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Chapter 24

80 Years of the Khrunichev Space Center—From Cars to Space Vehicles*

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This paper contains a description of the history of the Russian Khrunichev Space Center, an 80-year anniversary which was celebrated in 1996. Continuing advances and developments in aviation technology and production capacities provided a transition to developments in the area of space/rocket technology beginning in 1960. The first launch vehicle developments are described, which evolved into well-known examples worldwide, such as the Proton. The processes and results of Khrunichev's work in the area of manned astronautics, such as the TKS ferry spacecraft and orbital stations are examined as well. Advances developments at Khrunichev such as the Angara heavy launcher, small launch vehicles and satellites and ferry spacecraft and modules on the FGB basis are also described. The paper examines information on prospects for development of production, test and launch bases at Khrunichev, including its international relationships and cooperation.

The history of our company is a history of the establishment and development of Russian strategic aviation, intercontinental ballistic missiles, and advanced space technology including launch vehicles, spacecraft, and orbital stations. It is also a history of new technological developments, an expansion into

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an international commercial space market, and a participation in the realization of some large international space programs (Fig. 1).*

At the present time Khrunichev is a large company providing complex work in the creation of modern space/rocket technology, beginning with preliminary developments; this includes the experimental confirmation of technical solutions, the manufacturing and testing of hardware, and providing operations (including commercial ones) in the conditions necessary to be at levels that conform to world standards (Fig. 2).

A lot of the present Russian and world space companies can be proud of their evolution from one of the most advanced technologies of the twentieth century: aviation. But only a few of them began their histories with one of the century's other early advanced technologies: automobile manufacturing. Our company's history took this route—it began in April 1916 when the Directors of the Russian/Baltic joint Stock Company purchased a large area of land in the Moscow suburb of Fili and began to construct a large automobile plant. It was named the "Second Russo-Balt" (the "First Russo-Balt" plant was in Riga, Latvia). After five years the plant had produced five cars (Fig. 3). However, the "automobile period" in our company's history was short.

In 1923 a government decision to transfer the plant through a concession agreement to the German "Junkers" aviation company was approved. This company manufactured its aircraft for Soviet aviation there up to 1926, but they did not justify the existence of the concession. In addition, the "Junkers" company did not fulfill several conditions of the agreement. Because of this the agreement was cancelled, and the plant turned to the production of Soviet aircraft designs. It is necessary to note that the most advanced aviation technologies of that time (for example, all-metal airframe structures) were adopted in our plant from the early beginning of the "aviation period" of its history. Airplanes like the TB-1 and TB-3 (Fig. 4) heavy bombers were eventually prototypes for all the monoplane multi-engine bombers in the whole world.

A lot of world records and numerous record flights were achieved by airplanes built by our plant. These capabilities were completely utilized when World War II came to the territory of the Soviet Union. The large-scale production of Il-4, Pe-2, and Tu-2 bombers at our plant provided the Soviet Air Force with the most modern aviation techniques. It is necessary to note especially the Tu-2 (Fig. 5) bomber, which was superior to all tactical bombers of that time in terms of performance. Putting into production such an advanced airplane during wartime was a remarkable event by itself, but thanks to its capabilities the plant was up to the task.

These capabilities provided the plant with an opportunity to remain on the cutting edge of aviation development in the post-war years as well. Thus, in

* **Note:** Figures suitable for publication were not available for this paper. For those wishing to view the figures, it is suggested that the reader try and locate a copy of the International Academy of Astronautics preprint (IAA-97-IAA.2.2.05).

1947-1949 the Tu-12 and Tu-14 (Fig. 6) pioneer Soviet jet bombers were manufactured. But the most important task became the production of the Tu-4 strategic bomber (Fig. 7); this was begun in 1949. Solving this task put the plant on a level with the most advanced aviation technologies of the time.

This level of achievement was exceeded when in 1951 the Design Bureau, headed by the remarkable Soviet aviation designer Vladimir Myasishev, was established on the grounds of the plant. During this period our plant developed the 3M and M-4 strategic jet bombers (known as the "Bison" in the West) (Fig. 8). They formed one main part of Soviet Strategic Aviation, and were notable for an astonishingly long life—it is enough to say that one of them was reconstructed into the "Atlant" (VM-T) carrier for the delivery of the "Buran" shuttle in the late 1980s (Fig. 9).

In the early 1960s the M-50 heavy supersonic bomber (Fig. 10) was made and other very promising projects were on the drawing boards, including a supersonic passenger airliner and even an intercontinental supersonic cruise missile (Fig. 11). However, at the end of 1959 a government decision was approved regarding switching to rocket technology. The "aviation period" of Khrunichev's history was ended with the manufacture of Mi-6 heavy helicopters in 1960-1961 (Fig. 12).

Of course, a change in the direction of activity was not simple, but the first rocket developed, the UR-200 missile (Fig. 13), was produced in a short amount of time. Numerous advanced technologies like gimbaled rocket engines, storable hypergolic propellant, waffle structures, etc. were used in its design. It is interesting that the UR-200 had a dual purpose (as an intercontinental ballistic missile and space launch vehicle) from early on in its development.

The UR-200 passed through 9 suborbital test launches but it was not accepted for operation. However, it laid down a basis for developments that followed. Thus, the UR-100 (called the SS-11 by the West) ICBM (Fig. 14) became a mainstay of the Soviet Strategic Rocket Troops. Its further modifications, including the RS-18 (SS-19) (Fig. 15) remain on duty in the Russian Army to the present day.

The UR-100 had no dual purpose, but the UR-500, which was put into development in 1962, did have this. However, initially developed as a super-heavy ICBM, by the end of its development only its designation as a heavy space launcher remained. This was the famous "Proton" (Fig. 16), a maiden launch of which (in its two-stage version) took place on July 16, 1965. There is no need to repeat the well-known history of "Proton" operations and to describe its present status and prospects. Interested persons can see its current versions and performance at the Khrunichev exposition in a section of this Congress's exhibition area.

But developing launch vehicles was not the sole aspect of Khrunichev's space activity. The company was involved in the development and creation of an orbital station and its ferry spacecraft (the TKS) within the scope of the

"Almaz" program. Following this, Khrunichev developed and manufactured all Soviet/Russian orbital stations, from the "Salyut" to the "Salyut-7" and "Mir" (Fig. 17). The creation of the "Mir" station was the realization of essentially a new concept—the construction of a large orbital structure made of unit-modules.

These modules were created mostly on the basis of the TKS Functional Cargo Block (FGB). The TKS itself was manufactured in four flight examples in the late 1970s. They provided for unmanned test space missions under the names "Cosmos-929, -1267, -1443, and -1686" including dockings with the "Salyut-6" and "Salyut-7" orbital stations. Despite a successful flight testing of the TKS, it was not used for manned missions. However, its FGB unit was adopted as a basic design not only for the "Mir's" modules but also for the "Energy" block, the first element of the International Space Station (ISS) which still maintains the initial FGB name (Fig. 18).

All of the above-mentioned examples of space technology can be seen at the Khrunichev exposition.

It is necessary to note that the FGB is also a service module of the "Polus" heavy experimental unmanned space station being developed by our company and used as a payload during the maiden flight of the "Energia" super-heavy launcher in 1987.

The direction of orbital space stations at the present time is concerned mostly with the FGB and Russian Service Module. Numerous projects involving other kinds of space hardware for the ISS, including ferry spacecraft and crew rescue vehicles are in a process of development and examination.

Among the numerous developments being provided by Khrunichev, the KRB (CS) cryogenic upper stage for the Indian GLSV launcher (Fig. 19) and the "Rockot" small launcher can be noted.

The development of the KRB, not only provided an initial experience with large-scale international cooperation, but also created a practical basis for the following development of the more powerful KVRB upper stage intended for use with the advanced heavy launchers of Khrunichev.

In turn, the creation of the "Rockot" small launcher—a conversion from the RS-18 (SS-19)—required the development of the quite new "Breeze" upper stage using a storable propellant. Advanced solutions used in its design were confirmed during three successful test flights of the "Rockot," including one orbital mission. In such a way the ground for Khrunichev's new direction of activity—the development of our own upper stage family—was laid down.

Models of the KVRB and "Rockot" are on display at the exposition.

Today Khrunichev continues to develop in all of the above-mentioned directions. Thus, besides the development of the "Proton-M" modified launcher which should be in flight next year and the deployment of the "Rockot" commercial operation, to say nothing about the continued operation of the "Proton," both for national and international (mostly commercial) purposes, Khrunichev is creating at the present the new advanced "Angara" heavy launch vehicle (Fig. 20); a competition for this development was won by our company in 1994. Khrunichev also provides other preliminary developments for space launchers of various classes, including reusable ones.

Besides the development of the KVRB and deploying for the production of the "Breeze-K" upper stage for the "Rockot" launcher, Khrunichev has also developed the "Breeze-M" upper stage for the "Proton-M" and "Angara." This upper stage has an original design—its core part, being made on the basis of the current "Breeze-K," is provided by an additional toroidal propellant tank which can be ejected after its propellant's consumption. The process of this upper stage assembly is shown in Fig. 21. A full-scale mock-up of this stage was shown in the Paris Airshow this year (its scale model is shown at the exposition.

The current directions of Khrunichev activity were joined by a new one—the development of small satellites. The first of them was developed and manufactured for the German/Japanese/Russian/Australian "Express" experimental project (Fig. 22). Being injected by a Japanese launcher into an uncalculated orbit in January 1995, this satellite nevertheless provided for the implementation of the mission for the most part; this was confirmed when its re-entry capsule was found in Africa after a year. A family of small satellites is in the process of development on the basis of the Unified Space Bus, which was derived from the "Express" satellite's bus. Satellites for Earth observation are included, in particular, in the composition of this family. It is necessary to note that work on Earth observation was begun by our company earlier when various projects involving special spacecraft were developed, and the "Priroda" module, providing mainly for this mission, is functioning successfully in the composition of the "Mir" station. At present a project for the All-European ecological data bank (Fig. 23) has been proposed by our company.

The activity of Khrunichev, in so wide a variety of directions, is provided for by its design and production capabilities. However, they would be insufficient without the necessary production cooperation. Such cooperation is supported and maintained by Khrunichev. It is sufficient to say that Khrunichev provides work for more than 100 subcontractors in Russia and the CIS.

Besides production cooperation, the infrastructure of the cosmodrome is necessary for providing space activity. Khrunichev has just provided for a reconstruction of a part of the Baikonur cosmodrome in order to achieve a world-class level of conditions for "Proton" commercial launch preparation and implementation. Reconstruction of the launch site for the "Rockot" at the Plesesk cosmodrome has begun. Work on the development for the use of the new Svobodny cosmodrome has been provided.

The greatest part of Khrunichev's present operational activity involves using the "Proton" launcher for commercial missions. This kind of activity is performed through the "International Launch Services" (ILS), a Russian/American

Joint Venture, a part of which, the "Lockheed-Khrunichev-Energia International" (LKEI) was founded in 1993. The "Proton" just provided a range of such commercial launches, and the ILS has a large list of signed contracts for its later usage, providing satisfaction in 50% of all geostationary injection demands for the world's market in the near future.

Within the scope of Khrunichev's international commercial activity, it provides injections into orbit of the "Iridium" satellites of the American Motorola Company, and has shared participation in this project. Khrunichev also has the Eurockot Joint Venture for "Rockot" commercial operation with the German DASA.

These are only Khrunichev's largest efforts in the area of international commercial space business. Cooperation with the American Boeing Corporation on the ISS, and with the largest European companies—DASA (Germany) and Aerospatiale (France)—and other examples of similar activity can be added. Our partners, customers, and competitors understand that the scientific potential, dynamic development, and high production quality of Khrunichev make it possible even today to offer a wide range of competitive products and services which correspond to the top standards of the world market. The Khrunichev management believes that only partner consolidation and mutual beneficial cooperation in the realm of space activity can produce good results.