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The First Space Project of Georgy N. Babakin

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Abstract—The paper covers historical events related to the launch of the *Luna-10* automated interplanetary station in 1966, which for the first time in the world became an artificial satellite of the Moon and performed a number of scientific studies and made discoveries in global astronautics.

Keywords: Georgy Nikolaevich Babakin, artificial satellite of the Moon, irregularity of the Moon's interior, radiation belts, concentration of meteorite matter, space synthesizer

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The preparation of *Luna-9*, its flight, successful landing on the Moon, and the operation of the station on the lunar surface played a huge role in the development of Georgy Nikolaevich Babakin as the chief designer (Fig. 1). In a few months of working on a new topic, with new related organizations and their leaders, Babakin quickly gained authority and respect, he was recognized as a competent technical leader, able to quickly understand the very complex processes of the space industry, draw the right conclusions, and take responsibility. Of course, all previous flights to the Moon and the analysis of their results in the experimental design bureau OKB-1 by Sergei Pavlovich Korolev played a huge role (Evic and Gubaidullin, 2017).

The successful completion of the *Luna-9* spacecraft program inspired confidence in further successes, met the desire of the entire staff of the OKB-1 and plant No. 301 to develop the capabilities and technologies of the enterprise, to work on new projects. Next, the Academy of Sciences proposed the research and development (R&D) apparatus for research at the orbit of the Moon, and in the near future. It is necessary to create the world's first artificial satellite of the Moon!

We had information that work on the LUNAR ORBITER project was also being developed in the United States and that the dates there were scheduled for the middle of 1966.

In the design department under the guidance of Mikhail Ivanovich Tatarintsev, the designers developed the structural layout of the Moon satellite based on the *Luna-9* station. It was Babakin's first space project, the first project of a spacecraft created at the Lavochkin machine-building plant.

Instead of the *Luna-9* automatic lunar station, a detachable sealed container was installed on the *Luna-10* spacecraft—an artificial Moon satellite (AMS), which was made quite simple in design and equipment composition. There was no AMS orientation system, so the apparatus made an nonorientable flight. The fol-

Fig. 1. Chief designer G.N. Babakin.

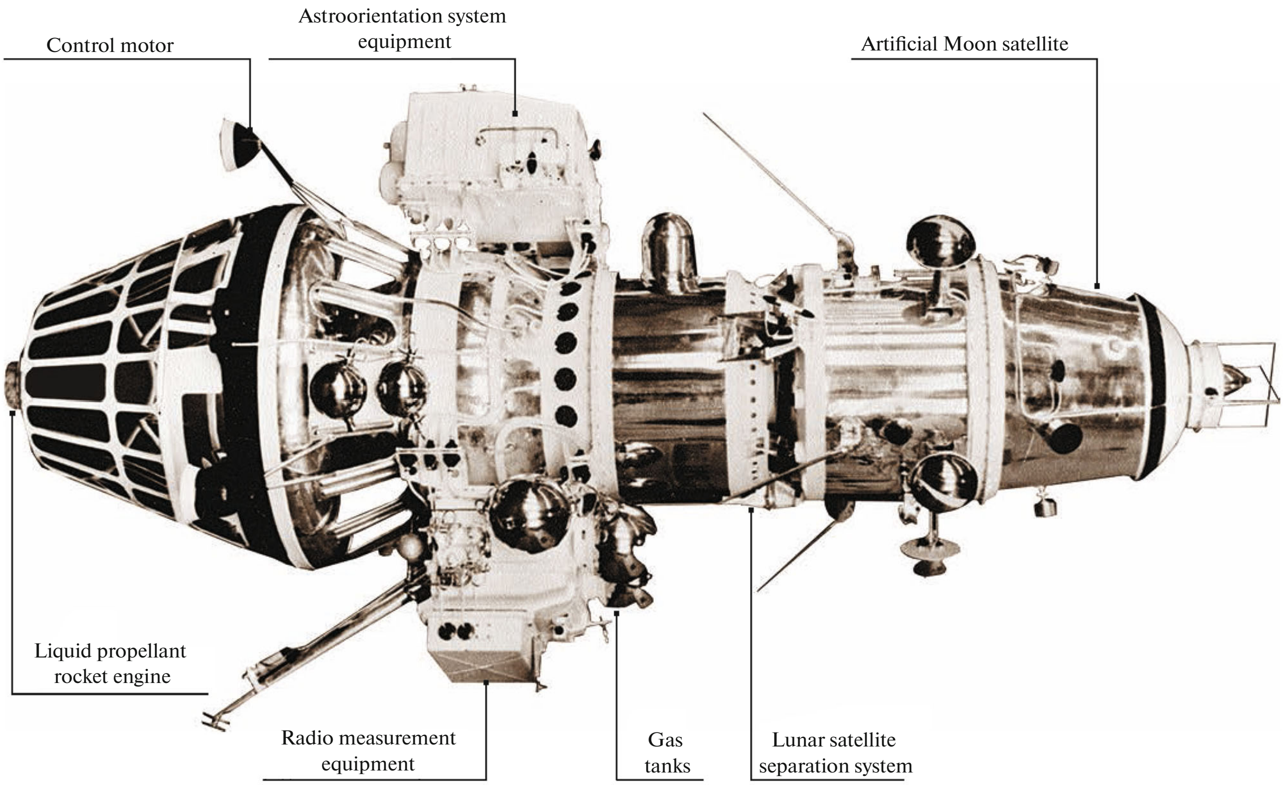

Fig. 2. Schematic view of the *Luna-10* AMS.

lowing items were installed inside the sealed container of AMS: telemetry equipment for collecting service and scientific information, a program-time device, a meter-range CRS radio system and an RKT-1 decimeter transponder, electronic units of scientific instruments and chemical current sources. The thermal control system of the sealed container included a fan, and heat was discharged directly through the walls of the container.

Antennas of radio complexes, a magnetometer rod 1.5 m long, as well as sensors of scientific instruments were placed on the outer side of the AMS (Fig. 2). The mass of the *Luna-10* AMS was 248.5 kg.

It is worth noting that both the Soviet and the American lunar programs at that time were accompanied by the improvement and refinement of launch vehicles, which did not exclude emergency situations. Thus, the flight of the *Luna-10* automatic station was preceded by an emergency launch of a similar station, which Soviet engineers developed and manufactured in record time. The launch of this station using the Molniya-M launch vehicle took place on March 1, 1966, 25 days after the soft landing of *Luna-9*. The first three stages of the rocket ensured the launch of the head unit into the reference orbit of an artificial Earth satellite. But this vehicle did not reach the Earth—Moon section. There was a loss of stabilization at the upper stage “L” operation phase, and the automatic station remained in Earth orbit; it was assigned the index *Cosmos-111*. As a result, a month later, its twin station became *Luna-10*.

Fifty-five years ago, on March 31, 1966, the launch vehicle Molniya—M was launched from the Baikonur Cosmodrome, which launched the *Luna-10* AMS into low-Earth orbit with an altitude of 200 × 250 km and an inclination of 52°. The AMS consisted of a lofted stage, which corrected the trajectory and transferred it to the circumlunar orbit, and a detachable satellite of the Moon (Shirshakov et al., 2019; Efanov et al., 2017; Khartov et al., 2010).

Then the AMS was transferred to the flight path to the Moon. On April 1, the trajectory was corrected. However, errors in the powered flight of the launch vehicle during the launch phase led to the fact that the spacecraft approached the Moon three hours ahead of the estimated time. Taking this into account, the settings for braking and the program of the sessions were adjusted. On April 3, 1966, at a distance of 8000 km from the Moon, the astroorientation and navigation system was turned on, which ensured the construction of a triaxial orientation along the Sun, Moon and Earth. The corrective braking propulsion system KTDU was turned on at the estimated time and, having worked for 26 seconds, ensured the maneuver of the *Luna-10* station with insertion into a lunar orbit (Fig. 3).

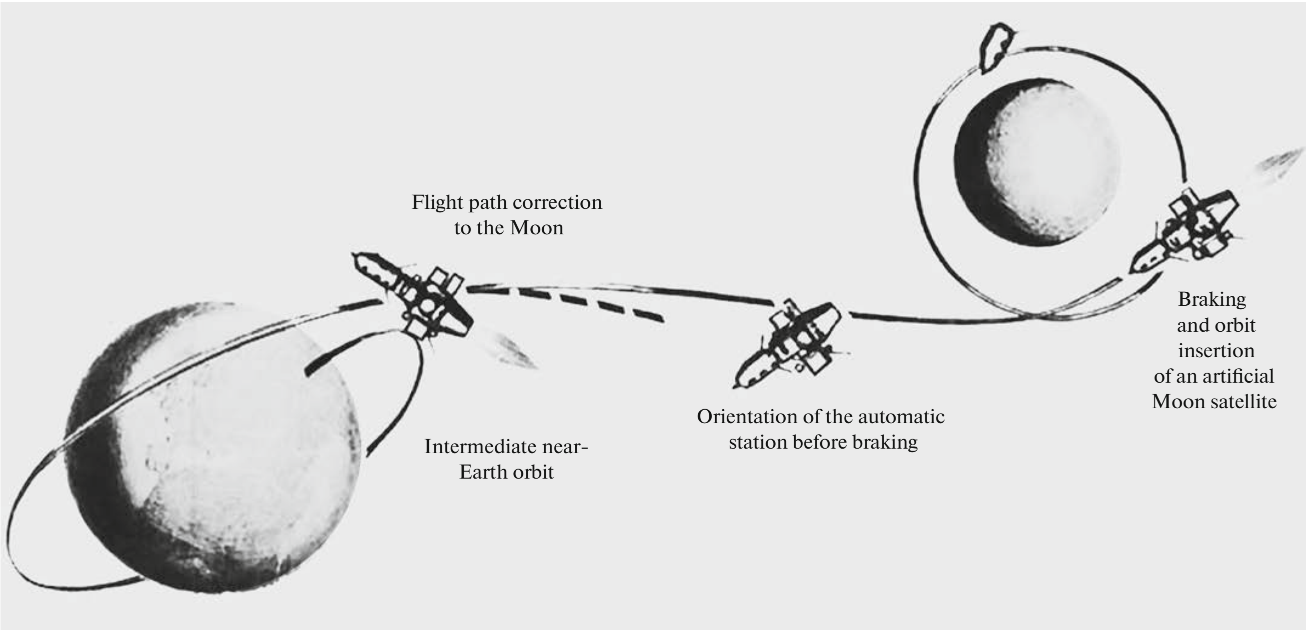

Fig. 3. Schematic flight path of *Luna-10*.

In 20 seconds after the end of the braking action, the satellite itself, the AMS, separated from the trajectory block with orbital parameters: apolune—1027 km, perilune—350 km, inclination—67°9′, and orbital period 2 h 58 min 11 s (*Avtomaticheskie kosmicheskie apparaty*…, 2010).

SC *Luna-10* became the world's first artificial satellite of the Moon.

The spacecraft (AMS) was designed to carry out scientific research of the Moon and circumlunar space in the orbit of an artificial lunar satellite.

Orbital measurements made it possible to establish the nonsphericity of the gravitational field of the Moon and for the first time to obtain its refined model. This was the first indication of a significant inhomogeneity of the Moon's interior. In addition, the mass of the Moon was refined.

The composition of the scientific equipment of the *Luna-10* AMS (*Avtomaticheskie kosmicheskie apparaty*…, 2010) included:

— Gamma-ray spectrometer 3134-03 for studying the intensity and spectral composition of gamma radiation from the lunar surface, characterizing the type of lunar rocks (Vernadsky Institute of Geochemistry and Analytical Chemistry).

— Radiometer SL-1 for studying the radiation environment near the Moon (Skobeltsyn Institute of Nuclear Physics, Moscow State University).

— Device D-153 for the study of solar plasma (Russian Academy of Engineering).

— Three-component magnetometer SG-59M on a rod 1.5 meters long for studying the interplanetary magnetic field and clarifying the lower limit of the possible magnetic field of the Moon (Pushkov Institute of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation).

— Device ID-1 for recording the infrared radiation of the lunar surface and for clarifying data on the thermal regime of the lunar surface (Skobeltsyn Institute of Nuclear Physics, Moscow State University).

— Device RMCH-1 for recording meteorite particles in circumlunar space with a mass of at least 10^{-8} grams (Vernadsky Institute of Geochemistry and Analytical Chemistry).

— Device RFL-1 for detecting X-ray fluorescence radiation (lines of silicon, aluminum, and magnesium) of the Moon (Lebedev Physical Institute of the Russian Academy of Sciences).

During the flight of the satellite in lunar orbit, it was possible to carry out a whole range of scientific research. For the first time, data on the general chemical composition of the Moon by its surface gamma radiation pattern were obtained. As a result, it was concluded that lunar rocks belong to the type of basaltic rocks found on Earth.

The measured intensity of corpuscular radiation showed the absence of any anomalies in the near-lunar space, similar to the Earth's radiation belts, and Soviet scientists concluded that the Moon had no radiation belts. During its powered flight, the station twice crossed the Earth's magnetosphere tail. The RFL-1 device detected electrons that form a continuation of the Earth's magnetosphere tail. Studies of the Moon's magnetism have confirmed that the Moon does not

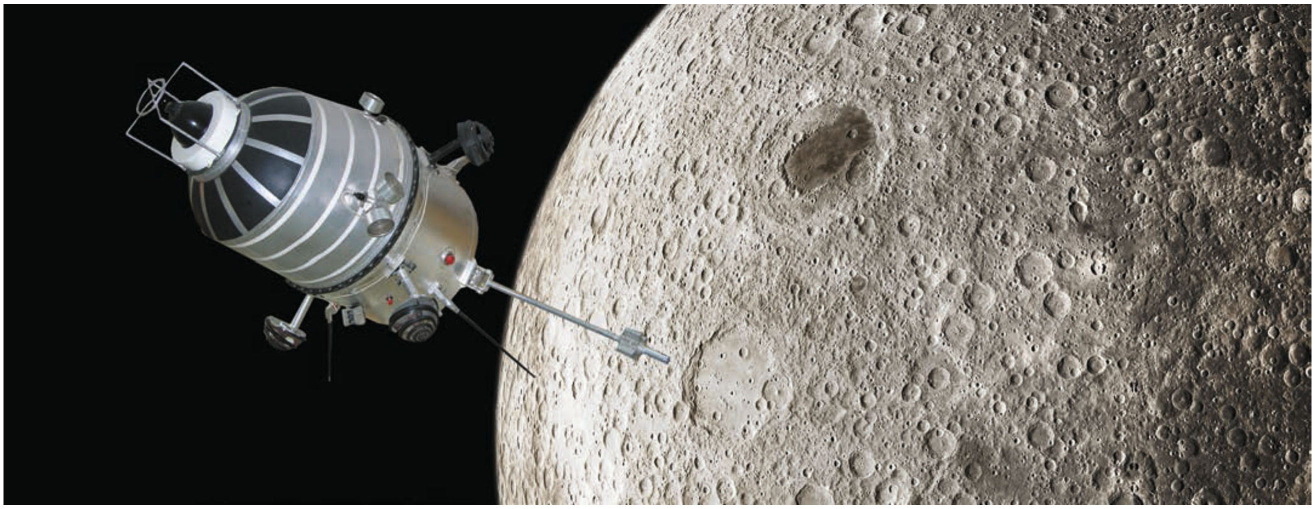

Fig. 4. *Luna-10* AMS is in orbit of the Moon's satellite.

have a dipole magnetic field. The AMS's magnetometer determined the strength of the Moon's magnetic field (about 1000 times less than the Earth's).

Using micrometeorite piezoelectric sensors glued to the AMS's skin (total sensitive area of sensors is 1.2 m^2, minimum mass of registered particles is 0.07 μg at a speed of 15 km/s), the concentration of meteorite material was measured at altitudes from 355 to 1030 km from the lunar surface. The measurements showed that in the AMS's orbit the average density of meteorites is two orders of magnitude higher than their average density in interplanetary space.

In addition to the scientific task, the *Luna-10* AMS also carried out a party assignment in orbit of the Moon. It was necessary to transmit from the orbit of the Moon's satellite the melody of the party anthem the *Internationale*. A sequence of frequencies and the duration of each note of the anthem were written. In the R&D establishment NII–885, Mikhail Sergeevich Ryazansky urgently developed and made a block of quartz oscillators with a programming device (*Shest' let i vsya zhizn'…*, 2004).

On the day of the completion of the XXIII Congress of the Communist Party of the Soviet Union, at exactly 10 o'clock in the morning, Sh.R. Rashidov, who chaired that day at the congress, raised the delegates and the melody of the *Internationale* was solemnly sounded in the hall, performed by a space synthesizer, transmitted from the first artificial satellite of the Moon. The entire hall applauded. *Internationale* was transmitted from the *Luna-10* station several more times, including in commemoration of the 96th anniversary of the birthday of V.I. Lenin; April 12, Cosmonautics Day; May 1, 1966; May 9, Victory Day; and on the opening day of the XV Congress of the All-Union Leninist Young Communist League (Fig. 4).

According to the results of the *Luna-10* flight, the International Aviation Federation (FAI) registered the priority scientific and technical achievements of the station:

— The launch of the world's first artificial Moon satellite.

— Carrying out for the first time in the world scientific and technical research and measurements with the help of an automatic station launched into an orbit of an artificial satellite of the Moon.

The *Luna-10* station set records registered and confirmed by FAI diplomas:

— The world record for the maximum mass delivered to lunar orbit, in class "C".

— The absolute world record for the duration of powered flight of an automatic station in lunar orbit.

— The world record for the duration of powered flight in lunar orbit in class "C".

FAI also awarded the Lavochkin machine-building plant among other enterprises for the development of *Luna-9* and *Luna-10* automatic stations with honorary diplomas (*Avtomaticheskie kosmicheskie apparaty…*, 2010). Fifty-six days after entering lunar orbit, having made 450 revolutions around the Moon, on May 30, 1966, the *Luna-10* AMS ended its active existence due to the exhaustion of the charge of chemical batteries (it was not equipped with solar batteries). At this point, the height of its orbit was 378 × 985 km with an inclination of 72.2°. Two hundred and nineteen radio communication sessions were carried out with the station, and extensive scientific information was received.

The whole of 1966 was a very tense year, it was quite crowded on the lunar tracks. The Americans gave us no respite: on June 2, 1966, the American station *Surveyor-1* landed on the Moon and successfully conducted research; on August 10, the United States launched the *Lunar-Orbiter-1* station; on August 18, the device went into orbit around the Moon, but due to the failure of photographic equipment, images of the lunar surface were not received; in November 1966, the American *Lunar-Orbiter-2* successfully flew, transmitting to Earth about 200 good photos of the lunar surface from an orbit around the Moon from a height of about 50 kilometers.

Our lunar program in 1966 (Shirshakov et al., 2019; Efanov et al., 2017; Khartov et al., 2010) was even more successful:

— February 9: *Luna-9* made the world's first soft landing on the Moon and the transmission of a television panorama.

— April 3: *Luna-10* is the world's first artificial lunar satellite.

— August 28: *Luna-11* is the second artificial satellite of the Moon.

— October 25: *Luna-12* performed the first photograph of the Moon from AMS orbit.

— December 24: *Luna-13* performed the second soft landing and transfer of the physical and mechanical characteristics of the lunar soil.

The flight of *Luna-10* was another victory for the Soviet Union in the space race, another confirmation that the country is capable of unique space achievements.

The assessment of the activities of Georgy Nikolayevich Babakin as the chief designer was high. In April 1966 he was awarded the honorary title of laureate of the Lenin Prize. But just a year prior he became the head of work on the creation of space stations for the study of the planets of the Solar System.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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