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Solar System Missions: Luna Program

Soviet Lunar Exploration

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Introduction

The Luna programme (from the Russian word Луна "Luna" meaning "Moon"), sometimes called Lunik by western media, was a series of robotic spacecraft missions sent to the Moon by the Soviet Union between 1959 and 1976. The programme accomplished many firsts in space exploration, including the first lunar flyby, the first deliberate impact on another world, and the first photographs of the Moon's hidden face. Each mission was designed as either an orbiter or lander.

They also performed many experiments, studying the Moon's chemical composition, gravity, temperature, and radiation. Twenty-four spacecraft were formally given the Luna designation, although more were launched. Those that failed to reach orbit were not publicly acknowledged at the time, and not assigned a Luna number. Those that failed in low Earth orbit were usually given Cosmos designations. The estimated cost of the Luna programme in 1964 was US$6-10 billion (equivalent to US$46-77 billion in 2024).

The Luna 25 mission also continues the Luna designation, although it is considered to be a part of the Luna-Glob exploration programme. The same applies to other planned missions such as Luna 26, Luna 27 and Luna 28. The name Luna was used to designate a variety of spacecraft designs, to achieve several types of missions: flyby, lunar orbiter, soft lander, and sample return spacecraft.

Notable achievements include the first Moon flyby (Luna 1), the first impact (Luna 2), the first photos of the far side (Luna 3), the first soft landing (Luna 9), and the first robotic sample return (Luna 16). Impactor spacecraft had the generic designation of Ye-1 (or E-1 depending on transliteration from Russian) and were designed to hit the near side of the Moon. Luna 1 (January 1959) missed its intended impact with the Moon and became the first spacecraft to escape the Earth-Moon system.

Luna 2 (September 1959) mission successfully hit the Moon's surface, becoming the first man-made object to reach the Moon. This was Luna's only impact success out of six tries from September 1958 to September 1959. A flyby is the simplest lunar spacecraft, requiring neither a propulsion device for slowing, nor a guidance system sensitive enough to hit the Moon. Flyby spacecraft had the generic designations of Ye-2 and Ye-3 (E-2 and E-3 depending on transliteration from Russian).

Their function was to transmit photographs back to Earth. Luna 3 (October 1959) rounded the Moon later that year, and brought home the first photographs ever taken of its far side, which can never be seen from Earth.

This was Luna's only successful flyby, out of three tries from October 1959 to April 1960. Soft landers require rocket propulsion to slow their speed sufficiently to prevent the craft's destruction.

The Soviet space program (Russian: Космическая программа СССР, romanized: Kosmicheskaya programma SSSR) was the state space program of the Soviet Union, active from 1951 until the dissolution of the Soviet Union in 1991.

One of the two cameras (intended to return stereo images) failed, but this did not diminish the quality of the photographs. The penetrometer measured the regolith density at 800 kg/m3. After a fully successful mission, contact was lost at 06:13 UTC on 28th of December when the on- board batteries were exhausted. List of artificial objects on the Moon

Luna 3, or E-2A No.1 (Russian: Луна 3), was a Soviet spacecraft launched in 1959 as part of the Luna programme. It was the first mission to photograph the Moon's far side, and only the third Soviet probe ever sent toward our neighbor in space.

The historic, never-before-seen views of the far side of the Moon caused excitement and interest when they were published around the world, and a tentative atlas of the Moon's hidden face was pieced together from the pictures. These views showed mountainous terrain, very different from the near side, and only two dark, low-lying regions, which were named Mare Moscoviense (Sea of Moscow) and Mare Desiderii (Sea of Desire).

Chapter 1: The Discovery of Luna Program

They can continue to transmit pictures from the surface, and possibly dig into the lunar soil or return other information about the lunar environment. Luna program landers had the generic designations of Ye-6 or Ye-6M (E-6 or E-6M depending on transliteration from Russian). Two successful soft landings were achieved out of thirteen attempts from January 1963 to December 1966. Luna 9 (E-6 No.13) became the first probe to achieve a soft landing on another planetary body in February 1966.

It transmitted five black and white stereoscopic circular panoramas, which were the first close-up shots of the lunar surface. Orbiter spacecraft require less thrust and propellant than landers, but still require enough to achieve lunar orbit insertion. Luna 10 (March 1966) became the first artificial satellite of the Moon. Luna program orbiters had the generic designations of Ye-6LF, Ye-6LS, Ye-6S or Ye-8LS (E-6, E-6LS, E-6S or E-8LS depending on transliteration from Russian).

Luna flew six successful orbiters out of eight attempts from March 1966 to May 1974. More sophisticated soft lander craft can deploy wheeled vehicles to explore a wider area of the lunar surface than the immediate landing site. Luna program landers with rovers had the generic designations of Ye-8 (E-8 depending on transliteration from Russian). The first attempted Lunokhod failed in February 1969.

Luna 17 (November 1970) and Luna 21 (January 1973) carried Lunokhod vehicles, which were the first robotic wheeled vehicles to explore the Moon's terrain. Lunokhod 1 travelled 10.5 kilometres (6.5 mi) in 322 days and returned more than 20,000 television images and 206 high-resolution panoramas. Lunokhod 2 operated for about four months, and covered 42 kilometres (26 mi) of terrain, A third Lunokhod was built and intended for launch in 1977, but never flew due to lack of launchers and funding.

More complex soft lander craft can robotically scoop up a small amount of lunar material, lift off from the surface, and return the material to Earth. Luna program sample return landers carried the generic designations Ye-8-5 and its modernized version Ye-8-5M (E-8-5 and E-8-5M, rendered in the alternate transliteration from Russian). Luna 16 (September 1970), Luna 20 (February 1972) and Luna 24 (August 1976), returned samples of lunar soil to Earth. A total of 301 g (10.6 oz) of soil sample was returned from the three missions.

Luna 15 (July 1969) flew at the same time as the Apollo 11 mission. Neil Armstrong and Buzz Aldrin had already performed the first crewed lunar landing when Luna 15 began its descent, and the spacecraft crashed into a

mountain minutes later. While the program was active, it was Soviet practice not to release any details of missions that had failed to achieve orbit. This resulted in Western observers assigning their own designations to the missions.

For example, Luna E-1 No.1, the first failure of 1958 which NASA believed was associated with the Luna programme, was known as Luna 1958A. Luna (rocket) Luna-Glob

Unlike its Space Race competitor, the United States, which consolidated its space program under NASA, the Soviet space program was divided between several competing design bureaus led by Korolev, Kerimov, Keldysh, Yangel, Glushko, Chelomey, Makeyev, Chertok and Reshetnev, often under the Ministry of General Machine-Building.

The program was an important part of the Soviet claim to superpower status. From the 1890s, Russian scientist Konstantin Tsiolkovsky pioneered the fields of astronautics and rocketry. Soviet rocketry began with the Gas Dynamics

Laboratory in 1921, and these endeavors expanded during the 1930s and 1940s. After the surrender of Nazi Germany, German V-2 rocket technology and expertise was utilized by Soviet and by US aerospace alike; Soviet spaceflight began with the derivative R-1 missile tests in 1948.

In the 1950s, the Soviet program was formalized, led by Sergei Korolev. The Soviet space program set many records in space exploration. In 1957, it achieved the first intercontinental missile (R-7 "Semyorka"), orbital launch vehicle (Sputnik), artificial satellite (Sputnik 1), and animal in Earth orbit (Laika the dog). From 1961, the Vostok and Voskhod programs achieved the first human spaceflight (Yuri Gagarin), woman in space (Valentina Tereshkova), multi-crew spaceflight, and spacewalk. Cancelled Soviet crewed lunar programs centered on the N1 super heavy-lift rocket.

The Salyut program (1971-1986) operated six crewed space stations, including the world's first, Salyut 1.

The first modular station, Mir (1986-2000), grew to seven pressurized modules. The Interkosmos program sent the first citizens of sixteen countries into space. The Energia super heavy-lift rocket and Buran spaceplane, a response to the US Space Shuttle, were briefly flown in the late 1980s. Soviet computerized robotic missions achieved further milestones.

The Luna program launched to the Moon, from 1959-70, the first flyby, impactor, imaging of its far side, soft landing, animals, and robotic sample return; the Lunokhod program deployed the first two robotic lunar rovers from

1970. The Venera and Mars programs launched the first interplanetary probes. Venus missions achieved the first flyby, first impact, first soft landing, first surface imaging, and first atmospheric flight on another planet. Soviet probes also made the first impact and soft landing on Mars.

The program provided key Soviet military systems during the Cold War, via satellites such as Zenit for reconnaissance, Tselina for signals intelligence, Oko for early warning, and US-A for naval radar. Soviet space industry contested the US in experimental technologies such as electric propulsion, fission-powered spacecraft, nuclear thermal rockets, and space weapons such as the Almaz space stations and Polyus laser. The program was primarily succeeded by Russia's Roscosmos, as well as Ukraine's State Space Agency.

The program's legacy includes Roscosmos' segment of the International Space Station, Soyuz and Progress spacecraft, Soyuz and Proton rocket families, and the GLONASS satellite navigation system. Internationally, Soviet designs were adapted to the Chinese Shenzhou crew vehicle and widely-used RD-170 engine variants. The largest Soviet cosmodrome, Baikonur, in Kazakhstan, is now under lease to Russia; Plesetsk continues to launch primarily military satellites into polar orbit.

The theory of space exploration had a solid basis in the Russian Empire before the First World War with the writings of the Russian and Soviet rocket scientist Konstantin Tsiolkovsky (1857-1935), who published pioneering papers in the late 19th and early 20th centuries on astronautic theory, including calculating the Rocket equation and in 1929 introduced the concept of the multistaged rocket.

Additional astronautic and spaceflight theory was also provided by the Ukrainian and Soviet engineer and mathematician Yuri Kondratyuk who developed the first known lunar orbit rendezvous (LOR), a key concept for landing and return spaceflight from Earth to the Moon. The LOR was later used for the plotting of the first actual human spaceflight to the Moon. Many other aspects of spaceflight and space exploration are covered in his works.

Both theoretical and practical aspects of spaceflight were also provided by the Latvian pioneer of rocketry and spaceflight Friedrich Zander, including suggesting in a 1925 paper that a spacecraft traveling between two planets could be accelerated at the beginning of its trajectory and decelerated at the end of its trajectory by using the gravity of the two planets' moons - a method known as gravity assist.

The first Soviet development of rockets was in 1921, when the Soviet military sanctioned the commencement of a small research laboratory to explore solid

fuel rockets, led by Nikolai Tikhomirov, a chemical engineer, and supported by Vladimir Artemyev, a Soviet engineer. Tikhomirov had commenced studying solid and Liquid-fueled rockets in 1894, and in 1915, he lodged a patent for "self-propelled aerial and water-surface mines." In 1928 the laboratory was renamed the Gas Dynamics Laboratory (GDL).

The First test-firing of a solid fuel rocket was carried out in March 1928, which flew for about 1,300 meters Further developments in the early 1930s were led by Georgy Langemak. A key contributor to early soviet efforts came from a young Russian aircraft engineer Sergey Korolev, who would later become the de facto head of the Soviet space programme.

In 1926, as an advanced student, Korolev was mentored by the famous Soviet aircraft designer Andrey Tupolev, who was a professor at his University. In 1930, while working as a lead engineer on the Tupolev TB-3 heavy bomber he became interested in the possibilities of liquid-fueled rocket engines to propel airplanes. This led to contact with Zander, and sparked his interest in space exploration and rocketry.

Practical aspects built on early experiments carried out by members of the 'Group for the Study of Reactive Motion' (better known by its Russian acronym "GIRD") in the 1930s, where Zander, Korolev and other pioneers such as the Russian engineers Mikhail Tikhonravov, Leonid Dushkin, Vladimir Vetchinkin and Yuriy Pobedonostsev worked together. On August 18, 1933, the Leningrad branch of GIRD, led by Tikhonravov, launched the first hybrid propellant rocket, the GIRD-09, and on November 25, 1933, the Soviet's first liquid-fueled rocket GIRD-X.

In 1933 GIRD was merged with GDL by the Soviet government to form the Reactive Scientific Research Institute (RNII), which brought together the best of the Soviet rocket talent, including Korolev, Langemak, Ivan Kleymyonov and former GDL engine designer Valentin Glushko.

RNII's research and development were very important for later achievements of the Soviet rocket and space programs.

During the 1930s, Soviet rocket technology was comparable to Germany's, but Joseph Stalin's Great Purge severely damaged its progress. In November 1937, Kleymyonov and Langemak were arrested and later executed, Glushko and many other leading engineers were imprisoned in the Gulag. Korolev was arrested in June 1938 and sent to a forced labour camp in Kolyma in June 1939. However, due to intervention by Tupolev, he was relocated to a prison for scientists and engineers in September 1940.

During World War II, rocketry efforts were carried out by three Soviet design

bureaus. RNII continued to develop and improve solid fuel rockets, including the RS-82 and RS-132 missiles and the Katyusha rocket launcher, where Pobedonostsev and Tikhonravov continued to work on rocket design.

In 1944, RNII was renamed Scientific Research Institute No 1 (NII-I) and combined with design bureau OKB-293, led by Soviet engineer Viktor Bolkhovitinov, which developed, with Aleksei Isaev, Boris Chertok, Leonid Voskresensky and Nikolay Pilyugin a short-range rocket powered interceptor called Bereznyak-Isayev BI-1. Special Design Bureau for Special Engines (OKB-SD) was led by Glushko and focused on developing auxiliary liquid-fueled rocket engines to assist takeoff and climbing of prop aircraft, including the RD-IKhZ, RD-2 and RD-3.

In 1944, the RD-1 kHz auxiliary rocket motor was tested in a fast-climb Lavochkin La-7R for protection of the capital from high-altitude Luftwaffe attacks. In 1942 Korolev was transferred to OKB-SD, where he proposed development of the long range missiles D-1 and D-2. The third design bureau was Plant No 51 (OKB-51), led by Soviet Ukrainian Engineer Vladimir

Chelomey, where he created the first Soviet pulsating air jet engine in 1942, independently of similar contemporary developments in Nazi Germany.

Nazi Germany developed rocket technology that was more advanced than the Allies and a race commenced between the Soviet Union and the United States to capture and exploit the technology. Soviet rocket specialist was sent to Germany in 1945 to obtain V-2 rockets and worked with German specialists in Germany and later in the Soviet Union to understand and replicate the rocket technology. The involvement of German scientists and engineers was an essential catalyst to early Soviet efforts.

In 1945 and 1946 the use of German expertise was invaluable in reducing the time needed to master the intricacies of the V-2 rocket, establishing production of the R-1 rocket and enable a base for further developments. On 22 October 1946, 302 German rocket scientists and engineers, including 198 from the Zentralwerke (a total of 495 persons including family members), were deported to the Soviet Union as part of Operation Osoaviakhim.

Luna 20 was the second of three successful Soviet lunar sample return missions. It was flown as part of the Luna program as a robotic competitor to the six successful Apollo lunar sample return missions. Luna 20 was placed in an intermediate Earth parking orbit and from this orbit was sent towards the Moon. It entered lunar orbit on 18 February 1972.

Mare Desiderii was later found to be composed of a smaller mare, Mare Ingenii (Sea of Cleverness), and several other dark craters. The reason for this

difference between the two sides of the Moon is still not fully understood, but it seems that most of the dark lavas that flowed out to produce the maria formed under the Earth-facing half. The space probe was a cylindric canister with hemispheric ends and a wide flange near the top.

The probe was 130 centimetres (51 in) long and 120 centimetres (47 in) at its maximum diameter at the flange. Most of the cylindric section was roughly 95 centimetres (37 in) in diameter. The canister was hermetically sealed and pressurized to about 0.22 standard atmospheres (22 kPa). Several solar cells were mounted on the outside of the cylinder, and these provided electric power to the storage batteries inside the space probe.

Shutters for thermal control were positioned along the cylinder and opened to expose a radiating surface when the internal temperature exceeded 25 °C (298 K). The upper hemisphere of the probe held the covered opening for the cameras. Four antennas protruded from the top of the probe and two from its bottom. Other scientific equipment was mounted on the outside, including micrometeoroid and cosmic ray detectors, and the Yenisey-2 imaging system.

The gas jets for its attitude control system were mounted on the lower end of the spacecraft. Several photoelectric cells helped maintain orientation with respect to the Sun and the Moon. There were no rocket motors for course corrections. Its interior held the cameras and the photographic film processing system, radio transmitter, storage batteries, gyroscopic units, and circulating fans for temperature control. It was spin-stabilized for most of its flight, but its three-axis attitude control system was activated while taking photos.

Luna 3 was radio-controlled from ground stations in the Soviet Union. The Soviet media called the spacecraft the Automatic Interplanetary Station. The probe was renamed to Luna 3 in 1963. After launching on a Luna 8K72 (number I1-8) rocket over the North Pole, the Blok-E escape stage was shut down by radio control to put Luna 3 on its course to the Moon.

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ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.