruise engine during the flight. The upper stage itself is made on the basis of tandem scheme with upper fuel tank. The tanks are interconnected by means of frame work providing compensation of temperature strains of their construction. The fuel tanks are manufactured from high-strength aluminum alloys. To maintain temperature rate of cryogenic components of propellant during launch preparation and flight the fuel tanks are coated on the outside with a layer of foamed polyurethane and evaluated screen thermal insulation.

The cruise engine is mounted stationary. As a cruise engine for the oxygen/hydrogen upper stage during powered flight two upper chambers mounted by means of gimbals suspension which permits to deflect chambers in two planes are used. Feeding of rudder chambers with the main propellant components is performed from turbo-pumping unit of the cruise engine. Besides two units of low thrust propulsion plant for stabilization and attitude control of the oxygen/hydrogen upper stage during powerless flight as well as sedimentation of fuel before starting of the cruise engine are mounted on the lower face of the oxygen tank. As propellant components for low thrust propulsion plant nitric tetrad and asymmetric dimethy-hidrazine are used. Oxidizer tank supercharging and pneumatic valve control are performed with the help of helium stored in ball bottles disposed in oxidizer tank. Fuel tank supercharging is effected by means of gaseous hydrogen from the cruise engine. The construction and characteristics of the oxygen/hydrogen upper stage allow to use it together not only with launch vehicle “Proton-M”, but also with a number of existing and prospective launch vehicles of the “Angara” family.

Flight tests of the oxygen/hydrogen upper stage are planned for 2003.

6. Upper Stage “BREEZE-M”

In an effort to increase capabilities of heavy launch vehicle in putting spacecraft into wide range of orbits the Khrunichev State Space Center is now developing a new upper stage “Breeze-M”.

The upper stage has a compact configuration consisting of central unit and surrounding droppable toroidal auxiliary fuel tank/ A cruise liquid-propellant rocket engine with a capability of multiple starting is mounted in a well disposed inside fuel tanks of the central unit. Liquid-propellant low thrust rocket engines, using the same components of fuel as cruise engine, provide attitude control and stabilization of upper stage during independent flight as well as sedimentation of fuel in fuel tanks white restart of cruise engine; The inertial control system mounted in the instrumentation compartment disposed in the upper part of the central unit carries out a control over the upper stage “Breeze-M” flight and its board system/ The upper stage is also equipped with power supply system and instruments for recording of telemetric data and for outer trajectory measurements.

Use for propulsion plant of upper stage “Breeze-M” of standard long-storing liquid fuel with high density permitted to create very compact and light construction of tanks. The advantages of the above quite compensate certain loss in specific impulse in comparison with cryogenic propellant, and the use of droppable auxiliary fuel tank increases energetic characteristics of the upper stage and improves flexibility of its application for different variations of payload delivery. The upper stage “Breeze-M” is destined primarily for application in Russian heavy class launch vehicles “Proton”, “Proton-M”. Besides the Khrunichev State Space Center is considering a possibility of its application with prospective Russian launch vehicle “Angara”.

Wide possibilities for use of upper stage “Breeze-M” in different launch vehicles permit to consider its use with foreign launch vehicles. The use of the upper stage “Breeze-M” as a part of modernized launch vehicles “Proton-B” will allow to obtain the following opportunities for delivery of payload from Baikonur space-launch site.

7. “Rockot” Light-Weight Class Launch Vehicle

ROCKOT Light-Weight Launch Vehicle was designed on the basis of SS-19 two stage ballistic rocket which is to be discarded from action and together with 3rd BREEZE upper stage was meant for injecting Space Vehicles of up to 2 tons into low near-earth orbits. The space head consist of a booster upper, a Launch Vehicle adapter, payload and a fairing. The Launch Vehicle adapter contains BREEZE upper stage separation hardware.

The role of the fairing is to protect the upper stage as well as payload from aerodynamic and thermal disturbances on ascent phase of a flight. Till now, within the frame work of flight program testing ROCKOT Launch Vehicle was launched three times from a silo. All these Launches were performed from Baikonur cosmodrome and were instrumental in testing functionality of all the launch vehicle systems. Equipment of an open launch site at Plesetsk is being finished in order to allow the exploitation of “Rokot” L.V. All these installations are linked by railways and roads and include:

1. Integration House to be used for space vehicle/launch vehicle testing and integration of space head;
2. Fueling Station for liquid components and pressure gas for the 3rd stage and Space Vehicle;
3. Surface Launch Pad, Service Tower, thermoregulating facilities, the 1st and 2nd stage fueling station, prelaunch processing equipment and control rooms.

VII. Number of employee

Number of employee: 17000

VIII. Commercial proposals

1. Rendering services as regards launch of various satellites by means of Russian launch vehicles "Proton" and "Rokot"
2. Development and manufacture of small-size satellites for environmental monitoring
3. Development and manufacture of accelerating engines for upper stages of carrier rockets
4. Development and manufacture of multi-functional space stations
5. Development and manufacture of various auxiliary systems for inhabited orbital vehicles and modules

トピック：ロシアで発行されている技術雑誌

ロシアの技術開発やハイテクについての雑誌がロシア（モスクワ）で発行されています。主なものを２誌ご紹介します。

特に、**THE SUMMARY OF TECHNOLOGIES** は内容が豊富で、誌面が美しく、英文版もあってお奨めです。

原則として、東京からでも購読できますので、ご関心の各位は直接お申し込み下さい。

1. Russian Technological Review

THE SUMMARY OF TECHNOLOGIES

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２. **RUSSIA and WORLD: SCIENCE and TECHNOLOGY**

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ロシアの新聞報道

産業科学技術省の解消すら話題になるほど、ロシアの技術開発と産業の隔たりが大きいことが分かる報道である。
また、軍需発注を受ける企業数は 1600 に及んでいる。

産業・科学技術省の運命

ｺﾒﾙｻﾝﾄ･ﾃﾞｲﾘｰ 2001 年 2 月 2 日

軍産複合体を管理する省庁に消滅の恐れがある。それはアレクサンドル・ドンドゥコフが大臣を務める産業・科学技術省と五つの国防関係のエージェンシーだ。もちろん、省庁は徹底抗戦するだろう。例えば、ドンドゥコフ大臣は二つの課題に取り組むと宣言した。一つは国の予算から出る金を 1600 の国防企業に行き届かせること、二つは「軍産複合体からの最新の技術開発」を産業に導入することである。これは永遠の課題でもあり、産業・科学技術省の役目にも終わりがないということになる。

最近、春に産業・科学技術省が解消され、その機能はゲルマン・グレフの省（貿易・経済発展省）に移管され、省名は産業貿易省になるという噂があった。

政府やクレムリンの高官から、「ドンドゥコフは任に堪えず、政府から弾き出される第一候補だ」と、本紙は何度も聞いた。もちろん、大臣は反駁している。モスクワで開かれた国際イノベーション・サロンで挨拶し、「省の解消は単なる噂でしかなく、幾つ省があるかより、経済を上向かせる結果が大事だ」と述べた。

ドンドゥコフ大臣の言う結果とは、最新の開発とハイテクを導入することで、それは軍産複合体にあり、軍産複合体を支援することが重要だということになる。そして、国防発注を受けている 1600 の企業に予算からの金をきちんと行き渡らせることが急務だとの考えだ。1990 年代後半に国からの支払いが滞ったことがよほど骨身に滲みたらしい（当時、大臣はヤコブレフ設計所の代表だった）。当時からの債務も含めて、2001 年から 2002 年にかけて支払いを行うよう財務省は首相から指示を受けているが、ドンドゥコフ大臣は信用していないようだ。

他にも問題がある。ドンドゥコフ大臣のデータによれば、ロシア産業の基本設備は 60～80％も老朽化しており、破滅から逃れるには新しいテクノロジーを大規模に導入するしかないと言う。産業・科学技術省は、50 のベンチャープロジェクトを選び、その総額の 10～15％を補助する用意があるとのことだ。

五つの国防関係のエージェンシー（航空宇宙、兵器、弾薬、他）については、産業・科学技術省がそれらを取り込み、内局にすることに吝かではないという。

いずれにせよ、ドンドゥコフ大臣が代表する産業・科学技術省に課せられた使命は巨大だ。