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Photographing Luna Incognita

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Before the West could catch its collective breath from the success of Luna 2 (see **Shooting for the Moon** in the January 1, 1999 issue of *SpaceViews*), the confluence of celestial mechanics and the availability of long delayed hardware quickly led to the next Soviet lunar mission on the second anniversary of Sputnik - Luna 3 launched on October 4, 1959 (40 years ago this month). Called the Automatic Interplanetary Station (AIS) by Soviet authorities, it was quickly apparent to Western analysts that this probe had a different mission from its predecessors. Instead of a suicidal 34-hour dash towards a lunar impact, AIS had a slower trajectory that passed 6,000 kilometers from the Moon two days after launch. The actual mission of AIS, photographing the farside of the Moon, took place the following day. The Soviet Union was about to attempt yet another space first that would leave the U.S. even further behind.

Designing the Probe

Viewing the farside of the Moon had long been a dream of astronomers. Throughout the mid-1950s Soviet planners examined a number of possible missions that could secure images of this unseen expanse. When Korolev formally submitted his plans for lunar exploration in December 1957, lunar farside photography came second only to the easier goal of a lunar impact. The coauthor of the lunar plan, Mikhail Tikhonravov, ran the group at OKB-1 (Experimental Design Bureau No. 1) that would design and build the first series of lunar probes.

According to Korolev's plan, lunar farside photography would be performed by the E-2 and E-3 probes. Unlike previous Soviet satellites, these probes would need an attitude control system to accurately point its payload of cameras at the Moon. In 1955 Academician Mtsilav Keldysh - Vice President of the Soviet Academy of Science and head of MIAN (The Mathematical Institute of the Academy of Sciences) - authorized a group of engineers and scientists led by Boris Raushenbakh of NII-1 (Scientific Research Institute No. 1) to examine the question of spacecraft attitude control. The exploratory work they finished in late 1956 would find direct application in the E-2 and E-3 probes.

Because of the required alignments of the Earth, Moon, and Sun, a farside photography mission could only be launched in the early fall or early spring. Throughout 1958 a team at OPM MIAN (the Department of Applied Mathematics of the V.A. Steklov Mathematic Institute) directed by Keldysh calculated detailed trajectories for these missions to find the best. As 1958 began, Korolev hoped for the first E-2 or E-3 launch in October or November of 1958. This schedule proved to be far too ambitious for such a complex mission.

The E2/3 program was assigned to a team at OKB-1 under Gleb Maksimov While they worried about the basic design, Maksimov subcontracted the construction of key subsystems to other design bureaus. The imaging and radio systems for the E-3 were the responsibility OKB-MEI (Experimental Design Bureau of the Moscow Energetics Institute) headed by Chief Designer Aleksey Bogomolov. The OKB-MEI team envisioned that Maksimov's spacecraft would be able to place their camera so that the Moon would be within 30 degrees of the line of sight. The photo-television system's single 750-mm focal length lens would then automatically acquire and photograph the Moon for later transmission to Earth.

The corresponding systems of the E-2 would designed and built independently of the E-3 effort. The radio system would be taken care of by a team led by M. Ryazansky at NII-885 then under Deputy Chief Designer Boguslavskiy. The contract for the photo-television package was given to NII-380 in

Leningrad directed by Igor Rosselevich in July 1958. By October 1958 NII-380 presented the first working prototype of their automated imaging system called Yenisey-1. It was a 35 mm camera system capable of taking 40 photos using 200 mm and 500 mm lenses. Upon command from the Earth, the system would take its photographs and process the film for later transmission to Earth.

As impressive as the quick development of Yenisey-1 was, troubles in other areas of the program were leading to lengthy delays. Originally the probes were to be launched on a 8K73 launch vehicle (see **The Soviets Reach for the Moon** in the June 1998 issue of *SpaceViews*). Essentially an enlarged version of the 8K72 that sent the E-1 impact probes to the Moon, development of the 8K73 escape stage's RD-109 engine at OKB-456 was falling hopelessly behind schedule just as Korolev had originally feared. Fortunately by the time development of the 8K73 was cancelled in early 1959, improvements in the performance of the 8K72 allowed it to launch the 300 kilogram photographic probes with payload margin to spare. But delays elsewhere ultimately led to pushing the first flight back to the fall of 1959. With more time on hand, development of the E-2 was cancelled in the summer of 1958 and work on an improved E-2A design immediately began. In August, NII-380 commenced work on an upgraded Yenisey-2 system that E-2A would carry.

But as work on the E-2A pushed ahead, problems with the E-3 design continued throughout 1958. To avoid missing the April 1960 launch window, Korolev authorized the development of yet another E-2 variant, the E-2F, in late 1958 which would carry a Yenisey-3 photographic system. With its development schedule continuing to falter, the E-3 was finally cancelled in early 1959. Around the same time development of an E-5 lunar orbiter meant to beat NASA's new Pioneer orbiter to the Moon was started with a launch in the October to December 1959 timeframe. In the mean time, all attention was focused on getting the E-2A off the ground in October 1959.

Getting the Photos

The E-2A was by far the most advanced spacecraft built by the Soviet Union up to that time. It was a cylinder capped by a pair of hemispheres with a total length of 1.3 meters (4.3 feet) and a diameter of 1.19 meters (3.90 feet). The exterior of the 278.5 kilogram (613.3 pound) probe was covered with banks of solar cells to recharge its batteries - the first Soviet spacecraft to do so. During its cruise the probe was spin stabilized which also provided some thermal control. Additional control was provided by rectangular thermal shutters between the banks of solar cells on the cylinder's exterior. The interior was pressurized to 0.23 atmospheres and circulating fans helped to keep interior temperatures in the 25 to 30 C (77 to 86 F) range.

Model of the Soviet Automatic Interplanetary Station later known as Luna 3. (NASA)

The development of the E-2A attitude control system started in earnest in early 1959 by the team under Raushenbakh at NII-1. They were responsible not only for the control jets, by the sensors designed to lock onto the Sun and Moon and feed commands to those jets. At the beginning the photography session, the probe's spin would first be negated. Next the AIS would turn to find and lock onto the Sun. The spacecraft would turn to within 0.5 to 0.7 degrees of the Moon so that the Yenisey-2 camera could photograph the farside. After the photos were secured, the probe would turn once more and set itself spinning again.

The Yenisey-2 package was a marvel of engineering simplicity. It carried a total of 40 exposures of radiation-resistant 35 mm isochrome film to be used by a 200 mm, f/5.6 and a 500 mm, f/9.5 lens. Once exposed, the film would be automatically processed on board and then scanned by a light beam upon command for transmission back to Earth. The images could be transmitted in one of two speeds and

could be scanned with a maximum resolution of 1000 lines.

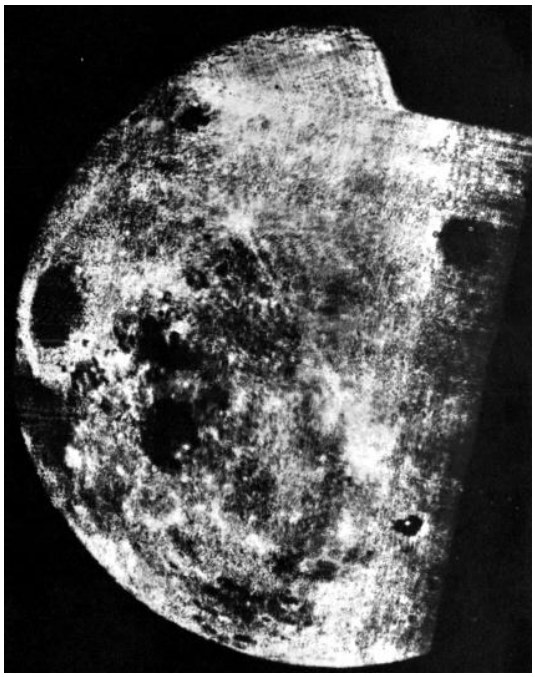
In addition to the Yenisey-2, the E-2A also carried instruments to detect micrometeoroids and cosmic radiation. As with the earlier E-1 impact probes, the E-2A did not take full advantage of the 8K72 lifting capability. The Blok-E escape stage carried an extra 156.5 kilograms (344.6 pounds) of instrumentation. The escape stage was also equipped a radio command system that would shut down the engine once the required velocity had been reached. Since the E-2A and its sisters had no course correction capability, high launch vehicle accuracy was essential.

The Mission

With the tight development schedule, final assembly and testing of the E-2A components took place at the NIIP-5 launch site in Kazakahstan. After its hasty ground tests, the E-2A probe was mounted on its 8K72 launch vehicle serial number I1-8 and prepared for launch. Late during the evening of October 4, 1959, the E-2A probe now officially designated AIS (and dubbed Lunik 3 in the West) was successfully launched towards the Moon.

When contact with AIS was established with the tracking station in the Crimea trouble was already evident - the radio signal had only about half of the expected strength. More worrisome still was the probe's steadily rising interior temperature which threatened to spoil the film. While low signal strength would continue to hamper the entire mission, a solution to the overheating problem was found and implemented by the evening of October 6. The orientation of the AIS spin axis was changed with respect to the Sun and various pieces of equipment were shut off until needed. These steps allowed the interior temperature to drop from a high of 40 C (104 F) to a safer 27 to 30 C (81 to 86 F).

After passing within 6,000 kilometers (3,700 miles) of the lunar south pole at 14:16 GMT on October 6, AIS swung behind the Moon and into an extended Earth orbit with an initial apogee of 480,000 kilometers (298,000 miles) and a perigee of 47,500 kilometers (29,500 miles). On October 7, 13 hours and 14 minutes after closest approach, AIS was 65,200 kilometers (40,500 miles) above the illuminated hemisphere of the Moon - a view that included 30% of the familiar nearside and 70% of the unseen farside. The overhead lighting with its short shadows was not ideal for spotting small details but it would do for an initial farside survey. Upon command AIS stopped spinning and proceeded with its automated sequence to photograph the Moon. A total of 29 photographs were exposed over 40 minutes even though the mechanism for the narrow angle, 500 mm lens jammed partway through the sequence. Afterwards the probe resumed its spinning and immediately began to develop its precious cargo of film.



First image of the farside of the Moon taken by Luna 3. (NASA)

As intended, the close lunar encounter also changed the inclination of the probe's orbit so that it would rise steadily higher in the sky as it returned towards the Earth. Eventually the probe would become circumpolar allowing for continuous communications. During the first four transmission attempts starting October 8, no usable images were returned because of low signal strength as AIS approached apogee on October 10. Decreasing distance and efforts to minimize radio interference in the area of the tracking station finally allowed the first two usable photos to be transmitted on the fifth attempt. Transmissions continued as the probe approached its October 18 perigee with a total of 17 usable photographs being received. But even the best were still heavily smeared with noise. On October 22 all contact with AIS was finally lost. Five days later Soviet authorities publicly released a three-photo composite showing the farside of the Moon to the world for the first time.

While these photos were crude, they did reveal the nature of the lunar farside. Most notable was the near absence of dark mare that dominate the appearance of

the familiar nearside. While some in the West would claim the photographs were fake, subsequent images returned years later by American and Soviet probes confirmed what AIS first saw. Despite its problems, AIS was an outstanding success.

Final Curtain

While the achievement of AIS was impressive, Korolev and his engineers knew they could do better for the next launch window in April 1960. But by February 1960 it was feared that the E-2F and its Yenisey-3 camera would not be ready in time. Instead, a pair of modified E-2A probes were constructed. They would have a more powerful communication system than AIS and take their images at much closer range.

The first of the improved E-2A probes (now assigned the defunct "E-3" designation) was launched on an 8K72 serial number I1-7 the evening of April 15, 1960. While at first it appeared to be a success, tracking showed that the Blok-E engine shutdown too early. As a result, the E-3 No. 1 reached a peak altitude of about 200,000 km (125,000 miles) before plunging back to Earth. With only a single chance left, Korolev decided to immediately launch E-3 No. 2 on launch vehicle I1-7b.

On the afternoon of April 19, E-3 No. 2 was launched but immediately ran into trouble. The RD-107 engine on one of the four strap-on boosters failed to ignite properly. After the 8K72 struggled upwards for 150 to 200 meters (500 to 650 feet), the rocket began to tumble with all four strap-ons breaking free of the core. Two of the boosters crashed and exploded near the pad. Another passed a mere 30 to 40 meters (100 to 130 feet) over the heads of spectators scrambling for cover 1.5 kilometers (0.9 miles) away. The booster detonated on impact near the MIK shattering its windows. The core with its Blok-E escape stage and payload crashed 800 meters (0.5 miles) from the pad near a small salt lake.

This would mark the end of the first chapter in Soviet lunar exploration. While another mission could theoretically be launched in October 1960, Korolev already had plans to launch the first of his new interplanetary probes that month. Limited resources at OKB-1 were tightened further as the Vostok program approached its first test flights as 1960 progressed. With the hastily conceived E-5 cancelled, Soviet lunar planners turned to the E-6 lunar lander and E-7 orbiter missions planned for launch in 1961. As NASA's new Pioneer lunar program stumbled through 1960, it looked as though the Soviets would maintain their lead in the great Moon race.

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