（No.5　2001年3月21日号目次）

特集：航空宇宙関連研究開発機関（その３）

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。
３号にわたる特集の最終回です。

トピックとして、ロシアでの技術開発に関する報道をご紹介します。

トピック：

⑩航空機エンジン中央研究所
(モスクワ市)

I. Name of the Institute (Organization)

In Russian: Государственный научный центр Российской Федерации Центральный институт авиационного моторостроения им.Баранова

In Russian abbreviation: ГНЦ ЦИАМ

In English: State Research Centre Of The Russian Federation
Central Institute of Aviation Motors

In English Abbreviation: SRC - CIAM

II. Location

Official address: CIAM, 2, Aviamotornaya St., 111250, Moscow, Russia

Mail address: CIAM, 2, Aviamotornaya St., 111250, Moscow, Russia

Telephone number: (095) 200-22-15

Fax number: (095) 267-13-54

Web-site: http://www.ciam.ru

E-mail for representative: avim@ciam.ru

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

III. History

Central Institute of Aviation Motors (CIAM) established in December 1930 according to the Government decision is the only research, design and development center in creating the home-built engines. The groundwork for the aviation engine science, of which the fundamental tenets were confirmed by experiments and realized in the first engines developed and manufactured at the Institute in 1930s, were laid within its precincts. Advances in developing the Soviet aviation are intimately associated with CIAM. The prefect aviation engines permitted the Soviet aviation to be superior to the enemy aviation during the Great Patriotic War.

CIAM is a school of high-skilled scientific-technical personnel of aviation engine building. The history of a number of design bureaus began within its precincts. Almost all the leading scientifical-technical personnel of these design bureaus is staffed from the CIAM leading specialists, among which were the leading designers: V.Ya.Klimov, A.A.Mikulin, A.M.Lyulka, S.K.Tumansky, A.D.Charomsky, V.A.Dobrynin, V.N.Chelomei and others.

CIAM is the largest research center, leading scientific-research organization of engine building. A large group of the outstanding scientists whose proceedings are well-known both in our country and abroad is successfully working at the Institute. The CIAM calculative-theoretical and experimental investigations are used in the design, development and operation of all the home-built engines of aviation application without exception.

The governmental decision about building the National experimental-research complex for testing all the engines being developed in design bureau and their main components under simulated altitude-speed flight conditions was taken with allowance for the prospects of the aviation development in 1947. The largest testing complex in Europe went into operation in 1955 and became a branch of CIAM.

At present CIAM is a leading research center of the aviation industry with a powerful modern experimental and computational bases and high-skilled personnel.

CIAM considers the carrying-out of the outstripping investigations and developments as its main task. One of the examples is the development of supersonic and hypersonic ramjets. CIAM was an ideologist and active participant of creating these engines. The priority of the country introducing the integral scheme ramjets, first flight testing of hypersonic ramjet is universally recognized. Another example is an investigation of hydrogen as the advanced aviation fuel for high speed vehicles which began at CIAM in late 1950s. The Tu-155 experimental aircraft equipped with a liquid hydrogen engine took a maiden flight in 1988. The engine was developed by N.D.Kuznetsov Design Bureau together with CIAM.

Since 1960-1970s the investigations of combined air-breathing engines have been carried out at CIAM. The works in this field generate the prerequisitesfor developing the powerplants for the future hypersonic and aerospace planes. The 2000-years engines (subsonic, turboshaft and supersonic variable cycle engines) are being developed, the problems of using non-metallic materials are being solved.

In recent years the scientific-technical collaboration of CIAM with the leading foreign companies and research organizations are progressing rapidly.

From 1989 in CIAM there was created a number of joint enterprises with foreign organizations.

CIAM maintains contacts with 52 leading aviation companies of different countries and demonstrates its achievements at the international exhibitions. The leading specialists take part in the work of 12 international societies.

IV. Management

Kind of organization: State Scientific Centre Of The Russian Federation

Ownership: State property of the RF

V. Executives

Dr.Sc., V.A.Skibin - Director

Dr.Sc., V.I.Solonin - First Deputy Director
Dr.Sc., S.A.Sirotin - Deputy Director Testing
Dr.Sc., V.N.Nasonov - Director Research Test Center
Acad. of Sciences RF, **O.N.Favorsky** - Deputy Director Ecology and Conversion
Dr.Sc., U.A.Nozhnitsky - Deputy Director Strength
Dr.Sc., M.Ya.Ivanov - Deputy Director Turbomachines
Dr.Sc., F.N.Olifirov - Deputy Director Control System

VI. Current major activities

The basic areas of CIAM scientific researches are as follows:

- fundamental investigations in the field of the gas dynamics, combustion and heat exchange; structural strength, theory of engine control;
- exploratory research in the field of air-breathing theory and optimization of the advanced engine characteristics;
- exploratory and applied investigations of engine components, units, systems and gas generators;
- scientific support of developments carried out in engine design bureaus;
- experimental investigation of prototype engines, their components and systems;
- advance technologies and improve data bases for supersonic combustion ramjets (scramjets);
- experimental investigation of hydrogen scramjet 2-D and axisymmetrical model engines, pressure and heat fluxes distributions, fuel injection, stable inlet/combuster operation, combustion stabilization and efficiency, injection of kerosene in the inlet, stabilization of combustion, effervescence of fuel & etc
- thermostable liquid and slurry hydrocarbon fuels for high velocity airbreathing;
- endothermic liquid hydrocarbon fuels;
- experimental studies with liquefied hydrocarbon gases
- flight test of an axisymmetric hydrogen-fueled scramjet engine on Hypersonic Flying Laboratory “Kholod”, obtain scramjet flight research data at Mach 6.5;
- conceptual work on the advanced turboramjets;
- advance the technology base for "low speed" (Mach 0 to 4) propulsion for hypersonic vehicles;
- studies of the aviation engine conversion ways and solution of ecological problems.

Along with the traditional tasks the Institute performs also the program coordination functions: prediction, determination of the rational aviation engine type and programs of their development, drawing-up of the technical requirements for new engines. In addition, a large volume of works is done on the main problem of present-day aviation engine building - improving the reliability, life time, flight safety and certification of engines.

VII. Number of employee

3500

VIII. Major facilities

Subdivisions of the State Scientific Center	Basic Experimental Equipment
Gas Dynamics Division	Facilities for experimental studies of air intake in aerodynamic elements of propulsion systems at M=4...10, study of interface in turbine vanes, ecological studies of combustion products; a complex of equipment for gas dynamics research
Durability Problems Division	Experimental laboratory for studying structural materials; a laboratory for hardware support of vibration measurements; a booster chamber n=70000 J/s, facilities for turbine disc cyclic testing; devices for strength tests of roller bearings and gear transmissions.
Full-size Engine Division	Facilities for high-altitude velocity and high-altitude climatic tests of full-size turbojet engines (TE) R < 5 tf (N < 12 khp, N < 6 khp), H=0...12 km, t= -60...+70°C (+90°C, +120°C). Devices for testing units and accessories of TE, including problems stemming from magnetic bearings use, devices for efficient oil purification.
Compressor Machine Division	A complex of facilities and benches for testing: centrifugal stages with high and low ∂; conducting model tests of two-loop stages of high- and low-pressure compressors, helical fans, axial-flow compressors, plane compressor cascades.
Automatic Control Systems Division	A complex of facilities and laboratory equipment for partial full-scale tests of aggregates and fuel feeding systems (FFS), regulating pumps of hydromechanical automatic control systems (ACS); testing of ACS and TE FFS and power facilities in actual layout; certification tests of hydromechanical and electronic ACS; wear resistance tests of pneumoautomatic systems.
Small-size Engine Department	Facilities for conducting ground tests of full-size small gas-turbine facility; G=8 kg/s, N=2000 hp, T < 800 K; testing of heat exchangers, dust-proof devices for ?multipurpose turbojet engines?; erosion resistance tests of centrifugal and axial-flow stages of compressors. Facilities for testing small-size aviation piston engines.
Aerospace Engines	Facilities for experimental study of working processes in engines, hydraulic characteristics, centrifugal pumps using fuel component mixtures.

Department	
Combustion Processes Department	Facilities for experimental studies of mixture formation processes, inflammation and burning in combustion chambers (CC) of TE, studying of combustion in a supersonic flow, of vibrational combustion; facilities for studying model and full-size CC, separate compartments, elements and systems of CC cooling.
Turbine Department	Facilities for experimental study of turbine cascade and small-size turbine gas dynamics, thermal tests of working and nozzle blades; facility for testing high-temperature turbines, annular cascades, vanes and channels.
Research and Testing Center CIAM	A complex of high-altitude test benches: for testing full-size TE, their compressors, basic combustion chambers and afterburners (max. thrust of engines R_{max} = 25...30 tf, simulated conditions are: H = 0...27 km, M = 0...3; air parameters at the inlet: G = 0...250 kg/s (up to 800 kg/s at t > 0), t= -60...+350°C, (p = 0...8; 0...21 kg/cm^2) Ground test benches: for propulsion system (PS) aerodynamic testing in spaceship layout; for testing full-size TE at flight velocities up to M=4...4.5; benches for the direct-flow air-jet engines and LPE testing. A complex of test benches for studying full-size turbines, testing model combustion chambers, models of output devices (including acoustic testing). Experimental base for studying strength and durability of engines and their parts, structural materials (including ceramic, carbon etc. refractory materials at t = 1400...2200°C). A complex of compressor-exhauster machines, refrigerating and heating systems supporting operation of experimental test benches and facilities: total electric power of the equipment exceeds 500 mW, maximum air consumption is 1500 kg/s, air working parameters are: t = -90...+1900°C, p=2...2000 kPa.
Pilot Production	Basic production assets incorporate more than 300 pieces of diverse equipment and occupy ~20 000 m^2 of production floors. The equipment has been arranged on the area according to subject-technological indices: - a metal working equipment (mechanical treatment) bay; - an assembly bay (incorporating vane polishing bay); - a fitting out bay (incorporating a template bay); - an argon-arc welding and plasma sputtering bay; - a gear cutting bay; - a precision casting bay. The pilot production provides manufacture of model and full-scale experimental specimens of diverse accessories of engines, their assembly, inspection and process tests. The potentialities of the equipment and technical personnel permit arranging small-batch and series manufacture of various specimens of general purpose products.

IX. Commercial proposals

Main directions of international cooperation are follows:

1. Development of cooling systems for turbine vanes & blades.
2. Experimental investigations of new cooling systems for turbine vanes & blades.
3. Development and designing of high-effective heat exchangers (air-to-air, fuel-to-air, gas-to-air, etc.).
4. Operability of air-to fuel heat exchanger at the temperature up to 1100K and at the pressure up to 5 MPa.
5. Heat exchanger calculation on both steady-state and unsteady-state operation modes.
6. Investigations of cooling systems for combustion chambers of advanced engines.
7. Optimization of high-effective cooling systems for combustion chambers.
8. Experimental investigation of heat transfer coefficient into holes of combustion chamber perforated wall.
9. Development and using of the thermometric paints with high adhesive ability for measurement of complicated temperature fields and express monitoring of heat process.
10. Development of combustion chambers for advanced engines.
11. Experimental investigations of advanced engine combustion chamber segments and models.
12. Development of engine components from ceramic and composite structural materials.
13. Development of AMT programs.
14. Experimental prediction of life and durability of engine components.
15. Experimental investigations of engine components LCF and HCF.
16. Experimental investigations of crack growth.

⑪製造企業 POLYOT
(オムスク市)

I. Name of the Institute (Organization)

In Russian: Производственное объединение «Полет»

In Russian abbreviation: ПО “Полет”

In English: Polyot Production Association

In English Abbreviation: Polyot PA

II. Location

Official address: 226, Bogdan Khmelnitskiy St., Omsk, 644021, Russia

Mail address: 226, Bogdan Khmelnitskiy St., Omsk, 644021, Russia

Telephone number: (3812) 57-73-38, 39-72-01
(095) 251-37-69

Fax number: (095) 251-37-69
(3812) 57-70-21, 57-91-00

Web-site: http://www.rbs.ru/vttv/firms/polyot/

E-mail for representative: po_polet@mail.ru

Access (transportation, necessary time): Moscow international airport Sheremetjevo-2, than 3 hours to Omsk by aircraft (airport Domodedovo) and one an hour by car

III. History

Polyot Production Association originates from the Aviation Plant #166, which had been established in Omsk in 1941 on the basis of two plants, evacuated from Moscow. The Directive of the Council of People's Comissars (Government) about creation of the Plant #166 was signed on 24 July 1941.

During the World War II Plant #166 manufactured Tu-2 high-speed diving bombers, Yak-7 and Yak-9 fighters. In 1950s the Plant mastered manufacturing of Il-28 jet bombers (758 were assembled) and the Tu-104 first passenger turbo jet plane (58 or 68 were delivered, production was organized in just 12 months).

In 1960s the enterprise became involved in missile and space programs activity). Between about 1961 and 1965 the Plant was subordinate to Omsk Council of People's Economy (SNKh), while the Design Bureau was the Branch #1 of OKB-586 (aka Omsk Branch of OKB-586). In 1965 the Plant together with the Design Bureau was transferred to the Ministry of General Machibe-building (MOM) and renamed Omsk Aviation Plant (OAZ), with the Design Bureau known as "Design Bureau of Omsk Aviation Plant"(KB OAZ).

As a major production facility, it was given a number of assorted tasks, sometimes those, which were rejected by more influential enterprises. Thus, in late 1960s it mastered serial production of *Kosmos* light-weight launch vehicles, later - of some satellites, developed by OKB-10 (now NPO PM). Eventually, in early 1980s, production of rocket engines for the *Energia* launcher was established. As a result, Polyot PA became the most diversified from major Russian space companies (and it is probably the only truly *aerospace* enterprise). By the beginning of 1990's Polyot PA was a part of the Mashinistroitel State Production Association (GPO), which probably unified Design Bureau, Production Association and perhaps some other related facilities, located in the area. With the disbandment of the Ministry of General machine-building, Mashinostroitel GPO also disbanded. Polyot Production Assn. reported to Ministry of Industry/State Committee on Defense Branches of Industry/Ministry of Defense Industry and most recently to the Ministry of Economy of the Russian Federation. In May 1998 it was resubordinated to the Russian Aviation and Space Agency.

Ballistic missiles and launch vehicles

- participated in production of 8K63 missiles (R-12 or SS-4) as well as R-16 (SS-7) and UR-100 (SS-11) ICBMs (More than 1500 of these missiles were produced at the Plant)
- manufactured 11K65 and 11K65M (Kosmos-3 and Kosmos-3M) light-weight launchers. (By 1996 more than 750 of Kosmos-3/3M launch vehicles were manufactured and 730 were launched beginning from 1964). Production was halted several years ago due to lack of state orders, but could be resumed provided sufficient minimal level of procurement.

Table 1. Payload capability of Kosmos-3M launcher

Orbit	Altitude, km	Payload mass, kg
Circular	400 800 1000 1600	1300 1100 800 600
Elliptic	Hp=200-300 Ha=2000	1100
Orbit inclinations: 51, 66, 69, 74, 83 deg.		

Spacecraft:

- manufacturing of serial spacecraft, developed by OKB-10/NPO PM:
- *Parus* low-orbiting navigation satellites
- *Tsikada* low-orbiting navigation satellite
- *Raduga-1* communications satellite
- joint development or development of follow-on spacecraft:
- *Nadezhda* navigation/rescue satellite, modified to carry COSPAS-SARSAT transponder (10 Nadezhda spacecraft were delivered in just 12 months; 8 has been launched between 1982 and 1998)
- *Uragan* satellites for the Glonass GPS (co-developed by NPO PM and KB of Polyot PA)

Rocket Engines:

- RD-216 for the first stage of *Kosmos-3M* launcher
- RD-170 engines for the first stage of *Energia* launcher (the first unit is produced in 1984, by now production ceased)
- tail (engine) sections for *Buran* orbiter (reportedly as many as 10 units were manufactured)

Others:

- rocket-space complex MIR-2 for upper atmosphere and space physics research was developed for the USSR Academy of Sciences and Interkosmos organization;

- In 1991-92 Polyot participated in development of SPK1 solar sailing ship (It was responsible for the launch vehicle fairing)

IV. Management

Kind of organization: Federal State Unitary Enterprise

Responsibly Ministry: Russian Aviation and Space Agency

V. Executives

Oleg P. Dorofeyev - General Director
Victor V. Markelov - Chief Designer
Vladimir P. Udalov - Deputy Director General for External Economic Activities

VI. Current major activities

Main directions of activity of Polyot PA include

- development of satellites and launch vehicles;
- serial production of spacecraft and launch vehicles as well as subsystems and components.
- aircraft manufacture.

Polyot manufactured a total of about 1500 missiles, more than 750 space launchers and more than 200 satellites, which makes it one of the greatest manufacturers in the Soviet missile and space industry. (In terms of launchers it is the second to Progress Plant, while in terms of satellites probably 4th after NPO PM, TsSKB and Yuzhnoe DB - Ukraine).

Currently in space development:

- *Kosmos-3MU* launcher (Vzlet) - with upgraded guidance system, to use up-to-date components, increase mission flexibility and decrease ecological damage by reducing impact zones of the 1st stage
- *Nadezhda-M* advanced navigation/search & rescue satellite with additional dispatch transponder (first flown in 1995)
- *Uragan-M* satellite for advanced global positioning system
- *Coscon* LEO communications system (Polyot is the lead developer of the system). *Informator-1* spacecraft to demonstrate initial capabilities was launched in January of 1991. Since then activities were slow due to financial problems until cooperative agreement with an American company Final Analysis Inc. was signed. In 1997 it was announced, that a joint system, called *FAIsat-Coscon* will be created.

Currently in aircraft manufacture

Since 1993 Polyot PA has been marking AN-74 airplane of the base variant which can be equipped as AN-74 TK transport-passenger plane, AN-74 T transport plane (carrying capacity of 10 tons), and as a supper comfortable business type “Saloon” airplane, and also of the other variants at Customer request. AN-74 airplane passe State Acceptance test (Airworthiness

certificate No. 13-74 from August 2, 1991). This is one of a few planes which is in accordance with the international standards on “Noise on a district” limits and is equipped in accordance with the International Civil Aircraft Convention requirements.
AN-74 is intended for transportation of freights and people on airplanes of average extent in any climatic condition on any latitudes, including North Pole conditions and high-mountain regions. Reliable modern navigation system is installed in the airplane to provide safety flights on the non-equipped air lines at any season of the year and day period at any weather conditions. The plane is capable to land on block of ice, unpaved airfields, gravel seashores due to its high-practicability chassis and high mounted airplane engines. The propeller in made of modern highly strong materials, carbon plastics, composite materials, hon-eycomb sandwich structures and other upgrades improving safe operation of the airplane. Modern technologies and techniques are used in manufacturing of the airplanes. All airpalnes of AN-74 type are equipped with a onboard loading device with capacity of 25 kN (2500 kgf), with a wench and fixing on the ramp and in the cargo cabin. Business type super comfortable “Saloon” airplane is equipped with telephone and fax communication and designed for transportation of 10-16 passengers. At present time much attention is given to AN-74 TK transport-convertible plane which is capable to transport up to 52 passengers and up to 10 tons of freight with the speed of 650-700 km/h. Maximum distance of flight is 4500 km.

International Cooperation /Joint ventures

- Polyot and the French 'Thompson Electromenager' established 'THEMPOL' joint venture to manufacture modern automatic washing machines.
- Polyot has an agreement with Ploghshares Technologies Ltd. (London) and Polyot Astro Satellite Systems (Arlington, Va.) to market Kosmos SLV services in the U.S. (In 1995 Polyot Astro offered Kosmos to NASA as a candidate for *MedLite* launcher RFP, but lost to a US competitor.)
- Cosmos International GmbH is a joint venture of Polyot and OHB-Systems GmbH, marketing Kosmos LV.
- Cosmos USA was established on 20 Sep 1995 by an agreement of Polyot Design Bureau and Assured Space Access (Arlington, Va.)
- in October 1995 formed FAIsat-Coscon alliance with Final Analysis Inc.

In 1994 Polyot got its first contracts for a piggy-back launch of Western payloads from Final Analysis Inc. (Greenbelt, Md.) and Swedish Space Corp. In January of 1995 the FAIsat-1 experimental 'little LEO' comsat and *Astrid* scientific satellite were successfully launched. Second commercial launch with FAIsat-2V as a piggy-back payload occurred on 23 September, 1997. Later FAI planned to deploy a complete operational constellation of 30 satellites, using 2 piggy-back launches in 1998 and 4 dedicated launches with 7 satellites on each rocket in 1999-2000.
The third launch of Polyot-made *Kosmos-3M* with a piggy-back commercial payload, another Swedish satellite *Astrid-2*, occurred on 10 December 1998. This contract, initially signed by Polyot, had to be renegotiated after the Russian government earlier in 1998 ordered to consolidate commercial launch services of *Kosmos* and *Start* rockets under a newly established company Launch Services, controlled by the RASA and Komplex NTTs. Nevertheless, instead of Launch Services, the contract was captured by Rosvooruzhenie.
Polyot also has orders for launches of the German *Abrixas* and *CHAMP* satellites on dedicated *Kosmos-3M* rockets in 1999.

VII. Number of employee

13500

VIII. Major facilities

Production Technology Capabilities

- casting by the lost-wax process, by open and vacuum melting for carbon, high-alloy steels, high-temperature steels with guaranteed air-tightness and durability of produced articles. Maximum weight of a cast prefabricate is 300 kg, maximum size is 600 x 600 x 600 mm;
- mechanical and erosion processing of special high-temperature and high-alloy steels with formation of complex, high-precision surfaces- augers, turbines, seals for units and systems.
- welding of practically all kinds of steels and alloys, soldering, varying from the thinnest wires up to large-sized aggregates, including ceramics and multy-layer ribbed copper-steel heat exchangers.
- Association has a significant experience in manufacturing of a large variety of sylphons: from single-layer up to unique 12-layer sylphons, operating in extreme conditions. Diameter may vary from 18 up to 660 mm, and lengths from 30 to 300 mm. Seamless sylphones could be manufactured with diameters from 18 to 300 and length from 30 to 200 mm).

Testing facilities of Polyot PA follows:

- to estimate quality of materials and ready products;
- simulate outer space environment,
- conduct climatic and other testing.

IX. Commercial proposals

Polyot PO offers:

- joint development of the universal orbiter platform (service system module) of the light class as a base for small-size spacecraft manufacturing to solve a wide range of different tasks;
- joint development and manufacture of small size satellites and placing them into operating orbits as a useful load in passing or as completely deployed constellation;
- joint manufacture and development of low-orbit commercial satellite system (communication, environmental monitoring, etc.);
- manufacture of AN-74 TK-200 transport-convertible airplane;
- customer advertising on launch vehicles and spacecraft;
- establishment of a joint venture to deliver cryogenic products at a foreign market;
- business partnership in delivery of complex diagnostic equipment and tools for general, micro- and cardio surgery;
- establishment of joint ventures to employ available production capabilities (foundry, forging, sheet pressing and testing);
- joint development and manufacturing of oil production and oil processing equipment (drilling mud purification unit, well bore sidetracking rigs);
- manufacturing of equipment for trenchless laying and replacing of metal pipes and manifolds;

- joint development and manufacture of passenger buses and spacial purpose vehicles;
- joint development and manufacture of the industrial units based on diesel and mineral oil purification separator, diesel purification separator, oil slag separator;
- development and manufacture of environment cleaning facilities (separation of the plastic substances from the wastes, oil spillage collection from water surfaces).

⑫ラーボチキン研究所
（モスクワ州ヒムキ市）

I. Name of the Institute (Organization)

In Russian: Научно-производственное объединение им.С.А.Лавочкина

In Russian abbreviation: НПО им.С.А.Лавочкина

In English: Lavochkin Research and Production Association

In English Abbreviation: Lavochkin RPA

II. Location

Official address: 24, Leningradskoe Shosse, Khimki-2, Moscow Region, 141400, Russia

Mail address: 24, Leningradskoe Shosse, Khimki-2, Moscow Region, 141400, Russia

Telephone number: (095) 573-9056, 573-9201, 573-5738, 251-9249, 251-2434

Fax number: (095) 573-3595, 573-1786

Web-site: http://www.berc.rssi.ru

E-mail for representative: commerce@npol.msk.ru

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

III. History

The enterprise was established in 1937 as an aircraft design bureau (OKB-301), headed by Semyon Alexeyevich Lavochkin. It was best known for its wartime fighter planes, La-5 and La-7. After WWII OKB-301 developed jet fighters, including "article 176", which in December of 1948 became the first Soviet aircraft to reach the speed of sound in a horizontal flight. In 1950 the Design Bureau was re-targeted for development of surface-to-air missiles (when this direction was transferred to the Ministry of Aviation Industry from the Ministry of Defense Industry). Lavochkin's first SAM was the R-101, a replica of a German *Wasserfal*, transferred from NII-88. After gaining experience with the R-101, OKB-301 developed the R-113 missile for the first Moscow Air Defense System. The Lavochkin bureau also developed a number of air-to-air missiles associated with their own planes, such as the La-250 Anaconda.

In 1953 SAM activities were taken over by a new independent enterprise, off-shot from KB-1 and headed by Lavochkin's ex-Deputy Pyotr D. Grushin. (This company is now known as Fakel Machine-building Design Bureau named after Grushin). In the same year 1953 Lavochkin's OKB-301 was given responsibility for development of a rocket-boosted supersonic intercontinental cruise missile, called *Burya* and similar to the U.S. *Navaho* missile. Despite significant success in test firings of *Burya* during 1957-1959, the program was canceled as operationally inferior to ICBMs. After death of Lavochkin in 1960 the Bureau quickly lost all its customers and was left idle.

When in 1959 Chelomei and Korolyov agrued over whom was going to take over the Central Artillery Design Bureau, headed by Grabin, Minister Dmitriy Ustinov offered Lavochkin's KB to Chelomey as a settlement. As a result, in December of 1962, OKB-301 became a Branch of Chelomei's OKB-52.

Around 1965, apparently, under pressure from Korolyov, the Branch was taken away from OKB-52 and was reassigned to the development of automated Moon probes and interplanetary stations, transferred from Korolyov's OKB-1. Afterwards, spacecraft, developed by the company were the world first to land to the Moon, Venus and Mars, first to automaticlally bring samples of lunar soil back to Earth and to perform a remotely controlled study of the lunar surface. From 1965 till 1991 the enterprise reported to the Ministry of General machine-building of USSR (MOM). Since 1994 it reports to the Russian Aviation and Space Agency.

Projects participated:

Missiles:

- R-101 SAM (canceled in early 1950s)
- R-113 (SA-1 Guild) SAM (for the S-25 system)
- V-350 Burya intercontinental cruise missile (canceled in 1959)

Spacecraft:

Lunar probes:

- *E6* series (Luna landers and orbiters) - 9 launched between 1966-1968;
- *E8* (Lunokhod) - 3 launched between 1969-1973;
- *E8-5* (automatic Lunar sample returner) - 8 launched between 1969-1972;
- *E8LS* (Lunar satellite) - 2 launched in 1971 and 1974;
- *E8-5M* (advanced Lunar sample returner) - 3 launched between 1974-1976.

Interplanetary probes:

- *V-67* (Venus lander) - 2 launched in 1967;
- *V-69* (Venus lander) - 2 launched in 1969;
- *M-69* (Mars lander) - 2 launched in 1969;
- *V-70* (Venus lander) - 2 launched in 1970;
- *M-71* (Mars lander/orbiter) - 3 launched in 1971;
- *V-72* (Venus lander) - 2 launched in 1972;
- *M-73* (Mars lander or orbiter) - 4 launched in 1973;
- *4V-1* (Venus lander and/or orbiter) - 6 launched between 1975-1981;
- *4V-2* (Venus radar mapper) - 2 launched in 1983;
- *5VK* (Venus-Halley Comet mission)- 2 launched in 1984;
- *1F* (Phobos probe) - 2 launched in 1988;
- *1M* (Mars'96 probe, initially developed as Mars'94) - launched 16 Nov 1996, failed to enter interplanetary transfer orbit.

Magnetospheric/Astrophysical observatories:

- *Prognoz* (solar/magnetosperic probe) - 10 launched between 1972-1985;
- *Astron* (UV observatory) - launched in 1983;
- *Granat* (X-ray observatory) - launched in 1989 and still operational.
- *Oko*, early warning satellite (Lavochkin is the Lead contractor for the spacecraft) - in production;
- *11F664* optico-electronic reconnaissance satellite (first launched on 6 June, 1997).

Block L series kick/escape stages for Molniya launcher;

IV. Management

Kind of organization: Federal State Unitary Enterprise

Responsibly Ministry: Russian Aviation and Space Agency

V. Executives

A.Paletskiy - General Director
Stanislav D. Kulikov - General Designer
Igor P. Zaitsev - Deputy General Director, responsible for foreign relations
Vladimir V. Kainov - Chief of Foreign Relations Department (573-9056)
Roald S. Kremnev - Director of Babakin Science and Technology Center
Oleg G. Ivanovskiy - Director of Museum (575-5467)

VI. Current major activities

Principal directions of activity of Lavochkin NPO include:

- design and manufacturing of automated spacecraft;
- analysis of spacecraft trajectories;
- testing of equipment at levels of system, subsystem and unit;
- preparation of spacecraft for a mission, including pre-launch checkout and testing at the launch site;
- control of spacecraft from the Center for Deep Space Communications (Yevpatoria) and from the Mission Control Center (Moscow region)

Under preliminary development:

- *Lomonosov* solar probe
- New small-scale bus for interplanetary stations to be orbited by Molniya-M or Soyuz-2 launchers
- *Interball/Prognoz-M2* (solar/magnetosperic probe) - two launched in August of 1995 and August of 1996;
- *Spektr* series of observatories (Spektr-UV, IR, X-gamma, Radioastron)

Fregat universal kick stages for Vostok/Soyuz/Molniya/Rus, based on propulsion unit of Phobos probe. Further derivative of Fregat, Fregat-2, is proposed for use with Zenit, Proton and, possibly, Angara.

VII. Number of employee

7500

VIII. Major facilities

Lavochkin possesses a number of testing facilities:

- centrifuge for stress and functional testing of assemblies under linear accelerations (the greatest g-load centrifuge in the former Soviet Union;
- facilities for stress and functional testing of assemblies under alternating cyclic loads;
- vibration tables for vibration testing of systems, subsystems and units;
- chambers for testing systems, subsystems, units and instruments against hot and cold temperatures, cyclic temperature variations and moisture;

- thermovacuum chamber for environmental testing against hot and cold temperatures, and cyclic temperature variations under conditions of high and low pressure and with simulation of solar radiation;
- anechoic chamber for electromagnetic testing of fixed and steerable antenna systems,
- operating at frequencies, ranging from 50 MHz to 50 GHz.

There are also facilities for

- testing of electromechanical step motors to determine their accuracy in terms of output shaft position error as a function of rotation angle.
- hydraulic loading and destructive testing of tanks, pressure vessels, pipes and fittings;
- pressure resistance testing of assemblies, instruments, functional units, thermal control and ventilation elements;

IX. Commercial proposals

Lavochkin undetakes a variety of projects to directly convert its space technologies for civil applications, including commercial projects. Such projects include:

- *Kurier* - LEO communications network

- *Zerkalo* - GEO communications satellite system, using spot-beams to flexibly serve remote areas. The project was implemented through NOOS Space technologies, Ltd. Current status is unclear.

- *Bankir* - system of inter-bank communications. This project is being implemented in a framework of Global Information Systems consortium and is funded by the Central Bank of Russia. Originally expected in late 1993 - early 1994, the launch of the first *Kupon* satellite for the Bankir system occurred on November 12, 1997. In March of 1998 this satellite failed in orbit, making further schedule of project implementation unclear;

- *Nord* - HEO communications satellite system for servicing remote Northern regions.

- *Lavochkin* - microgravity processing facility for production of medical substances and super-pure semiconductors. (The spacecraft was designed to be orbited by the SS-18 ICBM, slated for dismantlement under START-1 treaty. One proposal claimed, that Lavochkin spacecraft could be developed very fast, "because it is based on the Venera reentry vehicle". However, there are other proposals, entitled both Lavochkin and Merkuriy (Mercury), which call for development of the very similar spacecraft, using the same SS-18 launcher - but with a VA recovery vehicle, based on NPO mashinostroyenia's design for Almaz/TKS;

- *Plamya* - fire detection satellite system;

There were also proposals for a microgravity spacecraft under yet another name *Sadko*, as well as for a number of Earth observation satellites, called *Ekol, Ozone, Arkon, Monitor*.

⑬アルセナル設計所
(サンクト・ペテルブルグ市)

I. Name of the Institute (Organization)

In Russian: Конструкторское бюро «Арсенал» им. М.В.Фрунзе

In Russian abbreviation: КБ “Арсенал”

In English: Arsenal Frunze Design Bureau

In English Abbreviation: Arsenal DB

II. Location

Official address: 1/3, Komsomol Str., St. Petersburg, 195009, Russia

Mail address: 1/3, Komsomol Str., St. Petersburg, 195009, Russia

Telephone number: (812) 542-2973 (Chief Designer)
(812) 542-2846
(812) 542-3630 (Deputy Director)

Fax number: (812) 542-2060, 542-7127

Web-site:

E-mail for representative: kbarsenal@infopro.spb.su

Access (transportation, necessary time): St. Petersburg international airport Pulkovo, one hour by car

III. History

Arsenal ascends to the Cannon Foundry Shops, established in St. Petersburg in 1711 or 1719 by a Decree of Peter I. (Coincidentally, the very same artillery plant two centuries later partially moved to Podlipki to create the facility, which later served as a basis for the startup Soviet missile Institution, NII-88 and its versatile off-shots, including TsNIIMash, RSC “Energiya”, etc.).

The Arsenal Design Bureau was established in 1958 with a special purpose to develop solid-propellant ballistic missiles. (According to other sources, the Design Bureau was established in 1949 as the Central Design Bureau #7 - TsKB-7)

In 1970's the Design Bureau developed the first Soviet solid-fueled sea-launched ballistic missile. In late 1960's (1969, according to) Arsenal Plant and Design Bureau were given responsibility for serial manufacturing of ocean reconnaissance satellites, developed by Chelomey's OKB-52/TsKBM (now NPO Machine Building). The Design Bureau almost immediately proceeded to modernization of those and later developed new generations of ORSATs, for which it already acted as the Lead Developer.

<u>Projects participated</u>

Ballistic Missiles

- In early 1960s TsKB-7 participated in development of *RT-2* solid-fueled ICBM. It was also responsible for development of *RT-15* mobile IRBM, based on *RT-2*. The *RT-15* was canceled.
- In 1971-1980 developed 3M17 (SS-N-17) SLBM - the first Soviet solid-propellant SLBM. Because of opposition of competitors the missile was not introduced into serial production and only a single Project 667A submarine, equipped with these missiles, was commissioned for experimental operation. (However, that project reportedly forced Makeyev to eventually embrace the concept of solid-fuelled SLBM and to develop one for *Typhoon* submarines.)

Spacecraft

- spacecraft for maritime reconnaissance (RORSAT, EORSAT); Manufacturing of ORSATs was transferred from OKB-52/TsKBM in late 1960s, reportedly after Chelomey's *UR-200* was finally abandoned as a potential launcher. When Arsenal DB production facilities were given responsibility for manufacturing, Arsenal DB should have received responsibility for construction oversight and, later, for upgrades and follow-on developments of those spacecraft.
- nuclear powered active radar satellites (RORSATs) were used until 1988, when they were abandoned because of global concerns about nuclear accidents; Solar-powered passive eavesdropping satellites (EORSATs) continue to operate (and to be produced by Arsenal). A total of more than 70 ocean reconnaissance satellites were launched in the course of 30 years.

Other projects

Besides these major projects, Arsenal DB developed and manufactured:

- satellite thermal control components;
- satellite transportation containers;
- ground station components;
- (reportedly participated in the L3 project, presumably supplying the block of attitude control engines);
- steering drives for *Energia* launcher

IV. Management

Kind of organization: Federal State Unitary Enterprise

Responsibly Ministry: Russian Aviation and Space Agency

V. Executives

Boris I. Poletayev - Chief of Design Bureau and Chief Designer
Leonid D. Fedotov - First Deputy Chief Designer
Vladimir I. Sapozhnikov - Deputy Chief Designer (tel.: 248-9842)
Vadim L. Sedykh - Chief Engineer
Mikhail I. Kislitskiy - Chief of Sector of Conversion, Marketing and Innovation (tel.: 248-7842, 542-2252)

Arsenal Holding Company

Vyacheslav G. Petrov - President, General Director (tel. 542-2846)
Vitaliy A. Sychev - Vice-President (tel. 542-9835)
Mikhail A. Myslin - Deputy Director
Alexandr N. Chlennikov - Deputy Director
Petr S. Kushnir - Deputy Director for Foreign Economic Relations (tel. 542-7127)

Sergey N. Bogatov - Manager of Arsenal Machine-building, Joint Stock Co
Vladimir N. Abariayev - Manager of Arsto Joint Stock Co.

VI. Current major activities

The Arsenal Design Bureau performs research and development on spacecraft. Manufacturing of spacecraft is performed by Arsenal Machine-building Plant under a technical management of the Design Bureau

Arsenal DB reportedly works on advanced versions of their (ocean reconnaissance) spacecraft to be launched by more powerful *Zenit* (or, possibly, by the domestic *Soyuz-2*) launchers and feature greater payload and higher orbits.

Current main activities are:

- research aimed at developing advanced spacecraft and space systems;
- development of space systems and spacecraft of the *Kosmos* series;
- technical supervision of spacecraft manufacturing;
- ground and in-orbit operations of *Kosmos* spacecraft;
- preparation and manufacturing of scientific experiments onbiard *Kosmos* spacecraft;
- offering commercial services by launching a succession of spacecraft into orbit.

Arsenal DB suggested development of complete satellite systems:

- *Predvestnik* ("precursor")- a system for global monitoring of events, preceding earthquakes; (Arsenal estimates cost of the system, including 6 satellites, as $200 millions)
- *Obzor* ("survey") - system for Earth remote sensing, with 4-frequency, multi-polarization side-looking radar, capable of ground resolution of 100 m in survey mode and 20 m in detailed mode with a swath of 250 km;
- *Odissey* - operational dispatch and information system for relaying data from objects, equipped with radio beacons, to ground stations.

<u>International Cooperation</u>

Arsenal DB was actively looking for foreign investments, particularly to keep expertise in advanced space-faring technologies.

Arsenal had preliminary negotiations with several American companies about development of multifunctional satellites. The *Predvestnik* proposal reportedly drew attention of some U.S. representatives, which offered to submit it to the Congress, but nothing resulted as of January 1996. However, in March of 1996 Arsenal was reported to sign an agreement with the German Dornier Satellitsystem and an American company (Galaxy) for joint development of *Predvestnik* system. The American company promised to look for an investor for the project, which was this time said to cost $300 millions. (Nothing has been heard about further development of this project lately).

Sfinks project (see item IX. Commercial Proposals) was explored together with Finnish organizations, but funding issues appear unresolved.

VII. Number of employee

Employment: Before conversion started, Arsenal PO employed a total of about 12000 people. Other sources quote - 9000, including 3500 in defense activities; - 8000 as of Oct 1992, including 1500 at DB

VIII. Major facilities

Test and production facilities:

- Vacuum chamber
- Environmental test facilities
- Structural strength and hermeticity test stands
- Vibration tables
- Shock test equipment
- Centrifuges
- Anechoic chambers for testing spacecraft antennas
- Equipment for testing electromechanical drives

The Arsenal Machine-building Plant deals with mechanical tooling, electrochemical processes, sheet metal punching, non-metallic materials, galvanizing and painting technology, thermal processing, welding, electrical equipment, assembly, and integration.

IX. Commercial proposals

As a part of conversion efforts, Arsenal DB offers commercial applications of its available space technologies. Arsenal proposed the following "direct conversion" projects:

- *Poputchik* ("Hitchiker") program - launching of customer's satellite piggy-back to a regular spacecraft;
- *Escort* program - placement of customer's payload aboard of a regular spacecraft;
- *Platform* program - development of a dedicated spacecraft according to customer requirements on the basis of the available spacecraft platform.

Under Poputchik program, a spacecraft with a mass of up to 130 kg and stowed size of up to 800 x 1000 x 1500 mm^3 can be delivered to near circular orbit with a height of 400-500 km and an inclination of 65 degrees. In the future envisioned possibility of increasing hitchhiker payload mass up to 500 kg and size up to 1300 x 2000 x 3000 mm^3.

Under Escort program, user's payload of similar weight and size (130 kg, 800 x 1000 x 1500 mm3) can be accommodated on board of a regular spacecraft. The basic spacecraft would provide constant 3-axis stabilization in its operational orbit (400-500 km high, 65 degrees inclined) and up to 200 W of electric power. Upon user's desire, up to 7 Mbytes of information could be stored aboard and dumped to Russian receiving station for further transmittance to user.

Under *Platform* service Arsenal DB offers

- integration of user's equipment with Arsenal's spacecraft platform (which provide guidance, power supply, attitude control, thermal control, telemetry, etc.);
- launch of spacecraft;
- in-orbit control of spacecraft;
- data reception from the spacecraft and their transmittance to customer.

Principal performances of the platform:

- mass of payload	- up to 700 kg
- power supply	- up to 1 kW
- payload accomodation volume	- 3 m^3 of non-hermetic space and

	- 0.5 m^3 in hermetic thermostatic section
- attitude	- constant, 3-axis in orbital frame of reference
- orbits	- circular up to 800 km
	- elliptic with an apogee up to 1100 km
	- inclination 65 deg
- launch vehicle	- Tsiklon-2

A new platform with extended capabilities, expected in the future, will offer:

- mass of payload	- up to 5 tons
- power supply	- up to 4 kW
- payload accomodation volume	- 25 m^3 of non-hermetic space and 2 m^3 in hermetic thermostatic section
- orbits	- circular up to 2000 km
	- elliptic with an apogee up to 8000 km
	- inclinations from 51 to 100 deg
- launch vehicle	- Zenit

Under this program Arsenal DB already pursues several projects:

- *Konus-A* - monitoring of space gamma-ray bursts ;
- *Predvestnik-E* - studying electromagnetic precursors of earthquakes;
- *Sfinks* (Sphynx) - studying of cosmic radiation.

Civil products by Arsenal include:

- compressors;
- facilities for production of highly pure liquid nitrogen;
- medical equipment;
- heaters;
- aluminum houseware;
- toys, etc

トピック：戦略的資源－ロシアの技術開発の商品化について

「エキスパート」誌 2000 年№16 に「戦略的資源」と題する科学技術の商品化がいかに困難な事業であり、ロシアがその面でいかに遅れを取っており、今後その為に何をすべきかについての論文が掲載されていました。たいへん興味深い内容なので、全文を和訳しました。
ロシアには今も世界の研究･開発者の 12%がいる（米国は 25%）等、文中の数字データも豊富で、ソ連時代の遺産を持て余すロシアの姿が浮き彫りにされています。

戦略的資源

ロシアの科学技術は依然として強力である。しかし、これを商品にするにはイノベーション・マネジャーが必要である。

冷戦時代、西側の人々はロシア人のテクノクラートとしての才能に脅威を感じていた。ロシア人はアメリカの秘密諜報機関が予想していたより数年早く原子爆弾を開発し、大陸間弾道ミサイルを最初に打ち上げ、宇宙では長い間リーダーの座を保っていた。それ故、鉄のカーテンが落ち、ソ連防衛産業の秘密が明らかにされ始めると、西側企業の密使たちは超効率的な新技術を求めてロシアに吸い寄せられるように集まってきた。期待通りだった。我々は多くの軍事分野で我が国の地政学上の敵と同じレベルにあり、いくつかの分野では彼らのはるか先を行っていることが明らかになったからである。しかし、多国籍企業のスパイたちがロシアのノウハウを必要としていたのは、純粋の平和産業市場における競争力の向上が目的であったことから、事態はより複雑となった。

この問題について研究した専門家の言葉によれば、外国企業家の観点からすると、我が国軍産複合体の開発品の大部分は半製品でしかない場合がしばしばあり、さらに「市場条件のレベルまで仕上げる」必要がある。これに対し、現在のイノベーション市場においては、発注者は既に完成済みの技術を選好する。このほうが簡単で安上がりだからである。設計者、発明者、あるいは科学者自身は、自分の創作物を市場条件に合わせて仕上げるなどという作業はやりたがらないものであり、そもそもその能力がない。一人の人間が科学者としての才能と企業家としての才能を併せ持つ確率は、きわめて低いからである。科学の歴史をひもとくなら、科学者が自分の発見が実際上はまったく無益だと言明している例が多数残されている。例えば、19 世紀の末、ハインリッヒ・ヘルツは「電磁波はけっして産業上の応用を見出せないだろう」と語っていたし、またニールス・ボーアは 1930 年代初頭には、「原子力は永遠に人類の手に届かない」と考えていた。

ロシアの指導部が思いつきで始めた軍民転換は、その道の最高級の専門家に別の市場で働くことを強制したばかりでなく、専門分野とは言わないまでも、職業を変えるよう勧奨するという、稀に見る愚かさを特徴としていた。著者はある省の廊下でこんな話を聞いたことがある。軍事部門で活動していたある設計事務所が自動ジャガイモ掘り機の試作機の

設計を依頼された。設計技師たちは転進を決意し、新たな製作物の設計にその全力を投入した。試験のために来訪した委員会が見たのは、おそらく世界で最も改良の進んだジャガイモ掘り機の試作機であった。機械は抜群の操縦性を備え、衛星通信を利用して起伏の大きい土地でも正しく進行方向を判断し、イモができている深さを高精度で読み取って掘り起こし、土を正確にすきほぐし、平らにならすことができた。機械の値段が最新式の戦闘用ヘリコプターより少し安いだけだったことは、言うまでもない。この機械に対して農業機械市場に参入せよとの指示が下された。

世界の研究・開発者の 12%がロシアに

ロシア連邦科学技術政策省の推定によれば、現在、世界のハイテク市場の 40%はアメリカによって支配されており、ロシアのシェアは 0.5%以下である。ところが人的潜在力の比較は、これとは別の様相を呈している。我が国で働く科学者・技術者の割合が、世界のすべての科学者・技術者の約 12%であるのに対し、アメリカはわずか２倍の 25%にすぎない。これらの数字は我々を気落ちさせると同時に、次のような疑問を抱かせる。我が国の潜在的科学技術力の質はあまりに過大評価されているのではなかろうか、あるいは、我々は我が国の最も貴重な資源の一つを活用する能力にまったく欠けているのではなかろうか、と。

科学者、専門家、科学技術産業省および経済省の役人にアンケート調査を行ったところ、我々は今もなお、多数のハイテク部門で潜在的に強力な地位を占めているという。原子力部門あるいは宇宙部門を例にとってみよう。原子力と宇宙というソ連時代の２つのスーパープロジェクトは見事に実現され、現在も強力なストックを持っている。核燃サイクルの創出を可能とする我が国の高速増殖炉は世界で最もすぐれた増殖炉の一つである。オブニンスクとスネジンスクで開発された原子核ポンプレーザーは、アメリカではまだ開発されていない（同国では国家対弾道弾ミサイル防衛計画の枠内でこれまで開発作業が進められ、現在も行われているにもかかわらず）。我が国の衛星打上げロケットは最も安く、かつ信頼性が高い。ロッキード・マーティン社は同社の将来の新型ロケット用エンジンの選定を行った際、ヒムキ市にある科学生産企業「エネルゴマシ」の RD-180 型エンジンの採用を決定した。現在、2015 年における火星有人探査の可能性を検討しているアメリカとヨーロッパは我が国の専門家に照会を行っている。有人宇宙飛行と原子力ロケットエンジンの分野で、我が国に大きく遅れを取っているからである。

専門家はさらに、原子力と宇宙以外に我が国が世界的レベルにある分野として、航空機製造、新素材、化学（特に触媒化学）、バイオテクノロジー、応用数学およびプログラミング、原料採取・精製技術、超伝導およびレーザー技術、非在来型エネルギー技術、SHF 電子工学をあげている。言うまでもなく、このリストはそれぞれの専門家の関心や専門上の目標に応じて、もっと長く続けることができる。しかしいずれにせよ、科学にとって厳しい時代であった 1990 年代を経たにもかかわらず、我が国社会には現在もなお、先進国

に十分ふさわしいテクノクラート層が維持されていることは間違いない。しかし、我が国が世界経済のイノベーション分野に占める割合は、0.5%でしかないのである。

この不一致の原因がどこにひそんでいるかを理解するためには、次の事情を想起する必要がある。すなわち、ソ連時代の科学界の構造を原因として、改革の開始に伴い、旧ソ連時代の部門別研究所およびアカデミー研究所（その数は1990年頃には数千に達していた）が、イノベーション市場の主要参加者とならざるを得なかったという事情である。アメリカのソ連科学史研究家ローレン・グレハムは、ソ連においては、「“科学研究所”という言葉は、西側諸国では聞いたこともないほどの意味と地位を獲得していた」と指摘している。第二次世界大戦後のソ連の著名な科学者とエンジニアのほとんどすべては、何らかの研究所の研究員であるか、または研究所と密接な関係を持っていた。ソ連指導部は、革命以前の科学研究組織のシステム改革に当たっては、カイザー・ウィルヘルム協会傘下の研究所が国家科学の基礎をなしていたドイツを模範に選んだ。「科学と産業の関係という問題に関しては、ドイツの科学と教育が産業界の利益によって冒涜されていなかった時代を郷愁をもって思い出す額の広いドイツ知識人の見解と、資本主義産業の影響による科学の歪みについて語るソ連の社会主義者の見解との間に、興味深い類似が生じていた」と、ローレン･グラハムは書いている。しかし、ソ連の指導者はドイツ人よりはるか先まで進み、基礎研究分野だけでなく、産業技術開発分野にまで中央集権的研究所システムを適用した。「ドイツ人教師の遺訓」に対する忠誠は、時として不条理の域にさえ達した。例えばフェリクス・ジェルジンスキーは、研究所の目的と関心を個々の生産現場と結合させてはならないと考え、研究所を工場に連結させるべきであるとする一部テクノクラートの提案に強く反対していた。実体経済部門（特に民生部門）からの「研究所科学」の分離が確立したのは、スターリン時代に入ってからのことである。この断絶を克服せよとの党と政府の再三の呼びかけ（ゴルバチョフに至るまでの）にもかかわらず、事態はまったく変わらなかった。その結果、ソ連の「産業開発」はきわめて脆弱なものとなった。既に80年代には准博士号を持つソ連の科学者全体のわずか３%しか生産現場で働いておらず、「研究所は、組織的にも、地理的にも、さらには理念的にも工場から分離されていた」と、グレハムは指摘している。

中央集権的研究所システムは、例えば水力発電所の建設、原子爆弾の製造、あるいは弾道弾ミサイルの開発といった優先分野における巨大な資源の動員を必要とする大規模プロジェクトではその真価を発揮したが、「トップダウン」された詳細な優先課題が存在しない条件下での事業、すなわち、あらゆる種類のハイテク部門（特に消費財市場志向部門）の事業にはまったく適さないことが明らかになった。研究所の敷地の賃貸が大部分の研究所のほとんど主たる収入源となったまさに過去10年間に、このことが証明された。

もちろん例外はあったが（次章ではその一つについて詳しく述べる）、全体的に見るなら、ロシアの研究所は完成した技術の買い手を見つける能力も、また自分の開発成果を市況に適合するレベルまで仕上げる能力も遺伝的に持たないことが明らかになった。――研究所は助手を求めていたのだ。

「ターンキー」技術

発明品や開発品を市場全体の状況に適合させる任務を負っているのは科学者や役人、いわんや買い手や投資家ではなく、まったく特別のある人々であるということを我々が理解したのは、つい最近のことである。西側の文献においては既に 20 年ほど前から、研究開発者、メーカーおよび投資家の仲立ちをして統一的な連鎖を創り出す専門家の種類を意味する、「イノベーション・マネジャー」および「テクノロジー・ブローカー」という用語が見られるようになっている。無論、我が国にはこのような専門家は存在しなかった。これが現れ始めたのはこの数年のことである。そして彼らはイノベーション市場での仕事の経験を持たなかったことから、開発管理（イノベーション・マネジメント）ではなく、既に完成した技術の取引（技術仲買業）から始めるのを常としていた。実際のところ、これもまたひじょうに難しい仕事であることが明らかになった。

ノウハウ取引の秘訣を教えてくれる場所は我が国にはなかった訳であるが、その先例は、クルチャトフ研究所がその技術の一つ（原子力分野で大きな競争優位性を持つ電磁パルス溶接技術）をアメリカの発注者に初めて売却した 1974 年に既に存在していた。この時は科学者や役人の力で何とか対処することができたが、最近、研究所の新聞「クルチャトベッツ」に発表された彼らの回想から判断すると、この案件の参加者たちは、自分たちにとってまったく新たな馴染みのない種類の仕事に取り組んでいるのだと感じつつ、「歩きながら学ぶ」ことを余儀なくされた。

テクノコンサルト社は 1993 年、まさにこの技術仲買業で利益を得る目的で設立された。その設立者たちは、個々の発注者に合った必要なノウハウを効率的に探し出せるようにするための「エキスパート・パネル」を作ることを決定した。テクノコンサルト社のセルゲイ・シマラノフ社長は、「我々は様々な企業、特に外国の会社からの依頼に応じてロシアの開発者を探し出す仕事をしていたが、次にどんな引合いが来るかわからないため、例えばエレクトロニクス、あるいは化学といった具体的な分野に会社を特化させることは不可能だった」と語っている。科学技術のきわめて多様な分野の専門家数百人が会社の専門家としてスカウトされた。ノウハウの探求は開発や研究自体に劣らず創造的な仕事であることが明らかになった。どこで探し出すかを形式論理的に判断してはうまく行かない場合がしばしばあった。シマラノフ氏はこう回想する。「ある外国企業が、飛行機エンジンの騒音防止技術を見つけ出すよう当社に依頼してきた。発注者自身がロシアの航空機関係の設計事務所と工場のリストを我々に手渡し、これに従って探すよう指示した。我々は正直にリスト全部に当たってみたが、何も見つけることはできなかった」。求められている技術（特殊な騒音吸収被覆）が存在することがわかった。しかしそれは航空機工業部門ではなく、工作機械製造部門にあった。したがって、仮に部門間にまたがる専門家の人材基盤がなかったとすれば、形式論理に従うばかりで、探求は失敗に終わっていたに違いない。

これと同じほど印象的なもう一つの例は、清涼飲料水市場に関するものである。よく知られているように、ペットボトルの主な欠点は、ごくわずかではあるが炭酸ガスを通すことで、これが保存期間に決定的に影響する。ある西側メーカーが、ガス透過性が一桁小さ

いプラスチックの製造技術を発見するようテクノコンサルト社に依頼した。必要とされるノウハウは、砲弾の安全保管に関する専門家のところで見出された。「ペットボトルの開発者は、砲弾用の被覆に取り組んでいる人には決して相談をもちかけない。また軍の専門家は、自分の技術をボトル用として提案しようなどとは決して思い付かない。放置されている限り、ロシアの開発者と西側の発注者が相互を発見し合うことは、まずあり得ないことだ」と、セルゲイ・シマラノフ氏は話を締めくくった。

隣接する専門分野

ノウハウの探求と販売に熟達したテクノコンサルト社の最高経営陣は、もし必要とされる技術がどうしても見つからない場合でも受注を断るのではなく、開発の基礎となるものを探し出し、プロジェクトに出資するよう顧客に提案し、プロジェクトの管理は同社が完全に引き受けるほうが得策であることに気が付いた。すなわち、同社は隣接する専門分野であるイノベーション・マネジメントへの進出を決意した訳である。

チャンスは間もなく到来した。外国のある大きな家庭用電子機器メーカーが、ロシアの専門家の協力の下にまったく新しいタイプのマイクロエレクトロニクス装置を開発し、これによって事務機器市場における強力な競争優位性を獲得しようと決定した。この外国の発注者はこの課題を解決する力を持つ研究センターをロシアで見つけようと２年間努力したが、潜在的な実行者（アカデミー研究所および部門別研究所）がいずれもこの有利な提案を断ったため、この試みは不首尾に終わった。問題は、装置の作動原理の基礎となる物理的プロセスが複雑であるばかりでなく、例えばその適切な数学的モデルが存在しないなど、研究が十分に進んでいないという点にあった。しかも、試作品を開発するためには、ユニークな生産施設だけでなく、熱力学、固体物理学および半導体物理学、化学、材料学、マイクロエレクトロニクス、さらには数学の知識を併せ持つ開発者の集団が必要とされていた。テクノコンサルト社はこの仕事を引き受けることを決定し、手持ちの専門家部隊の大部分をこの戦闘に投入した。このプロジェクトのためにロシアの 27 の指導的研究センターから科学者と設計者を招聘することが必要となり、生産施設は９つの企業と研究所の協力がなければ確保し得ないことが明らかとなった。

装置の創出は９ヶ月間で成功し、しかも、専門家の評価によれば、その開発の過程で特許取得の要件を備えた 24 件の着想が実施された。ちなみに、この発注者の主な競合企業の一つは、これと同様の装置を開発するのに４年の歳月と５倍の投資を要した。

ところが、きわめて有望な技術の発見または開発に成功したにもかかわらず、顧客が何らかの理由でそれを断るというケースがあった。そしてこの時、会社の事業の第３の分野となる独自技術の市場参入という着想が生じた。「この分野にとって、現在はひじょうに好都合な時期だ」と、シマラノフ氏は断言する。「我々がこれを感じ始めたのは、“危機”の直後だった。“８月 17 日”（1998 年）、それはイノベーション・ビジネスにとって、素晴らしい日付となった」。このチャンスの魅力は、平価切下げが技術輸出に対して単なる競争上の価格優位性を与えたことのみではない。さらに重要なもう一つの点は、鉱

工業生産の上昇の結果、生産施設の近代化を必要としているロシア国内の顧客がますます多くテクノコンサルト社の事務所を訪れるようになったということである。セルゲイ・シマラノフ氏はこれを次のように説明している。「以前、ロシアの企業家は短期資金と高い収益性を期待する場合が多かったが、イノベーション・ビジネスはそれを保証することはできなかった。現在、彼らは別の考え方をするようになった。— 自分は明日もこの市場で自分のシェアを維持できるだろうか、そして明後日は、この部門を掌中に収められるだろうか、と」。そしてそのためにはリスクを取り、イノベーションを探求し、導入しなければならない。この問題を抱えたロシアの企業家が訪ねる先は、実際の市場から遊離した異言語で語る部門別研究所ではなく、イノベーション・マネジャーなのである。

そもそも、これは今までになかったことなのだろうか？ 実のところ、これは効率的経済の単純な構造モデルにすぎない。すなわち、科学者や技術者はイノベーション・マネジャーの指揮の下で技術開発を進め（幸いまだまだ余力が残されている）、イノベーション・マネジャーはその開発成果を実際の市場に適合させ、成長する産業界は喜んでそれを買い取るという構造である。ただ一つ残念なのは、テクノコンサルト社は今のところ、さしたる競争を感じていないということだ。

ハイテクは常に新しい

「ハイテク」と「ローテク」の区別はあくまでも相対的なものである（かつては蒸気機関も立派なハイテクだった）。境界線がどこを通っていたかが明確に認識されるのは、新たな技術体制が既に形成され終わり、それまでの体制を根本から押しのけ始めた時に限られる。例えば、自動車製造、金属工業、電気工業、石油生産・精製、有機・無機化学工業が技術体制の中核をなしていた工業時代の末期に入ると、「ハイテク」とはソフトウェア、半導体技術（マイクロ回路製造）、光ファイバー通信線、原子力、省エネルギーであり、これらが次の「脱工業」体制の技術的集合体を形成するということが明確になった。現在の時期の特徴は、「脱工業化」体制に続く技術体制（その呼び名はまだ考え出されていない）が、あまりにも急速に到来しつつあるという点である。各種専門家の意見によれば、バイオテクノロジー、非在来型エネルギー（例えば太陽エネルギーや水素エネルギー）、ナノテクノロジー、分子エレクトロニクス、超伝導技術、マルチメディア通信、さらには月経済や火星経済といった珍奇なもの（これは有用鉱物の採取だけでなく、有害・危険生産施設の地球圏外への移転も意味する）さえが、その技術的中核を形成することになる。それ故、今日、「ハイテク」という用語をめぐってある種の混乱が生じており、工業体制以降に生じたものすべてを安易にこれに分類する傾向が見られる。

科学にいくら金をかけるか

教育と科学は金のかかる予算科目である、どの財務大臣もそう考えている。研究センターの維持運営は慈善事業に類する、どの所長もそう考えている。この考えと訣別しない限り、我々は、輸入技術により輸入設備で採掘され、輸入品のパイプで輸送され、外国の相場で外国の貿易業者によって販売される石油に頼って暮らし続けるだろう。

ところで、アメリカは毎年 300 億ドル以上の知的財産権を売っており、知的財産権取引に関する合衆国の黒字残高は 200 億ドル余りに達している。これだけで既にロシアの石油輸出額を大きく上回っている。アメリカにおける知的財産権取引の急増が可能となったのは、国家助成金を利用して資金調達された発明であっても個人的に特許を取得することが大学の科学者に許可されてからのことである。基礎科学が巨大な数の応用結果を生むことは、周知の事実である。ビジネスがこの結果を利用することを合衆国は容認したのである。

しかし、重要なのは、知的創作物は絶対的に換金性の高い商品となり得るという点だけではない。経済が研究開発にどれだけ投資するかと、経済がどれだけ発展するかとの間の明確な相関関係に注意を向けることこそ、きわめて重要である。

ある国の GDP 成長率に対する技術進歩の寄与を算定する際、現代のエコノミストはこの要因に 70～80%の割合を割り当てる。このような評価を公理とすれば、今日の研究開発投資の水準が今後長期間続いた場合には、ロシア経済は高い成長率を達成することは不可能であると断言することができる。現在、ロシア経済が研究開発に対して僅か GDP の１%以下しか投資していないのに対し、欧州連合はその全加盟国に対して研究開発投資の水準を GDP の 2.5%まで引き上げるよう勧告している。しかし、この数字が上限でないことは当然である。アメリカは研究開発に 2.7～2.8%を常時投資することにより、ハイテク市場における自らの安泰を確かに感じることができている。この意味で、これより GDP が小さい国はより高い比率を科学に費やすことを余儀なくされている。なぜなら、研究開発の額は全世界でゆっくりと、しかし確実に統一化されつつあるからである。例えば日本はより高い比率を自覚的に投資している。日本は知的創作物の輸出をアメリカと競おうとしているからである（日本は知的財産権取引に関して安定的に貿易黒字を続けているアメリカ以外の唯一の国である）。

研究開発投資は国家の絶対的義務という訳では決してない。G７参加諸国では研究開発投資への国家の関与は縮小し続けている。これは、民間部門が自らイニシアチブを握る必要があると考えているためである。先進諸国においては研究開発費の 70%近くが予算ではなく、民間部門によって支出されている。国家は教育と基礎研究のみに投資すればよく、それ以外のすべては産業界自体によって行われている。G７参加諸国の研究開発投資額全体のちょうど半分を占めるアメリカでは、いくつかの企業が国家全体の投資額に比肩し得るほどの額を研究開発に投資している。ゼネラルモーターズ社は毎年 100 億ドル、フォード社は 70 億ドル、IBM 社は 40 億ドルを費やしている。

ラテンアメリカ諸国と東南アジア諸国の戦後における成長速度を十分正確に比較してみると、研究開発投資が総合的に経済効率を向上させるという事実を確認することができる。前者は研究開発の点でロシア式のやり方を取り、その額は GDP 比１%以下となっていた。その結果はロシアの場合と同様、経済の停滞であった。これに対し、いくつかの東南アジア諸国は、国家による研究開発費増加奨励策のおかげで GDP の 2.7%近くを研究開発に回すことが可能となり、一時期にはこの指数の点でアメリカやドイツを追い越したこともある。その結果、マレーシアはマイクロプロセッサー市場で、シンガポールはソフトウェア市場およびバイテク分野で、台湾はパソコン製造分野で、韓国は家庭用電子機器分野で絶対的競争力を備えるプレーヤーとなった。最も単純な無線電子機器の組立から出発し、その収益を一方ではアメリカの零細企業の開発品のライセンス取得に、他方では自社の研究開発に振り向けたサムソン社が、今や日本やアメリカの競合企業全体を相手に、独自のチップ、バイオテレビ、超大画面テレビ、壁掛けフラットテレビ、ノートブック用カラーディスプレイを生産していることに驚く者はいない。

このような会社は、ロシアにもブラジルにも存在しない。なぜなら、これらの国は天然資源と原始林が豊かで、それを誇りに思っているからだ。