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The Soviets Reach for the Moon

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Introduction

The launching of the first Sputniks caused such a stir in the West that Soviet Premier Nikita Khrushchev could not help but exploit the propaganda value of Soviet space missions. But with the successful launching of the first three Sputnik satellites, all the "easy" space spectaculars had already been achieved. By the beginning of 1958 the Soviet Union's infant space program had set its sights on the Moon.

Even in the opening months of the Space Age, Soviet engineers and scientists had already spent years preparing for lunar missions. While serious work on Earth satellites was moving forward during the early to mid-1950s, a handful of Soviet theoreticians and designers were quietly making the first tentative steps required to explore the Moon. At this point in time, the most basic questions had to be answered: What sort of missions were needed? What are the velocity requirements for these missions? How long would these missions take?

Over time a number of missions types were identified and investigated including lunar orbiters and "cycling stations" that would orbit continuously between the Earth and Moon. By far the most advanced concept publicly announced by Soviet authorities was revealed on April 26, 1955 by Radio Moscow and later detailed in a Russian-language magazine article by Yuri S. Khlebtsecich the following November. Plans were outlined for a radio-controlled lunar "tankette" that would be launched by a large, multi-stage rocket. This remote-controlled rover could make observations over large stretches of the lunar surface and report its findings back to Earth. However, this sort of mission was still years away.

The Lunar Program Takes Shape

Lunar missions were always part of Chief Designer Sergei Korolev's space plans. When his satellite program was approved by the Soviet government in the beginning of 1956, work on more advanced missions also began to move forward not only at Korolev's OKB-1 but at other institutions as well. Among these was a group at MIAN (Mathematical Institute of the Academy of Sciences) under Academician Mstislav V. Keldysh who began making detailed calculations of over 600 trajectories to precisely define the requirements for various lunar missions.

A young Tikhonravov (left) and Korolev (right) together in 1947 on the occasion of the 90th anniversary of the birth of Tsiolkovsky. (Andrew LePage)

Based on scientific objectives and the projected availability of technology, a three-step strategy for long-term lunar exploration was eventually devised. The first step, which could make use of current or

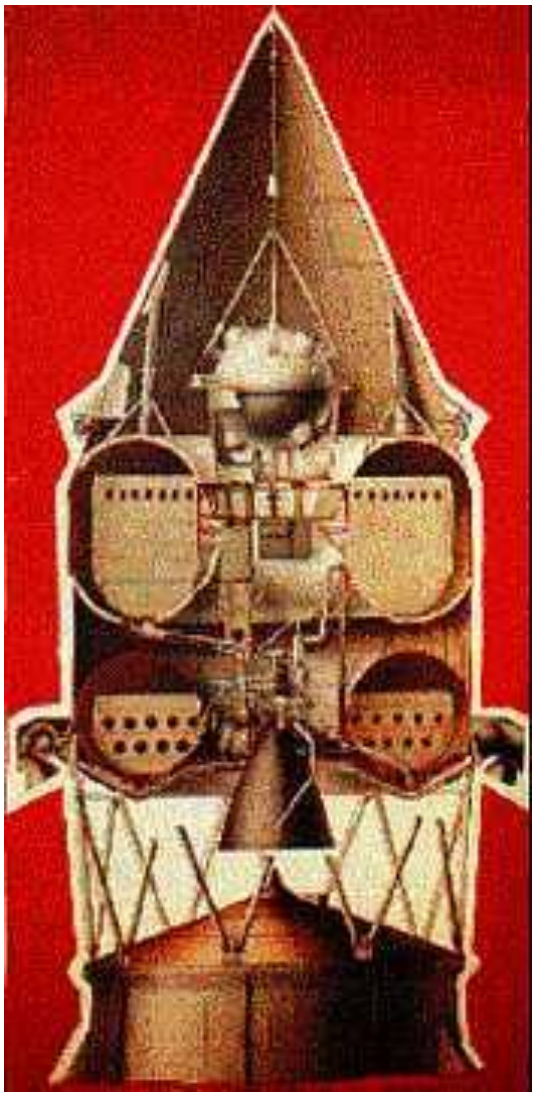
soon to be available technology, consisted of a series of flyby, impact, or hard landing missions. With a few more years of development, the second step would become possible. In this phase, payloads would be delivered to the lunar surface and into orbit. The last phase, which would require many years of work, involved delivering automated probes to the Moon and returning a payload of surface samples or exposed film back to Earth.

In April of 1957 the project department for the development of spacecraft at OKB-1 under Mikhail Tikhonravov submitted a report on the exploration of the Moon and the launching of manned satellites. The one point that was immediately made clear was the need to build a launch vehicle more capable than the existing derivatives of the two-stage R-7 that would launch the first satellites. As early as 1955, Korolev had anticipated this need and considered attaching a third stage on top of the basic R-7 ICBM (also known as the SS-6 or Sapwood in the West) to greatly improve its performance. By the summer of 1957 development of this stage, called Blok E, had begun.

The Gas Dynamics Laboratory at OKB-456 under the direction of Valentin P. Glushko was given the assignment of developing an engine, designated RD-109, for the Blok E. Glushko and his engineers felt that a fuel other than kerosene, which the R-7 used, should be employed. Ultimately they chose UDMH (unsymmetrical dimethyl hydrazine). Since there was little experience in developing a large engine to burn such an exotic (not to mention corrosive and toxic) fuel, Korolev felt that developing the RD-109 would take much longer than Glushko expected. In order to avoid delays and despite Glushko's protests, Korolev started parallel development of his own engine, the RO-5, at OKB-1 that burned the more conventional fuel, kerosene. Based on the S1.25800 steering rockets OKB-1 developed for use with the RD-107 engine that powered the R-7, the RO-5 would only be half as powerful as Glushko's RD-109. Despite its smaller size, the RO-5 still provided the performance needed to reach the Moon.

The Start of the Moon Program

With the successful launch of the first Sputnik and the furor that ensued, Khrushchev bypassed the existing chain of command and quickly conferred directly with Korolev to determine what other space spectaculars were possible. With Khrushchev's backing, Korolev's dreams for space exploration were to advance much more quickly than he could have ever imagined. The launching of additional satellites, such as Objects PS-2 and D (which became Sputnik 2 and 3, respectively), was immediately approved. Resources were also made available for the development of manned spacecraft as well as probes to the Moon and planets. Upon returning from his meeting with the Soviet leader, Korolev directed Tikhonravov and his project department to begin work on vehicles to explore the Moon. Tikhonravov delegated the task of designing and building the first Soviet lunar probes to a team of young engineers and scientists at OKB-1 affectionately known as "Lunatics".



Drawing of an E-1 Moon probe mounted on its 8K72E escape stage (Andrew LePage)

By December of 1957 the outline for two lunar launch vehicles based on the R-7 ICBM, or 8K71, had been worked out. Both launch vehicles would use a stripped down version of the R-7 designated

8K71/III. The first rocket, the 8K72 (eventually called SL-3 in the West), would use a Blok E third stage built around Korolev's RO-5 engine which by this time was being jointly developed with OKB-154 under Semyin A. Kosberg. This engine produced 49.9 kilonewtons (11,200 pounds) of thrust for 450 seconds by burning about 6.93 metric tons (15,300 pounds) of kerosene and LOX (liquid oxygen) held in separate torroidal tanks. This Blok E third stage, called 8K72E, was 2.66 meters (8.73 feet) in diameter and stood 5.0 meters (16 feet) tall with its conical nose shroud in place. It was attached to the top of the 8K71/III "basic packet" by a simple open truss. Depending on the mission profile, the 8K72 could send up to about 400 kilograms (880 pounds) of useful payload on a direct ascent trajectory to the Moon.

The second lunar launch vehicle, called the 8K73, would have a Blok E third stage incorporating the much larger RD-109 being developed by Glushko's OKB-456. The RD-109 produced 101.6 kilonewtons (22,800 pounds) of thrust and would consume 8.05 metric tons (17,700 pounds) of UDMH and LOX during a 330 second burn. Despite the different engine, the 8K73E stage's construction was very similar to the 8K72E. The 8K73E stage had the same diameter as the 8K72E but was 1.1 meters (3.6 feet) taller to accommodate the larger propellant load. With 16% more propellant, an engine that was 2% more efficient, and a 26% shorter burn time that cut gravity losses during a direct ascent towards the Moon, the 8K73E was better than the 8K72E for missions to the Moon and beyond. The 8K73 would be able to loft over 550 kilograms (1,200 pounds) of payload towards the Moon. Which ever upper stage was used, these new launch vehicles could lift more than ten times the payload of the rockets that would be assembled for the first American Moon project, "Operation Mona" (see **Operation Mona: America's First Moon Program** in the April 1998 issue of *SpaceViews*).

The Plan

In December of 1957 Korolev formally submitted his lunar plans for approval. The primary objective of the first mission would be to impact the Moon. In order to determine what instrumentation should be carried on this and subsequent lunar missions, Korolev met with Soviet astronomers to get their input. Given the secrecy that enveloped the development of Soviet space hardware and the fact the Space Age had just begun, these astronomers were amazed to discover that a flight to the Moon was not only possible but almost at hand. Eventually it was decided that the first lunar probes would measure magnetic fields, assess the radiation environment, and determine the density of micrometeoroids during its flight. These missions would only require a simple probe that could be quickly developed weighing about 170 kilograms (375 pounds).

This Moon probe, designated E-1 ("E" being the next letter after Object "D"), would use the 8K72 which was scheduled to make its first test flight in June or July of 1958. In order to maximize the payload, the launch was restricted to a two to three-minute window during a three-day period when the Moon was either about 10 or 23 days old, depending on the season. A short flight time of about 34 hours would ensure that the probe would be visible from the Soviet Union during its lunar encounter. This type of trajectory also had the benefit of minimizing the effects of aiming and final velocity errors. To help reduce the latter, the 8K72E stage would use radio commands to shutdown the RO-5 engine when the proper velocity had been achieved.

In the original proposal, post-launch tracking of the receding lunar probe would be aided by either an inflatable 30-meter (100-foot) in diameter aluminized balloon or, as proposed by Soviet astronomer Professor Iosef Shklovsky, an artificial comet of lithium or sodium vapor released from the spent Blok E. Depending on the available payload margin of the 8K72, additional engineering and scientific equipment could be carried by the Blok E to supplement investigations by the E-1 probe. Korolev scheduled this flight to take place around August or September of 1958.

The next set of missions would use more advanced, three-axis stabilized probes designated E-2 and E-3. These probes, weighing about 280 kilograms (620 pounds) each, would image the unseen farside of the Moon using an automated photographic system. In addition to this primary instrument, these probes could carry other sensors to continue investigations of the cislunar environment. Because of the alignments of the Earth, Moon, and Sun these missions required, the E-2 and E-3 could only be launched in October-November or April-May. The development of these more sophisticated probes, which was made the responsibility of Yuri A. Mozzhorin, would require more time than the E-1. If all went according to schedule, the 8K73 would be available to launch the first of these probes in October or November of 1958.

One last lunar "probe" that was considered at this time was the E-4. Its mission would be to set off a nuclear explosion on the lunar surface that could be viewed from the Earth leaving no doubt that a Soviet probe had reached the Moon. Weighing in at about 400 kilograms (880 pounds), the E-4 would require the lifting capability of the 8K73. While an interesting publicity stunt, Korolev was not enthusiastic about beginning an era of lunar exploration with the nuclear bombardment of the Moon. Ultimately the project was cancelled. After these lunar missions Korolev intended to move on and use the 8K73 to launch the first probe to Venus, designated V1, in June of 1959.

A Bad Start

Just as Korolev had feared, the development of the RD-109 dragged on much longer than planned. This delay along with problems with the R-7 and its engines uncovered during development flights and bench tests threatened to scuttle Korolev's original (and overly optimistic) lunar exploration schedule. But by May 1958 the first 8K71/III, serial number B1-14, had been modified in the shops at OKB-1 outside of Moscow and in early June it was delivered to the NIIP-5 range in Kazakhstan. Because of the lagging development of the RO-5, an engine-less Blok E equipped only with telemetry and control systems would be carried on this suborbital test flight.

The first 8K71/III finally lifted off on July 10, 1958. While there are conflicting accounts of what exactly happened, all the sources agree that the test was unsuccessful. With only a month until the first American lunar probe launch attempt, Korolev and his team would have to work hard to beat the Americans once again.

Bibliography

Wayne R. Matson (editor), *Cosmonautics: A Colorful History*, Cosmos Books, 1994

Ari Shternfeld, *Soviet Space Science*, Basic Books, 1959

Asif A. Siddiqi, "Before Sputnik: Early Satellite Studies in the Soviet Union 1947-1957 - Part 2", *Spaceflight*, pp. 389-392, Vol. 39, No. 11, November 1997

Timothy Varfolomeyev, "Soviet Rocketry that Conquered Space Part 2: Space Rockets for Lunar Probes", *Spaceflight*, pp. 49-52, Vol. 38, No. 2, February 1996