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Chapter 12

The Soviet Meteo Rockets History, 1946–1991*

Christian Lardier†

Abstract

In 1948, on the initiative of G. I. Golychev from the Central Aerological Observatory (TsAO), the laboratory no. 1 for stratospheric studies (30–100 km) was created. In doing this, the laboratory used altitude probes and automatic aerostats. The laboratory chief was V. A. Poutokhine (died in 1953) and the main engineer was A. M. Kassatkine. A little time after, a laboratory no. 2 was created for the study of the tropopause studies—25–30 km of altitude. The laboratory no. 1 came under the stratospheric studies sector (OSI), then the upper atmospheric layer physics sector (OFVSA). Poutokhine asked for the development of the first Meteo rocket to the main designer A. D. Nadiradze of KB-2—the agricultural machines ministry (ex-ammunitions).

The MR-1 of Nadiradze

Alexandre Davidovitch Nadiradze (1914–1987) began his career at 18 years old as a worker at the aeromodelism laboratory of the aviation and chemistry society (Osoaviakhim) of the Georgian Council in Tbilissi. Entering the Caucasian Industrial Institute in 1936, he received his engineer degree at Moscow

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† *Air & Cosmos*, Paris, France.

Aviation Institute (MAI) in 1940. During this time he also worked at the Central Aerohydrodynamic Institute (TsAGI) until 1938, studying a project of an airplane on air cushion with the engineer N. I. Efremov (Samoliot Efremov–Nadiradze or SEN). Later he was named main designer of the airplane UT-2N at the factory no. 22 imeni Gorbounov of Moscow.

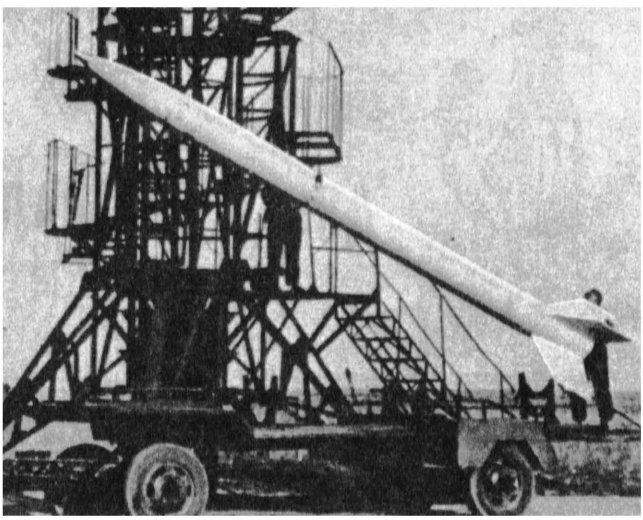
Figure 12–1: Alexandre Davidovitch Nadiradze (1914–1987). Credit: Lardier Archives.

At the beginning of the war, he started to work on rockets at TsAGI. At the end of 1941, he proposed an anti-tank rocket equipped with a warhead of NII-6 that was tested at the Sofrino test range during the winter of 1943, but all of them didn't reach their targets. An expert report showed that the combustion of the powder was slowed by the low temperature of the air. Later still, he studied a rotation turbo-reactive rocket based on Katiouchas (M- 13UK and M-31UK) with S. A. Khristianovitch, F. R. Gantmakher, L. M. Levin, Ya. B. Chor, and others.

From 1945 to 1948, he headed the Opytnoye Konstruktorskoye Byuro (OKB) of the weapons faculty (rockets) of the Mechanical Institute of Moscow (MMI) under the ammunitions ministry (which became MIFI). There, he gave lectures and undertook research on two-stage rockets.

In 1948, his OKB was transferred to KB-2 (which became NII-642 in December 1951). There, he started development of the Meteo rocket, MR-1. It was a two-stage rocket of 7.8 m length and 480 mm caliber. The first stage was a solid propellant booster (a cluster of eight motors), whereas the second stage was liquid propellant (nitric acid–kerosene) that employed a pressurized propellant feed system. At take off, the two stages were ignited simultaneously. After launch from spiral tubes that gave a rotation around the longitudinal axis, burnout velocity of 1,100 m/s was achieved at an altitude of 30 km. Moreover, the rocket was equipped with aerodynamic stabilizers.

Weighing in at 680 kg, the vehicle projected a payload of 72 kg to an altitude of 100 km. The payload included thermometers to measure temperature, thermic manometers and a membrane to measure pressure, bolometers, and four cameras. Sometimes, the MR-1 carried balloons to take air samples and ultraviolet (UV) spectrometers to measure ozone density. The scientific data were sent by telemetry.



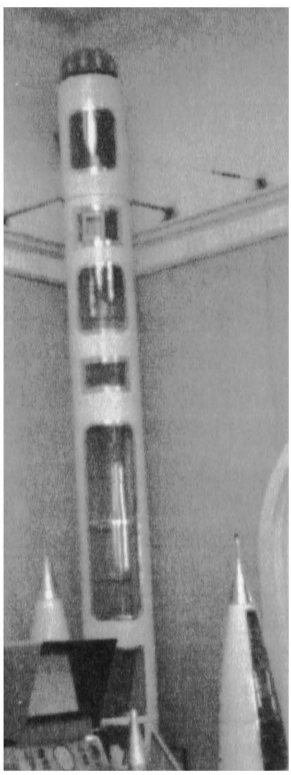


Figure 12–2: The MR-1 rocket of A. D. Nadiradze made its first flight in 1951.
Credit: Lardier Archives.

The payload was separated at the altitude of 70 km, and the second stage and the payload were recovered with the help of parachutes made by the institute of O. I. Volkov, which allowed reuse a second time as the landing speed was only 5–6 m/s.

The first flight was in October 1951 at Kapustin Yar (station M-202 of Volgograd), and the rocket was observed during ascension by cinetheodolite until it reached 60 km altitude. During descent, the parachutes slowed the payload, allowing the determination of high altitude wind direction speed. In total, there were 50 launches for TsAO (M. N. Izakov, G. A. Kokine, A. M. Kassatkine, N. S. Livchitz, and E. A. Bessiadovsky) until 1958.

At NII-642, there were four design bureaus (OKB) headed by main designers D. L. Tomachevitch/M. V. Orlov for the naval missile HS-293-RAMT-1400-KSCh-Chouka; A. D. Nadiradze for the Taïfun-Strij-RZS-115-Voron and Fritz-X missiles and Tchaïka-Kondor; D. M. Svetchanik/N. M. Tchinenkov for the flying bomb Krab-Snab-3000; and E. N. Kacherininov for the air-to-air missiles. Svetchanik was transferred to NII-48 in Novossibirsk in August 1955, whereas Kacherininov went to NII-1 in 1955 (guided rockets sector). The NII-642 was absorbed by the OKB-52 of Tchelomei at the end of 1957 (which became the GNPP Vympel). On his side, Nadiradze had conflicts with Tchelomei during 1958–1961 and left NII-642 becoming the chief of NII-1/MIT during 1961 to 1987.

The MMR-05 and MMR-08 of Sevrouk

In order to be able to launch Meteo rockets from any place around the globe, in 1956 it was decided to develop a new mobile sounding rocket derived from tactical military rockets. The TsAO requested Dominik Dominikovitch Sevrouk (1908–1994) of the NII-88 in Kaliningrad (today TsNII Mach in Korolev) to undertake the work. Graduating from the electrical machine-building institute of Moscow in 1932, Sevrouk worked in TsIAM. After being arrested in 1938, he worked in Charachka at OKB-16 (Gouchko) in Kazan during 1941–1946. After liberation in July 1944, he became the first deputy of Gouchko's OKB-456 between 1946 and 1952. From March 1952 to December 1958, he was chief of OKB-3 in NII-88. During this period he was responsible for creating:

- the engine S3-892 for the missiles Tchirok and 3R7/Korchoun from which meteorological rockets MMR were derived,
- JATO U-19 and U-21 for airplanes SM-12, SM-50, and E- 66,
- the engine of the missile 208,
- the turbo-pump engine S3-42A of the missile 217 of Lavotchkine,

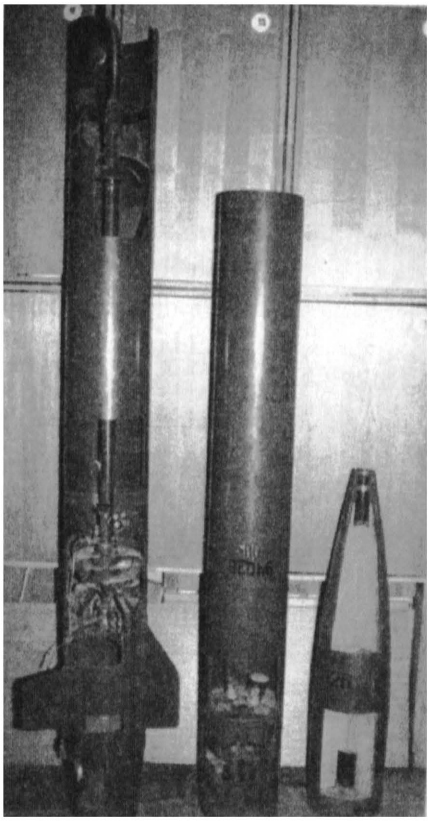
- the engine of the missile R-15 of Yangel,
- the engine of the missiles V-750 and V-1000 of Grouchine,
- the engine of a winged missile of Tchelomei,
- the engine of the missile R-17 (Scud) of Makeiev, and others.

Заместитель главного конструктора
Д.Д. Севрук

Figure 12–3: Dominik Dominikovitch Sevrouk (1908–1994). Credit: Lardier Archives.

After that, when Sevrouk refused to go to Dniepropetrovk, his OKB was given to A. M. Isaiev in December 1958. Sevrouk then returned to OKB-456 in 1959–1961 (as deputy main designer for electro-nuclear engines). He took over as head of the OKB Zaria (ex Engine Institute of Stetchkine) in 1962 and created the nuclear propulsion installation E-30, after which he returned to NII-88 in 1965 to 1972 (reliability) and became chief of the satellite energetic equipments chair at MAI in 1972 to 1988.

Initially, the German rocket Taïfun was developed in the Soviet Union in two versions: R-110 with liquid propellant (Tchirok) and R-110 with solid propellant (Strij). They were first both produced by the sector no. 6 of NII-88 headed by P. I. Kostine (1904–1970). Kostine, who had been main designer of guns at plant no. 8 in 1943–1946 (which became NII-88 in May 1946), was named, on 30 November 1945, as the head of the plant SKB to study Germans trophies. In August 1946, the SKB was given to K. I. Tritko, and Kostine became chief of sector no. 6, his deputy being V. F. Tcheremoukhine. The sector no. 11 was led by Nikolai Mourine, who was responsible for creating the launching complexes.



In 1950, the Strij was given to Nadiradze, who was a part of the RZS-115 system from which the carrier vehicle was developed by the TsNII-58 of V. G. Grabine (Podlipki near Moscow). This program was stopped in 1953 and gave birth to Voron, from which the launching complex was given to factory no. 232 Bolchevik (Leningrad). As for Tchirok, he was sent to the new OKB-3 of Sevrouk in March 1952. His deputy for testing was G. M. Tabakov, whereas P. I. Kostine was chief of sector. For the engine, a competition was introduced between Sevrouk and Isaiev. Sevrouk won with the S3-892 (nitric acid–kerosene). The Tchirok became the rocket 3R7 of the Korchoun system. It measured 5.53 m long, and 250 mm of caliber; the missile weighed 375 kg with 162 kg of propellant and 100 kg of payload.

Figure 12–4: The Korchun missile of Sevrouk used as basis of the Meteo rockets MMR-05 and MMR-08. Credit: Lardier Archives.

The rocket, serial produced by the Kovrov factory, was launched from a truck 2P5 (SM-44), built by TsKB-34 in Leningrad. The 2P5 had six spiral launch installations of the same type as the MR-1. Thus, the trajectory of the 3R7 was assured by rotation and by four aerodynamic stabilizers. The engine burned for 7.8 s and the rocket reached the speed of 1,000 m/s, giving a maximum range of 55 km. An 8B51 version, equipped with an Isaiev engine, was developed by P. N. Baïkovsky and M. I. Douplichev of SKB-385 in Zlatoust in 1952, but was canceled in 1954. Although the Korchoun was declared operational in 1957, it was soon canceled but found a second use in becoming the meteorological rocket MMR-05 during 1956–1959. Being longer than the 3R7—7.01 m instead of 5.53 m—this version weighed 396 kg and carried a payload of 60 kg at 50 km of altitude. As with the MR-1, the payload was recovered by parachute. The MMR-05 was used during the International Geophysical Year—being launched from Heiss Island (Novaya Zemlia) and from the *Obi* ship, mainly from Antarctica. It was

also equipped by the *Voeïkov* and *Chokalsky* ships of the Hydrometeorologic Service. In total, there were 260 launches of MMR-05 until 1959.

As for the MMR-08, it was 8.02 m long, weighed 485 kg at take-off, and could reach 80 km of altitude. Some 540 units were launched during 1959 to 1965.

The MR-12 of F. F. Petrov

At the end of 1959, on the request of TsAO, the OKB-9 of Fedor Fedorovitch Petrov (1902–1978) began the development of the Meteo rocket, MR-12. Graduating from MVTU in 1931, Petrov had worked in the field of artillery at the Motovilikhinsk plant near Perm. In 1942, he was main designer of the OKB of factory no. 9 (UZTM/OuralMachZavod) in Sverdlovsk (headed by L. R. Gonor in 1942–1946). In 1944, he received the medal of "Hero of Socialist Labour" and led the OKB until 1974, then worked for four years at the defense industry ministry (MOP).

Figure 12–5: Fedor Fedorovitch Petrov (1902–1978). Credit: Lardier Archives.

His successor was Vladimir Alexeievitch Goloubev (1933–1998), who after graduating from the military mechanical institute of Leningrad in 1957 entered OKB-9. He began his career with rockets in contributing to the realization of the D-90T and D-90S rockets for submarines. After the transfer of this activity to another company, he took the function of deputy during 1965 to 1974, then of chief and main designer of OKB-9 from 1974 to 1992. The actual chief of OKB-9 and main designer was Valeri Nasedkine.

Petrov's deputy for rockets was Nikolai Grigorievitch Kostrouline. The work on tactical rockets began in 1956. The Onega was studied from February 1958 to February 1960 and was a solid propellant rocket of 2–3 t, 9 m long, 450 mm caliber, and had a range of 50–70 km. The D-75M existed in a naval version and a ground version, which served in a nuclear bomb test in the atmosphere in 1962.

Figure 12–6: Victor Petrovitch Teslenko. Credit: Lardier Archives.

The meteorological version MR-12 was decided by decree no. 240-90 of 23 February 1960, and the development was under Victor Petrovitch Teslenko (1933) sector in two years. The engine (thrust of 10 t and specific impulse of 205 s) and propellant NMF-2 were provided by the polymer materials institute of Perm, headed first by A. M. Sekaline, then by L. N. Kozlov (NII-130, then NPO Kirov) The recovery parachute of the nose cone was produced by A. M. Kleiman of NII PDS. The rocket was 1.44 t (1.29 t of propellant), measured 8.77 m long with a 450 mm caliber, and carried 150 kg to 180 km altitude. The payload included 50 kg of scientific instruments. For launching, there was a ground installation D-76 and a naval installation D-78 and for the transport, the OKB-9 made the D-77 vehicle.

Test flights began with mockups in spring 1962 and the first flights from Kapustin Yar were in May of that year. Then, during the autonomous tests, four installations were used during nuclear testing at Semipalatinsk (Kazakhstan).

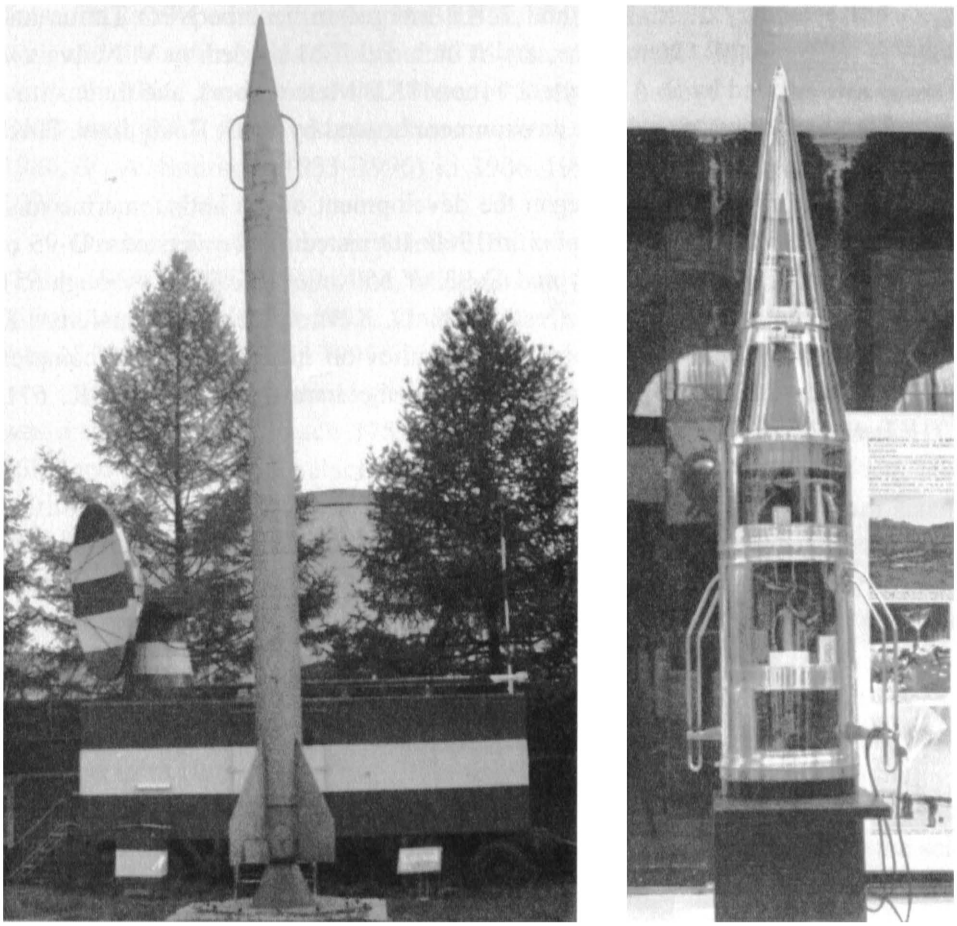


Figure 12–7: The MR-12 rocket of F. F. Petrov and V. P. Teslenko.
Credit: Lardier Archives.

In December 1963, a decree gave the serial production to the heavy machines factory of Petropavlovsk (PZTM) in Kazakhstan. PZTM, created in 1961, produced the launch installations of missiles 9K76 Temp-S, Oka and Totchka of NII-1/MIT.

The development of the MR-12 was finished in 1965 and was then launched from Kapustin Yar and Heiss Island (first flight on 24 January 1966), when the MR-12 was placed under supervision of the applied geophysical institute (IPG). V. P. Teslenko's group was transferred into the Obninsk subsidiary of IPG, which in 1968 became the Institute of Experimental Meteorology (IEM). In 1970 V. P. Teslenko's sector became the hydrometeorological apparatus TsKB (TsKB GMP). This sector was headed by Teslenko during 1963 to 1970, then by A. A. Chidlovsky, before it closed due to lack of activity in 1999.

On 1 January 1986, IEM and TsKB merged to become NPO Taïfun and today is led by V. M. Cherchakov, and it included IEM headed by V. N. Ivanov, TsKB GMP headed by S. A. Sarytchev (now SKB Meteopribor), and the institute of problems of monitoring of the environment headed by V. G. Boulgakov. There were 685 employees.

In addition, the OKB-9 began the development of the antisubmarine missile, Viouga, of the RPK-2 complex in 1960. It existed in two versions: D-95 of 533 mm of caliber (Viouga-53) and D-93 of 650 mm of caliber (Viouga-65). Meanwhile, the rocket thematic (team of N. G. Kostrouline) was transferred to OKB-8 Novator of Lev Veniaminovitch Liouliev on 1 July 1964. The complex was declared operational in August 1969 on the submarines 705, 705K, 671, 671RT, and 671RTM.

Figure 12–8: Lev Veniaminovitch Liouliev (1908–1985). Credit: Lardier Archives.

OKB belongs to the aeronautical industry ministry, whereas, for Petrov and PZTM, to the weapons industry ministry. Liouliev (1908–1985), became the new main designer of the MR-12. Having graduated from the Kiev polytechnic institute in 1931, he worked in the field of artillery in the Motovilikhinsk plant near Perm, and after that in factory no. 8 of Podlipki near Moscow. In 1941, the factory was evacuated to Sverdlovsk. In 1945, he was the main designer of the OKB of factory no. 8, which made at that time ground-to-air guns. In 1958, he developed the ground-to-air missile 3M8 Kroug and, in 1964, began working on antisubmarine missiles (RPK-2 Viouga, RPK-6 Volopad, RPK-7 Veter, 3M10 Granat, 3M14 Kalibr, 3M51 Alpha, and 3M54 Biriouza). In the field of air de-

fense, he developed the missiles 9M38 Buk, 9M82, and 9M83 of the S-300V system, and the antimissiles 5Ya26 et 53T6 (Gazelle of the ABM system of Moscow). In 1966, he received the "Hero of Socialist Labour" medal. He headed OKB until 1985 when his successors were A. F. Oussoltsev (1930) in 1958–1986, V. A. Smirnov (1933–1996) in 1986–1996 then P. I. Kamnev (1937) in 1996.

On his side, factory no. 8 imeni Kalinine was headed by M. V. Lavrov (1911–1969) in 1957–1969, A. A. Mekhrentsev (1925–1985) in 1970–1977, A. I. Tiziakov (1926) in 1977–1991, Vladimir Kazimirsky (1941) in 1991–1997, and then N. V. Klein (1955) in 1997.

In 1967, Liouliev developed the first variant of the MR-12, the M-175. It was a version able to reach 175 km altitude, launched from an installation D-76M, and carried by the vehicle KS-47, using telemetric systems RTS-8 and Meteorit-R. The flight tests (three flights including one which did not return scientific results) were carried out at the Emba polygon. The president of the state commission was the deputy of the technical department of the Hydrometeorological Service, L. A. Alexandrov. His deputies for the technical part were the deputy of Liouliev, A. T. Ginzbourg, and the chief of sector of the IPG subsidiary, V. P. Teslenko. Seven other launches were made on 21 and 22 June 1967 to measure ozone between 35 and 90 km. On 9 and 10 October 1967, MR-12s were launched from Heiss Island with instruments from the French Aeronomy Service of Centre National de la Recherche Scientifique (CNRS) to create sodium clouds in order to measure the temperature of the polar thermosphere. In 1967, the scientific ships, *Professor Zoubov* and *Professor Vize* of the Hydrometeorological Service of the Soviet Union, were equipped with launch installations D-78 for the rocket D-75M.

The first launch was on 9 May 1968 from *Professor Vize* (10 launches were made between 9 and 22 May). The president of the state commission was the technical director of the Hydrometeorological Service, B. G. Rojdestvensky, his deputy being V. P. Teslenko. On his side, *Professor Zoubov* tested the KS-52 complex (modification of D-78) in July/August 1969 (10 launches occurred, including 5 without scientific results). The president of the state commission was A. A. Fokine of IEM. Nine extra launches were made in October–December 1969 under the supervision of A. A. Chidlovsky. From 14 to 16 December 1971, in the framework of Cisaspe and Circe experiments of ionosphere study, a Veronique-61M was launched with Soviet mass spectrometers and two MR-12s were launched from *Professor Zoubov,* located off Kourou, with French mass spectrometers.

In 1967, another variant M-250 (complex MR-25) was built to reach the altitude of 250 km. The solid propellant rocket was stretched, and the payload increased (1.3 t instead of 1.0 t on MR-12). The flight tests were done in Emba in the spring and the state acceptance (10 launches) in June 1970. The rocket was created by OKB-8 (Liouliev, A. T. Ginzbourg, A. F. Oussoltsev, and others). The propellant was developed by NIIPM (L. N. Kozlov, E. A. Medvedev, G. K. Balabanov, R. V. Chirokov, and others). For the assembly, technological support was provided by the OKB-203 of A. I. Yaskine in Sverdlovsk (which became the KB KompressorMach in 1966, then NPP Start in 1994).

In July 1969, a modified version of the M-175 (D-75MG), launched from Kapustin Yar, served to create sodium clouds in the high atmosphere. This version gave birth to the M-180: two launches were made on 7 November 1971 and 21 March 1972 from Heiss Island (altitudes around 190 km were attained).

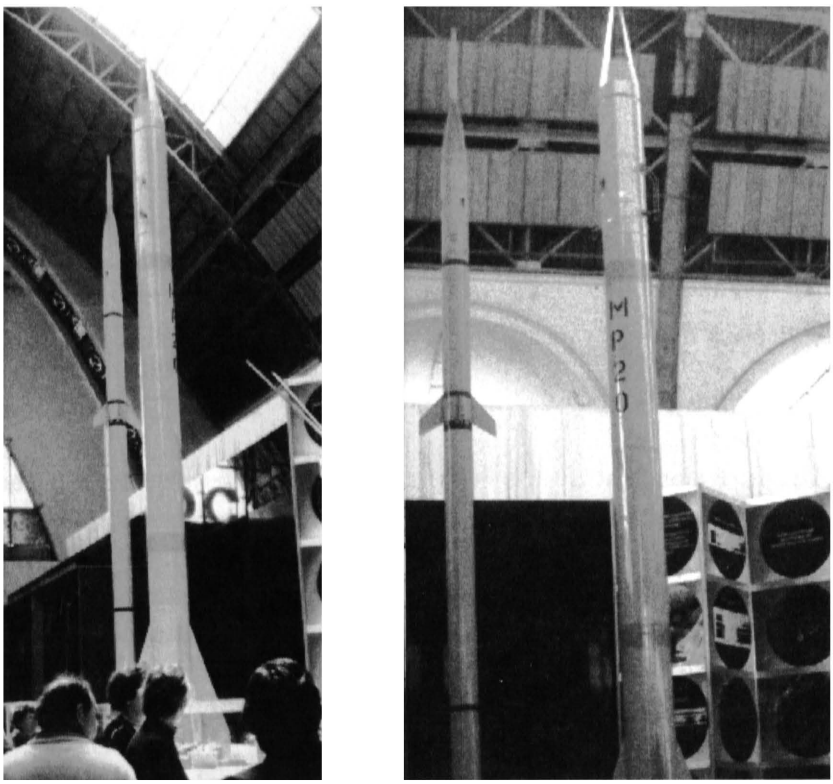


Figure 12–9: The MR-20 of L. V. Liouliev. Credit: Lardier Archives.

Finally, the MR-20 was developed in 1973–1980 on the basis of D-75MG. This new modification for high altitude was built by the TsKB GMP (A. A. Chid-

lovsky), PZTM (V. A. Choukine), and NIIPM (L. N. Kozlov). The solid propellant mass increased from 1.0 t to 1.2 t (against 1.3 t on MR-25). Due to a problem with the impact zone of the rockets, flight tests in Kapustin Yar were slower than planned and occurred from 1979 to 1985. The state commission was headed by the IPG director, S. I. Avdiouchine. The maximum altitude reached was 235 km. Starting in 1986, the MR-20 was launched from the *Professor Vize* and *Professor Zoubov* ships.

In total, there were 1,254 launches from 1962 to 1997, which allowed 2,725 scientific experiments to be flown. On 18 October 1983, an accident in Kapustin Yar partially destroyed the installations and killed three people.

The MR-12 has been equipped with many types of different nose cones (type RV, OV, SV, VP, E). The experiments were provided by IPG (S. I. Avdiouchine, You. F. Ivanov, G. F. Toulinov, V. V. Mikhnevitch, and others); TsAO (G. A. Kokine, E. A. Besiadovsky, A. F. Tchijov, and others); GOI (V. S. Davydov); GosNITsIPR (National Centre for Earth Remote Sensing, now NPO Planeta of Obninsk); et cetera. Some experiments were parts of larger systematic campaigns, such as Sun-Atmosphere (four campaigns in 1969, 1971, 1973, and 1976 with 22 launches of rockets D-75MG during the campaign from 24 September to 10 October 1971); Polar Morning (two campaigns in 1972 and 1974); Corpuscular Energetic Sources in High Atmosphere (campaign in 1976–1979); Tropical Dawn (1971); et cetera. Moreover, from 1964 to 1997, MR-12 served for 310 active experiments to study the high atmosphere, ionosphere, and magnetosphere (injection of neutral or charged particles, creation of artificial aurora borealis, et cetera). These studies were made by Izmiran (I. A. Jouline, V. N. Oraievsky, and others); IPG (S. I. Avdiouchine, Y. A. Romanovsky, and others); IKI (R. Z. Sagdeiev, G. G. Managadze, and others); et cetera. It included the experiments Zarnitsa-1 of 30 May 1973 and Zarnitsa-2 of 11 September 1975 with an electron accelerator (cesium); Spolokh-1 of 4 September 1975 and Spolokh-2 of 29 June 1978 with an injection of barium; Ariel-1 of 29 October 1977; Ariel-2 of 30 October 1977; Ariel-3 and Ariel-4 in 1979 with a plasma gun (100 to 1,800 joules); Aelita-1 and Aelita-2 with an electron accelerator (lithium); Stereotop of 1 December 1978 with an electrons accelerator; and others.

In the framework of the Interkosmos program, a flight was made from Kapustin Yar in November 1973 to carry out synchronous measures with the Interkosmos-10 satellite. In the framework of Franco–Russian cooperation, more than 30 experiments were performed with sodium clouds provided by France from 1967 to 1972. Then there was the IPOCAMP program for the study of the high atmosphere in 1973–1982: Ipocamp-1 in March 1974, Ipocamp-2 in March 1977, Ipocamp-3 in March 1979, and Ipocamp-4 in 1981. It was the study of polar

ionosphere by the research center in physics of the terrestrial and planetary environment of CNRS in Orléans. In the framework of American–Russian cooperation, five launches of D-75MG occurred from *Professor Vize* off Wallops Island in June 1978 for the Jaspic experiment (corpuscular source inside night ionosphere). Finally, the last two launches of 30 January and 6 February 1997, made from Kapustin Yar, flew the Flacus-1 and Flacus-2 experiments from the dynamic of geosphere institute of the Russian Academy of Sciences with the American Applied Physics Laboratory/Johns Hopkins University (APL/JHU).

Moreover, the MR-12 served also for technical qualifications. Thus, 21 launches of D-75MGP (18 successful) occurred from 1971 to 1976 to test a soft landing system for Martian probes developed by the parachute building institute (NII AU, then NII PDS). In the same way, three launches of D-75MGK occurred in 1977–1978 to test an aerodynamic braking system of NPO Lavotchkine.

The storage of MR-12 engines was the responsibility of the Baltic fleet, but it changed location three times: Liepaya (Lithuanie), then Tallin (Estonie), then Bolchaya Ijor near Leningrad. In 1986, the USSR made the decision to make two new launching sites—in Dixon and in Tixi—in the Arctic, but financial difficulties led to the cancellation of the project in 1991.

The M-100 of A. T. Tchernov

In 1963, the main designer A. T. Tchernov developed a new solid propellant meteorological rocket: the M-100 able to carry 15 kg to 100 km. It was a two-stage rocket of 250 mm caliber, measured 8.25 m long and weighed 475 kg. The second stage of 4.1 m weighed 1,968 kg. The thrust was 6.4 t for the first stage and 2.27 t for the second. Serial production was given to the StankoMach factory of Tcheliabinsk (already producing tanks, ammunitions, bombs, mortars, and Katiouchas), created in 1935, the factory also made machine tools. During the war, it produced weapons. On this site two factories were built: no. 78 and no. 200. After the war, two SKBs were formed and, in 1953, an OKB for the creation of aeronautical and rocket weapons. The two factories merged in Zavod imeni Ordjonikidze in 1957 and developed solid propellant boosters, the body for Luna tactical missiles, launch installations, and meteorological rockets. Today, the general director is Anatoli Tarassov (born in 1947). The designer that succeeded to Tchernov is Albert Georguievicth Ichtoulov (born in 1938). As chief of the factory design bureau, he contributed to the creation of rockets M-100B, MMR-06, targets MS-9ITs-B, MR-9ITs-B, and 96M6M.

Figure 12–10: A. T. Tchernov. Credit: Lardier Archives.

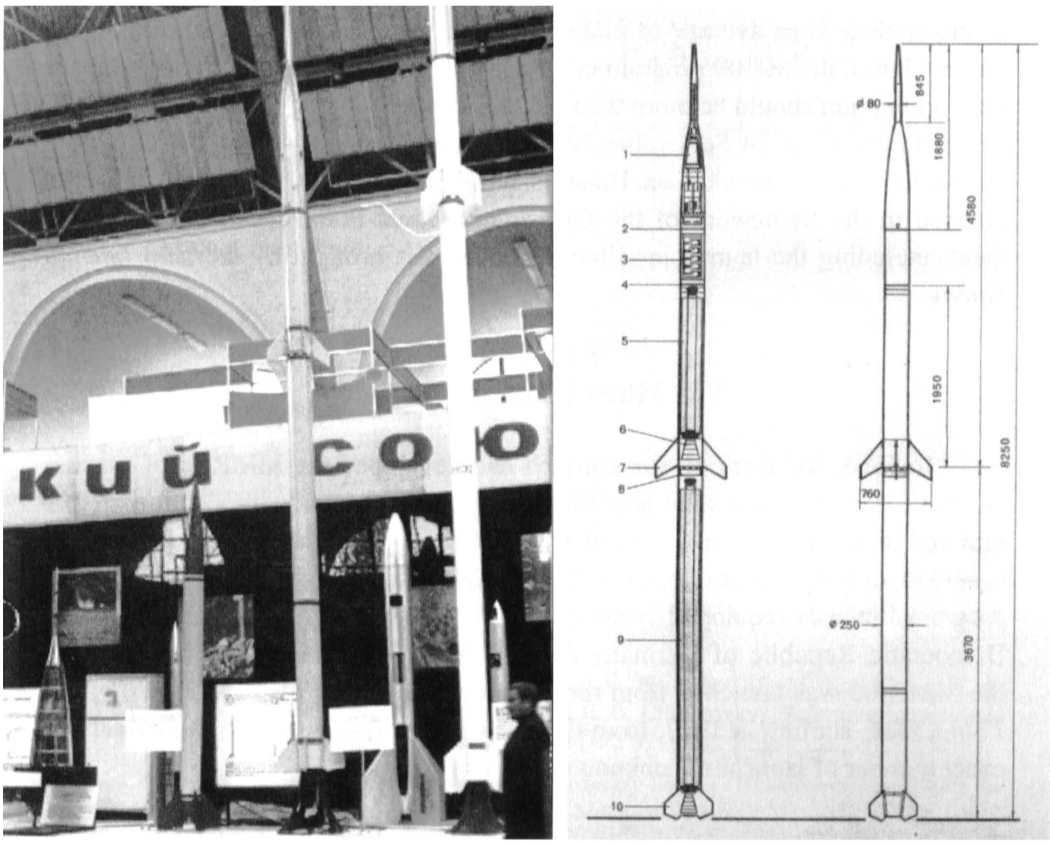


Figure 12–11: The M-100 and M-130 of StankoMach. Credit: Lardier Archives.

A more powerful version, the M-130, was developed and flight tested, but was never put into serial production. The rocket was stretched to 10 m and weighed 600 kg and carried 80 kg to 130 km altitude.

The M-100 has been launched in great numbers from Heiss Island (Droujnaya base), Kapustin Yar, Antarctica (Molodejnaya base), *Veïkov* and *Chokalsky* ships in 1960, then *Academician Korolev* and *Academician Chirchov*. In the framework of the Soviet–India cooperation, the M-100 has been launched from Thumba base, starting in December 1970.

From 27 February to 31 May 1973, M-100 rockets were launched from Heiss Island, Kapustin Yar, Thumba, Kerguelen Island, and Molodejnaya to obtain a profile of the high atmosphere along the 70° East meridian. This experiment was carried out over several years. From 20 September to 3 October 1973, M-100 rockets were launched from *Professor Korolev* off Kourou to allow comparative measurements in the framework of an international campaign (Soviet Union–United States–United Kingdom–France). This experiment was repeated from 3 to 21 October 1977. In total, from 1963 to 1972, 2,206 launches were made, leading to an average of 220 rockets per year. But after the demise of the Soviet Union, the M-100 program ceased in 1995. At the rate of 220 per year, the total production should be more than 7,000 rockets.

However, on 24 September 2007, there was a launch of an M-100B from the Meteo station Krenkel on Heiss Island. That was the first of 10 launches planned in the framework of the third International Polar Year. All the equipment, including the launch installation Kama, was brought by the ship *Mikhail Somov*.

The MMR-06 of StankoMach

In 1968, the team of StankoMach had developed the MMR-06. Launches began in 1970. It was a solid propellant, single-stage rocket with a caliber of 200 mm and measured 3.22 m long and weighed 135 kg. It could carry 5 kg payload to 60 km altitude. The thrust was 1,700 kg. Within the framework of Interkosmos program, it was equipped with a Polish payload DART (Soviet Union–Democratic Republic of Germany (RDA)–Poland–Romania). Starting in 1976, the MMR-06 was launched from the oceanographic ships *Ouchakov*, *Priliv*, and *Volna*, then, starting in 1977, from the ships *Krenkel*, *Passat,* and *Bougaiev*. The exact number of launches is unknown.

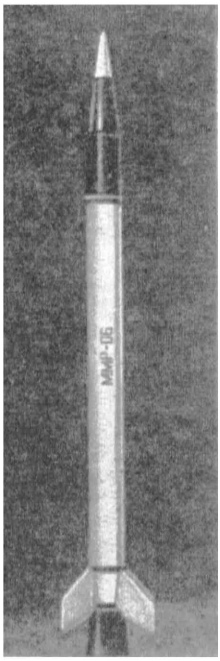


Рис. 4. Общий вид метеородогической ракеты ММР-06

Figure 12–12: The MMR-06 developed by StankoMach. Credit: Lardier Archives.

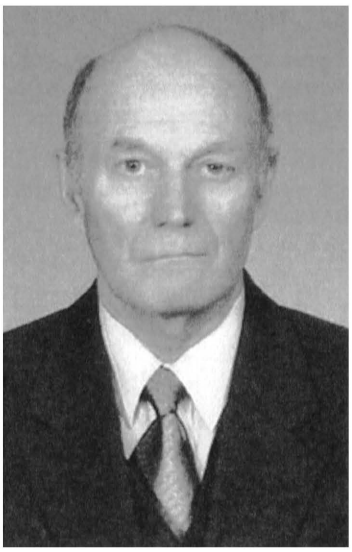


Figure 12–13: Albert Georguievicth Ichtoulov. Credit: Lardier Archives.

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