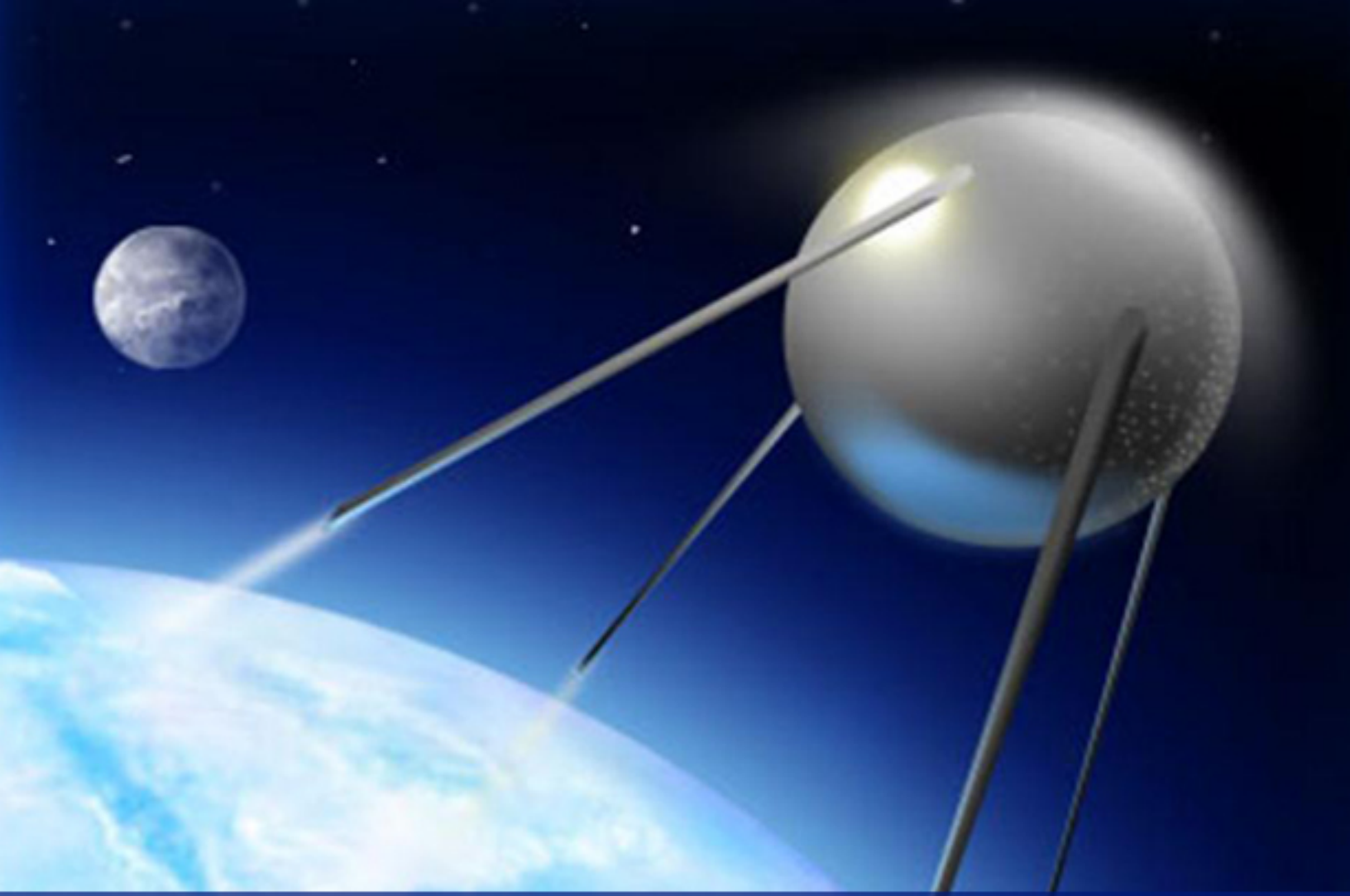

Handbook of Space and Solar System Exploration in 1950s

Marilou Valdes

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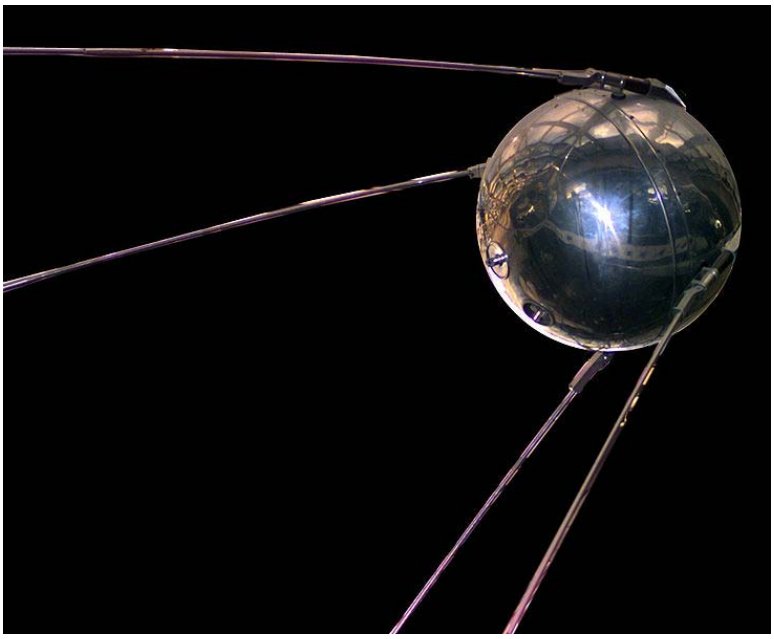
Sputnik 1

Sputnik 1
"Спутник-1"



Major contractors	OKB-1, Soviet Ministry of Radiotechnical Industry
Mission type	Atmospheric studies
Satellite of	Earth
Orbits	1,440
Launch date	19:28:34, October 4, 1957 (UTC) (22:28:34 MSK)
Launch vehicle	*Sputnik* rocket
Mission duration	3 months

Orbital decay	4 January 1958
COSPAR ID	1957-001B
Homepage	NASA NSSDC Master Catalog
Mass	83.6 kg (184.3 lb)
	Orbital elements
Semimajor axis	6,955.2 km (4,321.8 mi)
Eccentricity	0.05201
Inclination	65.1°
Apoapsis	7,310 km (4,540 mi) from centre, 939 km (583 mi) from surface
Periapsis	6,586 km (4,092 mi) from centre, 215 km (134 mi) from surface
Orbital period	96.2 minutes

Sputnik 1 was the first Earth-orbiting artificial satellite. It was launched into an elliptical low Earth orbit by the Soviet Union on 4 October 1957, and was the first in a series of satellites collectively known as the Sputnik program. The unanticipated announcement of *Sputnik 1*'s success precipitated the Sputnik crisis in the United States and ignited the Space Race within the Cold War. The launch ushered in new political, military, technological, and scientific developments. While the Sputnik launch was a single event, it marked the start of the Space Age.

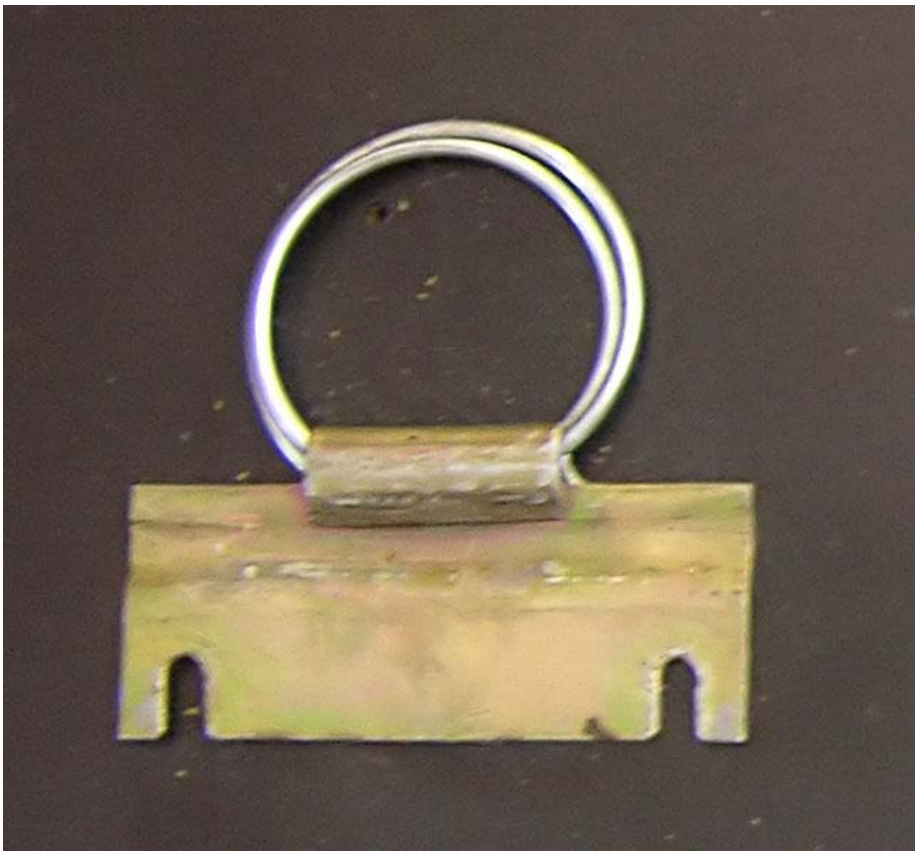
Apart from its value as a technological first, *Sputnik* also helped to identify the upper atmospheric layer's density, through measuring the satellite's orbital changes. It also provided data on radio-signal distribution in the ionosphere. Pressurized nitrogen, in the satellite's body, provided the first opportunity for meteoroid detection. If a meteoroid penetrated the satellite's outer hull, it would be detected by the temperature data sent back to Earth.

Sputnik 1 was launched during the International Geophysical Year from Site No.1, at the 5th Tyuratam range, in Kazakh SSR (now at the Baikonur Cosmodrome). The satellite travelled at 29,000 kilometers (18,000 mi) per hour, taking 96.2 minutes to complete an orbit, and emitted radio signals at 20.005 and 40.002 MHz which were monitored by amateur radio operators throughout the world. The signals continued for 22 days until the transmitter batteries ran out on 26 October 1957. *Sputnik 1* burned up on 4 January 1958, as it fell from orbit upon reentering Earth's atmosphere, after travelling about 60 million km (37 million miles) and spending 3 months in orbit.

Before the launch

Satellite construction project

The history of the *Sputnik 1* project dates back to 27 May 1954, when Sergei Korolev addressed Dmitry Ustinov, then Minister of Defense Industries, proposing the development of an Earth-orbiting artificial satellite. Korolev also forwarded Ustinov a report by Mikhail Tikhonravov with an overview of similar projects abroad. Tikhonravov emphasized that an artificial satellite is an inevitable stage in the development of rocket equipment, after which "interplanetary communication" would become possible. On 29 July 1955 the U.S. President Dwight Eisenhower announced, through his press secretary, that the United States would launch an artificial satellite during the International Geophysical Year (IGY). A week later, on 8 August the Presidium of the Central Committee of the CPSU approved the idea of creating an artificial satellite. On 30 August Vasily Ryabikov – the head of the State Commission on R-7 rocket test launches – held a meeting where Korolev presented calculation data for a spaceflight trajectory to the Moon. They decided to develop a three-stage version of the R-7 rocket for satellite launches.



This metal arming key is the last remaining piece of the first Sputnik satellite. It prevented contact between the batteries and the transmitter prior to launch. Currently on display at the Smithsonian National Air and Space Museum.

On 30 January 1956 the Council of Ministers of the USSR approved practical work on an artificial Earth-orbiting satellite. This satellite, named "Object D", was planned to be completed in 1957-58; it would have a mass of 1,000 to 1,400 kg (2,200 to 3,090 lb) and would carry 200 to 300 kg (440 to 660 lb) of scientific instruments. The first test launch of "Object D" was scheduled for 1957. According to that decision, work on the satellite was to be divided between institutions as follows:

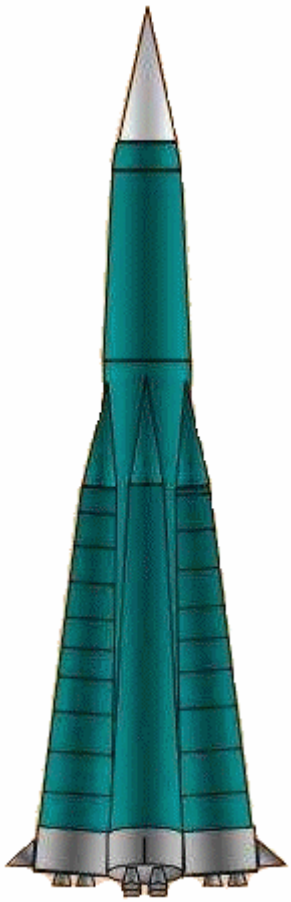
- USSR Academy of Sciences was responsible for the general scientific leadership and research instruments supply
- Ministry of Defense Industry and its main executor OKB-1 were assigned the task of creating the satellite as a special carrier for scientific research instruments
- Ministry of Radiotechnical Industry would develop the control system, radio/technical instruments and the telemetry system
- Ministry of Ship Building Industry would develop gyroscope devices
- Ministry of Machine Building would develop ground launching, refueling and transportation means
- Ministry of Defense was responsible for conducting launches

By July 1956 the draft was completed and the scientific tasks to be carried out by a satellite were defined. It included measuring the density of the atmosphere, its ion composition, corpuscular solar radiation, magnetic fields, cosmic rays, etc. Data, valuable in creating future satellites, was also to be collected. A ground observational complex was to be developed, that would collect information transmitted by the satellite, observe the satellite's orbit, and transmit commands to the satellite. Such a complex should include up to 15 measurement stations. Because of the limited time frame, they should have means designed for rocket R-7 observations. Observations were planned for only 7 to 10 days and orbit calculations were expected to be not quite accurate.

Unfortunately, the complexity of the ambitious design and problems in following exact specifications meant that some parts of 'Object D', when delivered for assembly, simply did not fit with the others, causing costly delays. By the end of 1956 it became clear that plans for 'Object D' were not to be fulfilled in time because of difficulties creating scientific instruments and the low specific impulse produced by the completed R-7 engines (304 sec instead of the planned 309 to 310 sec). Consequently the government re-scheduled the launch for April 1958. Object D would later fly as *Sputnik 3*.

Fearing the U.S. would launch a satellite before the USSR, OKB-1 suggested the creation and launch of a satellite in April–May 1957, before the IGY began in July 1957. The new satellite would be simple, light (100 kg or 220 lb), and easy to construct, forgoing the complex, heavy scientific equipment in favour of a simple radio transmitter. On 15 February 1957 the Council of Ministers of the USSR approved this, providing for launching the simplest version satellite, designated 'Object PS'. This version also facilitated the satellite to be visually tracked by Earth-based observers while in orbit, and transmit tracking signals to ground-based receiving stations. Launch of two satellites PS-1 and PS-2 with two R-7 rockets (8K71) was allowed, but only after one or two successful R-7 test launches.

Launch vehicle preparation and launch site selection



SS-6 rocket. (NASA)

30k USSR postage stamp depicting *Sputnik 1*

The **R-7** (Russian: P-7) was the world's first true intercontinental ballistic missile, deployed by the Soviet Union during the Cold War from 1959 to 1968. To the West it was known by the NATO reporting name **SS-6 Sapwood** and within the Soviet Union by the GRAU index **8K71**. In modified form, it launched Sputnik, the first artificial satellite, into orbit, and became the basis for the Soyuz space launcher and the Molniya, Vostok and Voskhod variants.

The widely used nickname for the R-7 launcher, "semyorka", means (colloquially, affectionately) "the digit 7" or a "group of seven" (usually people rather than inanimate objects) in Russian.

Description

The R-7 was 34 m long, 3 m in diameter and weighed 280 metric tons; it was two-stage, powered by rocket engines using liquid oxygen (LOX) and kerosene and capable of delivering its payload at around 8,800 km, with an accuracy (CEP) of around 5 km. A single nuclear warhead was carried with a nominal yield of 3 megatons of TNT. The initial launch was boosted by four strap-on liquid rocket boosters making up the first stage with a central 'sustainer' motor powering through both the first and the second stage. Each strap-on booster included two vernier thrusters and the core stage included four. The guidance system was inertial with radio control of the vernier thrusters.

Development

Design work began in 1953 at OKB-1 in Kaliningrad in Moscow oblast (presently Korolev, Moscow Oblast) and other divisions with the requirement for a two-stage missile of 170 tons with a range of 8,000 km carrying a 3000 kg warhead. Following first ground tests in late 1953 the initial design was heavily reworked and the final design was not approved until May 1954.

Contrary to statements that the R-7 was based largely on experience and assistance of German scientists, the missile is noteworthy for looking beyond past achievements that had used German ideas. For example, instead of using jet vanes for control, which increased resistance generated at the engine nozzle exhaust outlet, the R-7 used special control engines. These same engines served as the last stage's vernier thrusters.

Because of clustered design, each booster had its own propellant tanks. The design team had to develop a system to regulate the propellant component consumption ratio and to synchronize the consumption between the boosters.

Starting from the R-1, which was a copy of the German V-2, a free-standing missile was launched from a horizontal pad. It turned out that assembling a cluster of a central core and four boosters on the pad is almost impossible without it falling apart. Also, a wind gust could knock the missile off of the pad. The solution was to eliminate the pad and to suspend the entire rocket in the trusses that bear both vertical weight load as well as horizontal wind forces. The launch system simulated flight conditions with strap-on boosters pushing the central core forward.

The first testing of the new missile, codenamed 8K71, was on May 15, 1957 from Baikonur Cosmodrome. A fire in a strap-on rocket led to an unintended crash 400 km from the site. Following another unsuccessful test the first successful long flight, of 6,000 km, was made on August 21. It was announced by TASS on August 26. A modified version of the missile placed Sputnik 1 in orbit from Baikonur on October 4 and Sputnik 2 on November 3.

Following these first tests certain modifications were found to be needed and test flights were not completed until December 1959. The additional development resulted in the 8K74 (also known as R-7A), which was lighter, had better navigation systems, more powerful engines, extended its range to 12,000 km by carrying more fuel, and increased payload to 5,370 kg. The warhead was tested on Novaya Zemlya in October 1957 and again in 1958, yielding an estimated 2.9 Mt of TNT.

Operational history

The first strategic-missile unit became operational on 9 February 1959 at Plesetsk in north-west Russia. On 15 December 1959 the R-7 missile was tested at Plesetsk for the first time. The missiles were fully deployed by 1962.

Total service was limited to no more than ten nuclear armed missiles active at any time. A single launch pad was operational at Baikonur and from six to eight were in operation at Plesetsk.

The costs of the system were high, mostly due to the difficulty of constructing in remote areas the large launch sites required. At one point, each launch site was projected to cost 5% of the Soviet defence budget. However, these huge costs were not unique for a first generation missile and the US experienced similar problems.

Besides the cost, the missile system faced other operational challenges. With the U-2 overflights, the huge R-7 launch complexes could not be hidden and therefore could be expected to be destroyed quickly in any nuclear war. Also, the R-7 took almost twenty hours to prepare for launching, and it could not be left on alert for more than a day due to its cryogenic fuel system. Therefore, the Soviet force could not be kept on permanent alert, and could have been subject to an air strike before launching. Additionally the huge payload for which it was designed, adapted to early heavy H-bombs, became irrelevant with the coming of lighter bomb technology.

The limitations of the R-7 pushed the Soviet Union into rapidly developing second-generation missiles which would be more viable weapons systems. The R-7 was phased out from military service by 1968.

While the R-7 turned out to be impractical as a weapon, it became the basis for a series of Soviet expendable space launch vehicles. The derivatives of the R-7 missile became successful space launch vehicles, which are still being used in modified form.

The two-stage R-7 rocket was initially designed as an ICBM by OKB-1. The decision to build it was made by the CPSU Central Committee and the Council of Ministers of the USSR on 20 May 1954. A special reconnaissance commission selected Tyuratam as a place for the construction of a rocket proving ground (the 5th Tyuratam range, usually referred to as "NIIP-5", or "GIK-5" in the post-Soviet time). The selection was approved on 12 February 1955 by the Council of Ministers of the USSR, but the site would not be completed until 1958. Actual work on the construction of the site began on 20 July by military building units. On 14 June 1956 Sergei Korolev decided to adapt the R-7 rocket to the 'Object D', that would later be replaced by the much lighter 'Object PS'.

The first launch of an R-7 rocket (8K71 No.5L) occurred on 15 May 1957. The flight was controlled until the 98th second, but a fire in a strap-on rocket led to an unintended crash 400 km from the site. Three attempts to launch the second rocket (8K71 No.6) were made on 10–11 June, which failed because of a mistake made during the rocket's assembly. The unsuccessful launch of the third R-7 rocket (8K71 No.7) took place on 12 July. During the flight the rocket began to rotate about its longitudinal axis and its engines were automatically turned off. The packet of stages was destroyed 32.9 seconds into the flight. The stages fell 7 km (4.3 mi) from the site and exploded.

The launch of the fourth rocket (8K71 No.8), on 21 August at 15:25 Moscow Time, was successful. Its head part separated, reached the defined region, entered the atmosphere, and was destroyed at a height of 10 km (6.2 mi) because of thermodynamic overload after traveling 6,000 km. On 27 August TASS in the USSR issued a statement on the launch of a long-distance multistage ICBM. The launch of the fifth R-7 rocket (8K71 No.9), on 7 September was also successful, but the head part was also destroyed in the atmosphere, and hence needed a long redesign to completely fit its military purpose. The rocket, however, was already suitable for scientific satellite launches and this "time-out" of the rocket's military exploitation was used to launch the PS-1 and PS-2 satellites.

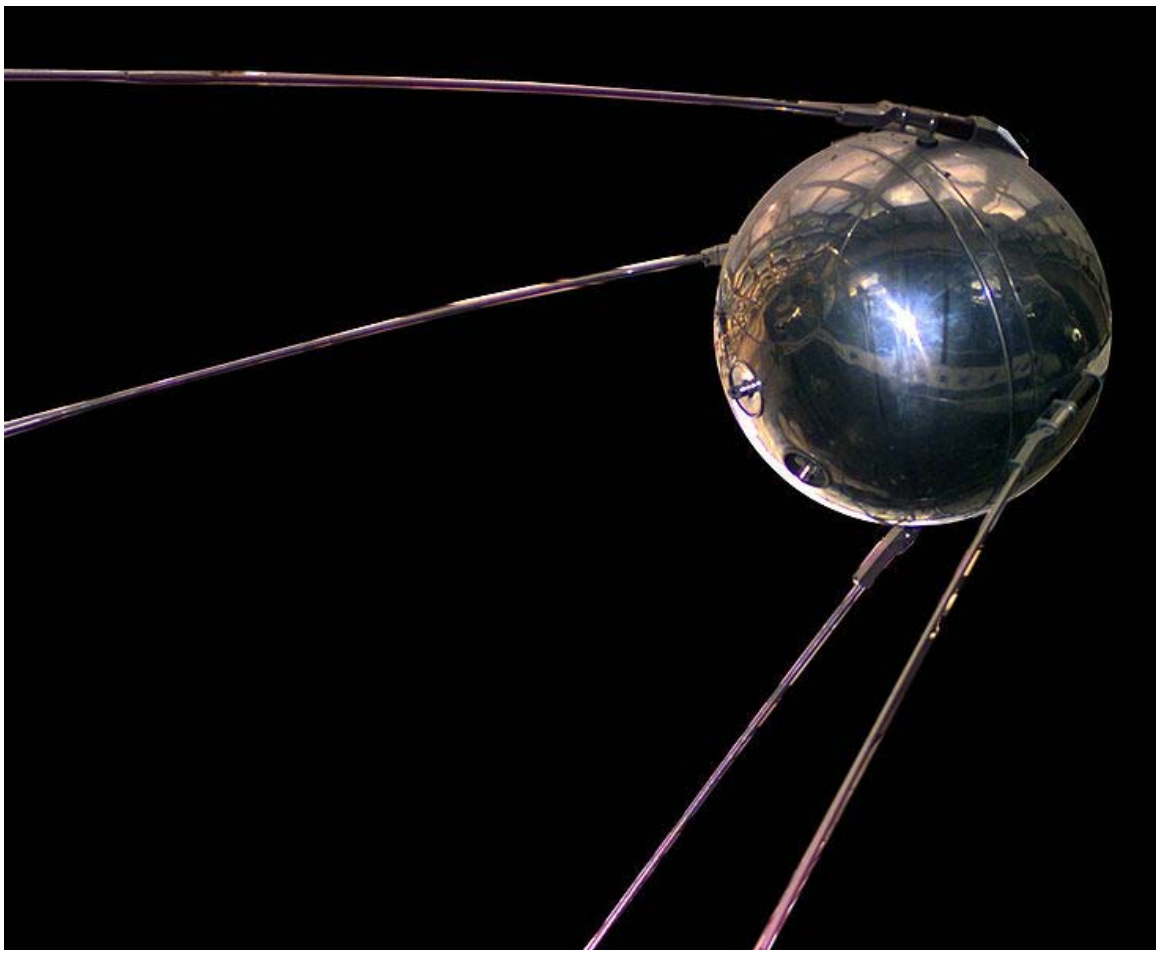
On 22 September a modified R-7 rocket, named the Sputnik rocket (Russian: ракета-носитель Спутник) and indexed as 8K71PS, with the satellite PS-1, arrived at the proving ground and preparations for the launch began. As the R-7 was designed to carry the much heavier Object D, its adaptation to PS-1 reduced its initial mass from 280 to 272.83 short tons (254 to 248 metric tons) and its mass at launch was 267 short tons (242 metric tons); its length with PS-1 was 29.167 metres (95 ft 8.3 in) and the thrust was 3.90 MN (880,000 lb_f).

Observation complex

The measurement complex at the proving ground for monitoring the launch vehicle from its launch was completed prior to the first R-7 rocket test launches in December 1956. It consisted of six static stations: IP-1 through IP-6, with IP-1 situated at a distance of 1 km (0.62 mi) from the launch pad. The main monitoring devices of these stations were telemetry and trajectory measurement stations, "Tral," developed by OKB MEI. They received and monitored data from the "Tral" system transponders mounted on the R-7 rocket; an on-board system that provided precise telemetric data about *Sputnik* 1's launch vehicle. The data was useful even after the satellite's separation from the second stage of the rocket; *Sputnik* 1's location was calculated from the data on the second stage's location (which followed *Sputnik 1* at a known distance) using nomograms developed by P.E. Elyasberg.

An additional observation complex, established to track the satellite after its separation from the rocket, was completed by a group led by Colonel Yu.A.Mozzhorin in accordance with the General Staff directive of 8 May 1957. It was called the Command-Measurement Complex and consisted of the coordination center in *NII-4* by the Ministry of Defence of the USSR (at Bolshevo) and seven ground tracking stations, situated along the line of the satellite's ground track. They were: NIP-1 (at Tyuratam station, Kazakh SSR, situated not far from IP-1), NIP-2 (at Makat station, Guryev Oblast), NIP-3 (at Sary-Shagan station, Dzhezkazgan Oblast), NIP-4 (at Yeniseysk), NIP-5 (at village Iskup, Krasnoyarsk Krai), NIP-6 (at Yelizovo) and NIP-7 (at Klyuchi). The complex had a communication channel with the launch pad. Stations were equipped with radar, optical instruments, and communications systems. PS-1 was not designed to be controlled, it could only be observed. Data from stations were transmitted by telegraphs into *NII-4* where ballistics specialists calculated orbital parameters. The complex became an early prototype of the Soviet Mission Control Center.

Design



A replica of *Sputnik 1*

The chief constructor of *Sputnik 1* at OKB-1 was M.S.Khomyakov. The satellite was a 585 mm (23 in) diameter sphere, assembled from two hemispheres which were hermetically sealed using o-rings and connected using 36 bolts. The hemispheres, covered with a highly polished 1 mm-thick heat shield made of aluminium-magnesium-titanium AMG6T ("AMG" is an abbreviation for "aluminium-magnesium" and "T" stands for "titanium", the alloy contains 6% of magnesium and 0.2% of titanium) alloy, were 2 mm-thick. The satellite carried two antennas designed by the Antenna Laboratory of OKB-1 led by M.V.Krayushkin. Each antenna was made up of two whip-like parts: 2.4 and 2.9 metres (7.9 and 9.5 ft) in length, and had an almost spherical radiation pattern, so that the satellite beeps were transmitted with equal power in all directions; making reception of the transmitted signal independent of the satellite's rotation. The whip-like pairs of antennas resembled four long "whiskers" pointing to one side, at equal 35 degrees angles with the longitudinal axis of the satellite.

The power supply, with a mass of 51 kg (110 lb), was in the shape of an octahedral nut with the radio transmitter in its hole. It consisted of three silver-zinc batteries, developed at the All-Union Research Institute of Current Sources (VNIIT) under the leadership of N. S. Lidorenko. Two of them powered the radio transmitter and one powered the temperature regulation system. They were expected to fade out in two weeks, but ended up working for 22 days. The power supply was turned on automatically at the moment of the satellite's separation from the second stage of the rocket.

The satellite had a one-watt, 3.5 kg (7.7 lb) radio transmitting unit inside, developed by V. I. Lappo from *NII-885,* that worked on two frequencies, 20.005 and 40.002 MHz. Signals on the first frequency were transmitted in 0.3 sec pulses (under normal temperature and pressure conditions on-board), with pauses of the same duration filled by pulses on the second frequency. Analysis of the radio signals was used to gather information about the electron density of the ionosphere. Temperature and pressure were encoded in the duration of radio beeps, which additionally indicated that the satellite had not been punctured by a meteorite. A temperature regulation system contained a fan, a dual thermal switch, and a control thermal switch. If the temperature inside the satellite exceeded 36 °C (97 °F) the fan was turned on and when it fell below 20 °C (68 °F) the fan was turned off by the dual thermal switch. If the temperature exceeded 50 °C (122 °F) or fell below 0 °C (32 °F), another control thermal switch was activated, changing the duration of the radio signal pulses. *Sputnik 1* was filled with dry nitrogen, pressurized to 1.3 atm. For the pressure control the satellite had a barometric switch, activated when the pressure inside the satellite fell below 0.35 kg/cm^2 (5.0 psi), changing the duration of radio signal impulse.

While attached to the rocket, *Sputnik 1* was protected by a cone-shaped payload fairing, with a height of 80 cm (31.5 in) and an aperture of 48 degrees. The fairing separated from both *Sputnik 1* and the rocket at the same time when the satellite was ejected. Tests of the satellite were conducted at OKB-1 under the leadership of O. G. Ivanovsky. *Sputnik 1* was launched by an R-7 rocket on 4 October 1957. It burned up upon re-entry on 4 January 1958.

Launch and mission

Soviet 40k stamp, showing satellite's orbit

The control system of the Sputnik rocket was tuned to provide an orbit with the following parameters: perigee height - 223 km (139 mi), apogee height - 1,450 km (900 mi), orbital period - 101.5 min. A rocket trajectory with these parameters was calculated earlier by Georgi Grechko, after completing the calculations over several nights on the USSR Academy of Sciences' mainframe computer.

The Sputnik rocket was launched at 19:28:34 UTC, on 4 October 1957, from Site No.1 at NIIP-5. Processing of the information, obtained from the "Tral" system showed that the side boosters separated 116.38 seconds into the flight and the second-stage engine was shut down 294.6 seconds into the flight. At this moment the second stage with PS-1 attached had a height of 223 km (139 mi) above Earth's surface, a velocity of 7,780 m/s (25,500 ft/s) and velocity vector inclination to the local horizon was 0 degrees 24 minutes. This motion resulted in an orbit with initial parameters: perigee height - 223 km, apogee height - 950 km (590 mi), initial orbital period - 96.2 minutes.

After 314.5 seconds PS-1 separated from the second stage and at the same moment at the small "Finnish house" of IP-1 station Junior Engineer-Lieutenant V.G. Borisov heard the "Beep-beep-beep" signals from the radio receiver R-250. Reception lasted for two

minutes, while PS-1 was above the horizon. There were many people in the house, both military and civil, and they were probably the first to celebrate the event. After 325.44 seconds a corner reflector on the second stage was opened, that also allowed measurement of its orbit parameters – like the working "Tral" system did.

The designers, engineers and technicians who developed the rocket and satellite watched the launch from the range. After the launch they ran to the mobile radio station to listen to signals from the satellite. They waited about 90 minutes to ensure that the satellite had made one orbit and was transmitting, before Korolyov called Khrushchev. The downlink telemetry included data on temperatures inside and on the surface of the sphere.

On the first orbit the Telegraph Agency of the Soviet Union (TASS) transmitted: "As result of great, intense work of scientific institutes and design bureaus the first artificial Earth satellite has been built". The *Sputnik 1* rocket booster (second stage of the rocket) also reached Earth orbit and was visible from the ground at night as a first magnitude object following the satellite. Korolyov had intentionally requested reflective panels placed on the booster in order to make it so visible. The satellite itself, a small but highly polished sphere, was barely visible at sixth magnitude, and thus more difficult to follow optically. Ahead of *Sputnik 1* flew the third object – the payload fairing, 80 cm (31 in)-long cone, i.e. a little bit bigger than the satellite.

Feedback

> *Our movies and television programs in the fifties were full of the idea of going into space. What came as a surprise was that it was the Soviet Union that launched the first satellite. It is hard to recall the atmosphere of the time.*
> John Logsdon

Teams of visual observers at 150 stations in the United States and other countries were alerted during the night to watch for the Soviet sphere at dawn and during the evening twilight. They had been organized in Project Moonwatch to sight the satellite through binoculars or telescopes as it passed overhead. The USSR asked radio amateurs and commercial stations to record the sound of the satellite on magnetic tape.

News reports at the time pointed out that "anyone possessing a short wave receiver can hear the new Russian earth satellite as it hurtles over his area of the globe". Directions, provided by the American Radio Relay League were to "Tune in 20 megacycles sharply, by the time signals, given on that frequency. Then tune to slightly higher frequencies. The 'beep, beep' sound of the satellite can be heard each time it rounds the globe," The first recording of *Sputnik 1*'s signal was made by RCA engineers near Riverhead, Long Island. They then drove the tape recording into Manhattan for broadcast to the public over NBC radio. However, as *Sputnik* rose higher over the East Coast, its signal was picked up by ham station W2AEE, the ham radio station of Columbia University. Students working in the university's FM station, WKCR, made a tape of this, and were

the first to rebroadcast the *Sputnik 1* signal to the American public (or such of it as could receive the FM station). The next morning two FBI agents took the tape from the station. It has never been returned.

At first the Soviet Union agreed to use equipment "compatible" with that of the United States, but later announced the lower frequencies. The White House declined to comment on military aspects of the launch, but said it "did not come as a surprise." On 5 October the Naval Research Laboratory announced it had recorded four crossings of *Sputnik-1* over the United States. U.S. President Dwight Eisenhower obtained photographs of the Soviet facilities from Lockheed U-2 flights conducted since 1956.

The USSR's launch of Sputnik spurred the United States to create the Advanced Research Projects Agency (ARPA or DARPA) in February 1958 to regain a technological lead.

1957 - October 4th - the USSR launches Sputnik, the first artificial earth satellite.
1958 - February 7th - In response to the launch of Sputnik, the US Department of Defense issues directive 5105.15 establishing the Advanced Research Projects Agency (ARPA).
The organization united some of America's most brilliant people, who developed the United States' first successful satellite in 18 months. Several years later ARPA began to focus on computer networking and communications technology.

Propaganda

The propaganda value of *Sputnik 1* was seen in both the response of the United States and the elevated status of the Soviet Union. The launch provided both pride for the Soviet people and embarrassment for the Americans.

The propaganda value of *Sputnik 1* for the Soviet Union was not capitalized immediately after the launch because the Soviets were distracted by their own scientific goals and determination to win the Space Race. The United States was presently working on a separate development, Project Vanguard, and was caught off guard by the Soviets' early launch, placing it behind the Soviets in the newly emerged space race. However, the Soviets' accomplishments were kept quiet in the homeland to prevent any exploitation of their failures or loss of secrets, which undermined the propaganda opportunity. The original article announcing the first launch never made a headline in the daily Pravda. *Sputnik* was a stunning propaganda achievement for the Soviets that was only recognized in hindsight.

The value of *Sputnik 1* as Soviet propaganda was especially evident in the response of the American public. *Sputnik* crushed the American perception of the United States as the technological superpower by demonstrating that the Soviets were not the ignorant Easterners they had been perceived as prior to the launch. As a result, panic overtook the American public, which created an enormous sense of vulnerability regarding the United States' ability to defend its territory. Adding to this fear was the element of surprise with which Sputnik entered the world, which left the American public in what was observed as

a “wave of near-hysteria”. The United States appeared at the mercy of a new technological power which shattered any notion of internal security or confidence for the American people and significantly elevated the perception of the Soviet Union in the international community.

The elevated status of the Soviet Union was further solidified by the actions of the American government following *Sputnik 1*. American society underwent an enormous shift that emphasized science and technological research. *Sputnik* forced the Americans to take up a more offensive stance in the emerging space race. Everything from the military to education systems were revamped by the government and unimaginable economic possibilities ensued. The federal government began pouring unmatched amounts of money into science education, engineering and mathematics at all levels of education. An advanced research group was assembled for military purposes. These research groups developed weapons such as ICBMs and missile defense systems, as well as spy satellites for the US. After several failed attempts, the US successfully launched a satellite, Explorer I, on January 31, 1958.

The launch of *Sputnik 1* both united the people of the Soviet Union and humiliated the United States with its lack of comparable technology. State propaganda increased the pride the Soviet people had in the project; millions of people listened to *Sputnik 1*'s signals on the radio. Citizens were told a particular place in the sky and time of night when they could see *Sputnik 1*. However, this was only something they were told by Pravda. The people actually witnessed a stage of the carrier rocket. Russians began to use their expedition into space as a form of propaganda and political leverage, mimicked by the United States. However, the United States' temporary status as second-rate technological superpower brought great embarrassment to the American people. Some theorize that this embarrassment provided the much-needed push that accelerated America's moon landing.

Replicas

A *Sputnik 1* replica, built by French and Russian teenagers and hand-launched from Mir on 3 November 1997, reentered Earth's atmosphere after two months in orbit.

A Sputnik 1 model was given as a gift to the United Nations and now decorates the entry Hall of its New York City Headquarters. Other replicas are on display at the Smithsonian's National Air and Space Museum, in Space section of the Science Museum, London and at the World Museum in Liverpool, UK.

Backup units

- A Sputnik 1 backup unit is on display at the personal library of Jay Walker, an Internet entrepreneur.
- In 2003 a back-up unit of Sputnik 1 called "model PS-1" failed to sell on eBay. It was offered while still on display in a science institute near Kiev. It is estimated that between four and twenty models were made for testing and as replicas.

- What is thought to be a backup of Sputnik 1 now hangs at The Museum of Flight in Seattle, Washington. The craft was manufactured by the Soviet Academy of Sciences and has battery acid remnants on the inside walls of the spherical shell, as well as fittings for the various components, suggesting that it was more than just a model.

Sputnik crisis

Soviet stamp depicting Sputnik's orbit around Earth

The **Sputnik crisis** was a key event during the Cold War that began on October 4, 1957 when the Soviet Union launched *Sputnik 1*, the first Earth satellite.

The United States had believed itself to be the world leader in space technology and missile development. The surprise of the Sputnik launch and the failure of the first two U.S. launch attempts proved otherwise.

Sputnik's appearance rattled the United States. President Dwight D. Eisenhower called the shock the "Sputnik Crisis" because of the looming threat of the Soviet Union. During the Cold War, America was in a state of fear from the Soviet Union. Once the Soviets started to launch satellites into orbit, even a payload harmless to the U.S., the concern

increased. If the USSR could launch a satellite, it could also launch a nuclear warhead able to travel intercontinental distances.

Less than a year after the Sputnik launch, Congress passed the National Defense Education Act (NDEA). The act was a four-year program that poured billions of dollars into the U.S. education system. In 1953 the government spent $153 million, colleges took $10 million of that funding; however, by 1960 the combined funding grew almost sixfold because of the NDEA.

US Rep. Clare Boothe Luce referred to Sputnik's beeps as "an intercontinental outer-space raspberry to a decade of American pretensions that the American way of life was a gilt-edged guarantee of our national superiority." After the initial public shock, the Space Race began, leading to the first human launched into space, Project Apollo and the first manned moon landing in 1969.

US response

The Sputnik crisis spurred a series of U.S. initiatives, many initiated by the Department of Defense:

- Within two days, calculation of the Sputnik orbit (joint work by UIUC Astronomy Dept. and Digital Computer Lab).
- Increased emphasis on the Navy's existing Project Vanguard to launch an American satellite into orbit, and a revival of the Army's Explorer program that preceded Vanguard in launching the first American satellite into orbit on January 31, 1958.
- By February 1958, the political and defense communities had recognized the need for a high-level Department of Defense organization to execute R&D projects and created the Advanced Research Projects Agency, which later became the Defense Advanced Research Projects Agency or DARPA.
- On July 29, 1958, President Eisenhower signed the National Aeronautics and Space Act, creating NASA.
- Education programs initiated to foster a new generation of engineers.
- Increased support for scientific research. For 1959, Congress increased the National Science Foundation (NSF) appropriation to $134 million, almost $100 million higher than the year before. By 1968, the NSF budget would stand at nearly $500 million.
- The Polaris missile program
- Project management as an area of inquiry and an object of much scrutiny, leading up to the modern concept of project management and standardized project models such as the DoD *Program Evaluation and Review Technique*, PERT, invented for Polaris.
- The decision by President John F. Kennedy, who campaigned in 1960 on closing the "missile gap", to deploy 1,000 Minuteman missiles, far more ICBMs than the Soviets had at the time.

Chapter- 2

Sputnik 2

Sputnik 2

Operator	Soviet Union
Major contractors	OKB-1
Mission type	Earth Science
Satellite of	Earth
Orbits	~2,000
Launch date	November 3, 1957 at 02:30:00 UTC
Launch vehicle	R-7/SS-6 ICBM
Mission duration	162 days

Orbital decay	April 14, 1958
COSPAR ID	1957-002A
Homepage	NASA NSSDC Master Catalog
Mass	508.3 kg (1,120 lb.)
	Orbital elements
Semimajor axis	7,314.2 km (4,545 miles)
Eccentricity	.098921
Inclination	65.33°
Apoapsis	1,660 km (1,031 miles)
Periapsis	212 km (132 miles)
Orbital period	103.7 minutes

Instruments	
Dog Laika:	Biological data
Geiger counters:	Charged particles
Spectrophotometers:	Solar radiation (ultraviolet and x-ray emissions) and cosmic rays

Sputnik 2 (Russian: Спутник-2, *Satellite 2*) was the second spacecraft launched into Earth orbit, on November 3, 1957, and the first to carry a living animal, a dog named Laika. Sputnik 2 was a 4-meter (13 foot) high cone-shaped capsule with a base diameter of 2 meters (6.6 feet). It contained several compartments for radio transmitters, a telemetry system, a programming unit, a regeneration and temperature control system for the cabin, and scientific instruments. A separate sealed cabin contained the dog Laika.

Engineering and biological data were transmitted using the Tral D telemetry system, which would transmit data to Earth for a 15 minute period during each orbit. Two photometers were on board for measuring solar radiation (ultraviolet and x-ray emissions) and cosmic rays. Sputnik 2 did not contain a television camera; TV images of dogs on Sputnik 5 are commonly misidentified as Laika.

Mission profile

Postage stamp of the USSR, «Спутник-2»

Sputnik 2 was launched into a 212 × 1660 km (132 × 1031 mi) orbit with a period of 103.7 minutes on an essentially unmodified ICBM R-7, similar to the one used to launch Sputnik 1. After reaching orbit the nose cone was jettisoned successfully but the Blok A core did not separate as planned. This inhibited the operation of the thermal control system. Additionally some of the thermal insulation tore loose causing interior temperatures to reach 40 °C (104 °F). It is believed Laika survived for only a few hours instead of the planned ten days because of the heat. The orbit of Sputnik 2 decayed and it reentered Earth's atmosphere on 14 April 1958 after 162 days in orbit.

Passenger

Laika (Russian: Лайка, literally meaning "Barker"; c. 1954 – November 3, 1957) was a Soviet space dog that became the first animal to orbit the Earth and the first orbital death. The technology to deorbit had not yet been developed, so there was no expectation for survival. Little was known about the impact of spaceflight on living things at the time Laika's mission was launched. Some scientists believed humans would be unable to survive the launch or the conditions of outer space, so engineers viewed flights by non-human animals as a necessary precursor to human missions. Laika, a stray, originally named **Kudryavka** (Russian: Кудрявка *Little Curly*), underwent training with two other dogs, and was eventually chosen as the occupant of the Soviet spacecraft Sputnik 2 that was launched into outer space on November 3, 1957. Laika likely died within hours after launch from overheating, possibly due to a failure of the central R-7 sustainer to separate from the payload. The true cause and time of her death was not made public until 2002; instead, it was widely reported that she died when her oxygen ran out, or (as the Soviets initially insisted) she was euthanised prior to oxygen depletion. Nonetheless, the experiment proved that a living passenger could survive being launched into orbit and endure weightlessness, paving the way for human spaceflight and providing scientists with some of the first data on how living organisms react to spaceflight environments.

On April 11, 2008, Russian officials unveiled a monument to Laika. A small monument in her honor was built near the military research facility in Moscow which prepared Laika's flight to space. It features a dog standing on top of a rocket.

Training

Laika was found as a stray wandering the streets of Moscow. Soviet scientists chose to use Moscow strays since they assumed that such animals had already learned to endure conditions of extreme cold and hunger. This specimen was an eleven-pound mongrel female, approximately three years old. Another account reported that she weighed about 6 kg (13 lb). Soviet personnel gave her several names and nicknames, among them Kudryavka (Russian for *Little Curly*), Zhuchka (*Little Bug*) and Limonchik (*Little Lemon*). Laika, the Russian name for several breeds of dogs similar to the husky, was the name popularized around the world. The American press dubbed her Muttnik (*mutt* + suffix *-nik*) as a pun on Sputnik, or referred to her as *Curly*. Her true pedigree is unknown, although it is generally accepted that she was part husky or other Nordic breed, and possibly part terrier. A Russian magazine described her temperament as *phlegmatic*, saying that she did not quarrel with other dogs.

The Soviet Union and United States had previously sent animals only on sub-orbital flights. Three dogs were trained for the Sputnik 2 flight: Albina, Mushka, and Laika. Soviet space-life scientist Oleg Gazenko selected and trained Laika. Albina flew twice on a high-altitude test rocket, and Mushka was used to test instrumentation and life support.

To adapt the dogs to the confines of the tiny cabin of Sputnik 2, they were kept in progressively smaller cages for periods up to 20 days. The extensive close confinement caused them to stop urinating or defecating, made them restless, and caused their general condition to deteriorate. Laxatives did not improve their condition, and the researchers found that only long periods of training proved effective. The dogs were placed in centrifuges that simulated the acceleration of a rocket launch and were placed in machines that simulated the noises of the spacecraft. This caused their pulses to double and their blood pressure to increase by 30–65 torr. The dogs were trained to eat a special high-nutrition gel that would be their food in space.

Before the launch, one of the scientists took Laika home to play with his children. In a book chronicling the story of Soviet space medicine, Dr. Vladimir Yazdovsky wrote, "I wanted to do something nice for her: She had so little time left to live."

Voyage

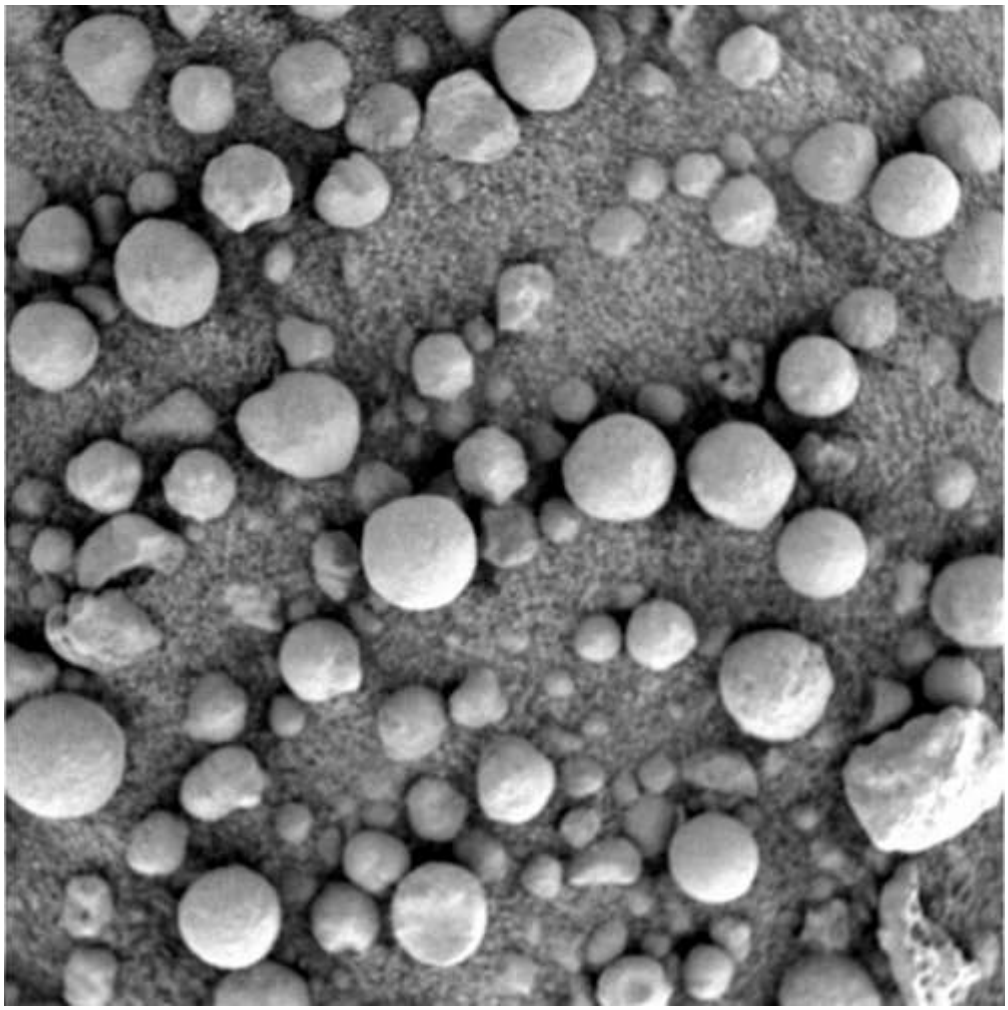
According to a NASA document, Laika was placed in the satellite on October 31, 1957—three days before the start of the mission. At that time of year the temperatures at the launch site were extremely cold, and a hose connected to a heater was used to keep her container warm. Two assistants were assigned to keep a constant watch on Laika before launch. Just prior to liftoff on November 3, 1957 from Baikonur Cosmodrome, Laika's fur was sponged in a weak alcohol solution and carefully groomed, while iodine was painted onto the areas where sensors would be placed to monitor her bodily functions.

At peak acceleration Laika's respiration increased to between three and four times the pre-launch rate. The sensors showed her heart rate was 103 beats/min before launch and increased to 240 beats/min during the early acceleration. After reaching orbit, Sputnik 2's nose cone was jettisoned successfully, however the "Block A" core did not separate as planned, stopping the thermal control system from operating correctly. Some of the thermal insulation tore loose, raising the cabin temperature to 40 °C (104 °F). After three hours of weightlessness, Laika's pulse rate had settled back to 102 beats/min, three times longer than it had taken during earlier ground tests, an indication of the stress she was under. The early telemetry indicated that Laika was agitated but eating her food. After approximately five to seven hours into the flight, no further signs of life were received from the spacecraft.

The Russian scientists had planned to euthanize Laika with a poisoned serving of food. For many years, the Soviet Union gave conflicting statements that she had died either from oxygen starvation when the batteries failed, or that she had been euthanized. Many rumors circulated about the exact manner of her passing. In 1999, several Russian sources reported that Laika had died when the cabin overheated on the fourth day. In October 2002, Dimitri Malashenkov, one of the scientists behind the Sputnik 2 mission, revealed that Laika had died by the fourth circuit of flight from overheating. According to a paper he presented to the World Space Congress in Houston, Texas, "It turned out that it was practically impossible to create a reliable temperature control system in such limited time constraints."

Over five months later, after 2,570 orbits, Sputnik 2 disintegrated—along with Laika's remains—during re-entry on April 14, 1958.

Controversy



NASA named this soil target on Mars after Laika during the Mars Exploration Rover mission

Due to the overshadowing issue of the Soviet vs. US Space Race, the ethical problems of this experiment went largely unaddressed for some time. As newspaper clippings from 1957 show, the press was more preoccupied with reporting the political perspective, while the health and retrieval—or lack thereof—of Laika was hardly mentioned. Only later were there discussions regarding the fate of the dog—which some initially insisted be called Curly rather than Laika.

Sputnik 2 was not designed to be retrievable, and Laika had always been intended to die. The mission sparked a debate across the globe on the mistreatment of animals and animal testing in general to advance science. In the United Kingdom, the National Canine

Defence League called on all dog owners to observe a minute's silence, while the Royal Society for the Prevention of Cruelty to Animals (RSPCA) received protests even before the Soviet Union had finished announcing the mission's success. Animal rights groups at the time called on members of the public to protest at Soviet embassies. Others demonstrated outside the United Nations in New York; nevertheless, laboratory researchers in the U.S. offered some support for the Soviets, at least before the news of Laika's death.

In the Soviet Union, there was less controversy. Neither the media, books in the following years, nor the public openly questioned the decision to send a dog into space to die. It was not until 1998, after the collapse of the Soviet regime, that Oleg Gazenko, one of the scientists responsible for sending Laika into space, expressed regret for allowing her to die:

Work with animals is a source of suffering to all of us. We treat them like babies who cannot speak. The more time passes, the more I'm sorry about it. We shouldn't have done it... We did not learn enough from this mission to justify the death of the dog.

Laika is memorialized in the form of a statue and plaque at Star City, Russia, the Russian Cosmonaut training facility. Future missions carrying dogs would be designed to be recovered. The only other dogs to die in a Soviet space mission were Pchyolka and Mushka, who died when Korabl-Sputnik 3 disintegrated on re-entry on December 1, 1960.

Sputnik 2 and the Van Allen radiation belt

Sputnik 2 detected the Earth's outer radiation belt in the far northern latitudes, but the significance of the elevated radiation was not realized. In Australia, Professor Harry Messel intercepted the signals but the Soviets would not provide the code and the Australians would not send the data. In 1958, with Sputnik 3, they began to cooperate and confirmed the findings of the US satellites Explorer 1, 3, and 4.

Chapter- 3

Vanguard (Rocket)

Vanguard

Launch of Vanguard rocket. (U.S. Navy)

Function	Satellite launch vehicle
Manufacturer	Martin
Country of origin	United States
	Size
Height	75 feet
Diameter	3.74 feet
Mass	22,156 lb (10,050 kg)
Stages	3
	Capacity
Payload to LEO	20 lb

Launch history	
Status	Retired
Launch sites	LC-18A, Cape Canaveral
Total launches	12
Successes	3
Failures	8
Partial failures	1
Maiden flight	October 23, 1957
Last flight	September 18, 1959
First stage - Vanguard	
Engines	1 X-405
Thrust	30,303 lbf (134.79 kN)
Specific impulse	248 lbf·s/lb
Burn time	2 min 25 s
Fuel	LOX/kerosene
Second stage - Delta	
Engines	1 AJ10-118
Thrust	7,599 lbf (33.80 kN)
Specific impulse	261 lbf·s/lb
Burn time	1 min 55 s
Fuel	Nitric acid/UDMH
Third stage - Grand Central or ABL	
Engines	1 Solid
Thrust	2,599 lbf (11.56 kN)
Specific impulse	230 lbf·s/lb
Burn time	31 s
Fuel	Solid

The **Vanguard rocket** was intended to be the first launch vehicle the United States would use to place a satellite into orbit. Instead, the Sputnik crisis caused by the surprise launch of Sputnik 1 led the U.S., after the failure of Vanguard TV3, to quickly orbit the Explorer 1 satellite using a Juno I rocket, making Vanguard I the second successful U.S. orbital launch.

Vanguard rockets were used by Project Vanguard from 1957 to 1959. Of the eleven Vanguard rockets which the project attempted to launch, three successfully placed satellites into orbit.

Overview

In 1955, the USA announced plans to put a scientific satellite in orbit for the International Geophysical Year (IGY) in 1957-1958. The goal was to track the satellite as it performed experiments. At that time there were three possible candidates for the launch vehicle: The

Air Force's SM-65 Atlas, a derivative of the Army Ballistic Missile Agency's SSM-A-14 Redstone, and a Navy proposal for a three-stage rocket based on the RTV-N-12a Viking sounding rocket.

The Army's Redstone-based proposal would likely be first ready for a first satellite launch. Its connection with German-born scientist Wernher von Braun, however, was a public relations risk. In any case, the Atlas and Redstone ballistic missiles were top-priority military projects, which were not to be slowed by pursuing a secondary space launch mission. Vanguard was a project of the Naval Research Laboratory (NRL), which was regarded more as a scientific than a military organization. This helped to emphasize the non-military goals of the satellite program. This was considered important, because a discussion of whether overflights of foreign countries by satellites were legal or illegal was to be avoided.

In August or September 1955, the DOD Committee on Special Capabilities chose the NRL proposal, named Vanguard, for the IGY project. The Martin company, which had also built the Viking, became prime contractor for the launch vehicle. The Vanguard rocket was designed as a three-stage vehicle. The first stage was a General Electric y-405 liquid-fueled engine (designated XLR50-GE-2 by the Navy), derived from the engine of the RTV-N-12a Viking. The second stage was the Aerojet General AJ10-37 (XLR52-AJ-2) liquid-fueled engine, a variant of the engine in the RTV-N-10 Aerobee. Finally, the third stage was a solid-propellant rocket motor. All three-stage Vanguard flights except the last one used a motor built by the Grand Central Rocket Company. Vanguard had no fins, and the first and second stages were steered by gimbaled engines. The second stage also housed the vehicle's telemetry system, the inertial guidance system and the autopilot. The third stage was spin stabilized, the spin being imparted by a turn-table on the second stage before separation.

Launch summary

The first two flights of the Vanguard program, designated Test Vehicle (TV)-0 and -1, were actually the last two remaining RTV-N-12a Viking rockets. TV-0, launched on December 8, 1956, primarily tested new telemetry systems, while TV-1 on May 1, 1957 was a two-stage vehicle testing separation and ignition of the solid-fueled upper stage of Vanguard. TV-2, launched on October 23, 1957 after several abortive attempts, was the first real Vanguard rocket. The second and third stages were inert, but the flight successfully tested first/second-stage separation and spin-up of the third stage. However, by that time, the Soviet Union had already placed the "Sputnik" satellite into orbit, and therefore project Vanguard was more or less forced to launch its own satellite as soon as possible. Therefore, a very small experimental satellite (called the "grapefruit" and weighing only 1.8 kg (4 lb)) was added to TV-3, which was to be the first test of an all-up Vanguard rocket. Although the NRL and Martin tried to emphasize that the TV-3 mission was a pure test flight (and one with several "firsts"), everyone else saw it as the first satellite launch of the Western world. Wernher von Braun angrily said about the *Sputnik* launch:

We knew they were going to do it. Vanguard will never make it. We have the hardware on the shelf. We can put up a satellite in 60 days.

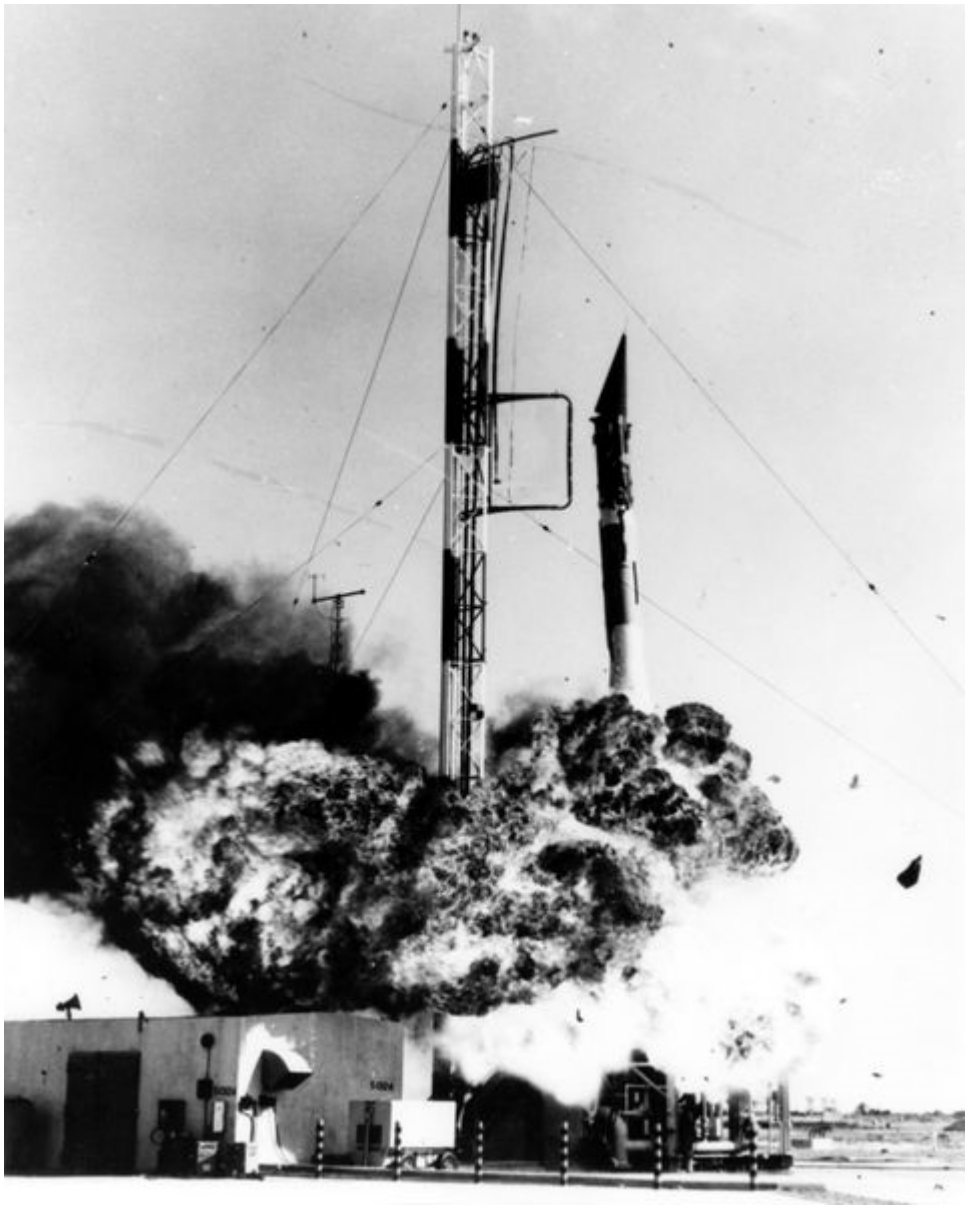
On 6 December the US Navy launched a Vanguard rocket,carrying a 1.3 kg(2.9 lbs) satellite,from Cape Canaveral.It only reached an altitude of 1.2 meters(4 ft),fell and exploded.The satellite was thrown clear,bleeping pathetically as it rolled away.The American press called it *Kaputnik*.

Flight TV-3BU (BU = Backup) on February 5, 1958 broke up after 57 seconds because of a control system malfunction, but TV-4 on March 17, 1958 finally succeeded in placing a "Grapefruit"-type satellite into orbit. By that time, however, the Army's Juno (Jupiter-C) had already launched the United States' first satellite. The TV-4 satellite, labeled Vanguard 1, reached a relatively high orbit (3966 km (2465 miles) x 653 km (406 miles)) and is currently the oldest human artifact in space. The following four flights, TV-5 and SLV (Satellite Launch Vehicle)-1 through -3 all failed, but on February 17, 1959, SLV-4 launched Vanguard 2 (weighing 10.8 kg (23.7 lb)) into orbit. The SLVs were the "production" Vanguard rockets. SLV-5 and -6 also failed, but the final flight on September 18, 1959 successfully orbited the 23.6 kg (52 lb) Vanguard 3 satellite. That last mission was designated TV-4BU, because it used a remaining test vehicle, which had been upgraded with a new third stage, the Allegheny Ballistics Lab X-248A2 Altair. This more powerful motor enabled the launch of the heavier payload. The combination of the AJ10 liquid engine and X-248 solid motor was also used, under the name Able, as an upper stage combination for Thor and Atlas space launch vehicles.

Launches

Vanguard launched 3 satellites out of 11 launch attempts:

- Vanguard TV3 - December 6, 1957 - Failed to orbit 1.36 kg (3 lb) satellite
- Vanguard TV3 Backup - February 5, 1958 - Failed to orbit 1.36 kg (3 lb) satellite
- **Vanguard 1 - March 17, 1958 - Orbited 1.47 kg (3.25 lb) satellite**
- Vanguard TV5 - April 28, 1958 - Failed to orbit 10.0 kg (22 lb) satellite
- Vanguard SLV 1 - May 27, 1958 - Failed to orbit 10.0 kg (22 lb) satellite
- Vanguard SLV 2 - June 26, 1958 - Failed to orbit 10.0 kg (22 lb) satellite
- Vanguard SLV 3 - September 26, 1958 - Failed to orbit 10.0 kg (22 lb) satellite
- **Vanguard 2 - February 17, 1959 - Orbited 9.8 kg (21.6 lb) satellite**
- Vanguard SLV 5 - April 13, 1959 - Failed to orbit 10.3 kg (22.7 lb) satellite
- Vanguard SLV 6 - June 22, 1959 - Failed to orbit 10.3 kg (22.7 lb) satellite
- **Vanguard 3 - September 18, 1959 - Orbited 22.7 kg (50 lb) satellite**



Vanguard rocket undergoing rapid unplanned disassembly shortly after launch at Cape Canaveral (December 6, 1957).

Specifications

- **Stage Number: 1** - Vanguard
  - Mass: 7,661 kg
  - Empty Mass: 811 kg
  - Thrust (vac): 134.7 kN
  - Isp: 270 s (2.6 kN·s/kg)
  - Burn time: 145 s
  - Isp (sea level): 248 s (2.4 kN·s/kg)
  - Diameter: 1.14 m

    - Span: 1.14 m
    - Length: 12.20 m
    - Propellants: Lox/Kerosene
    - Engines: X-405

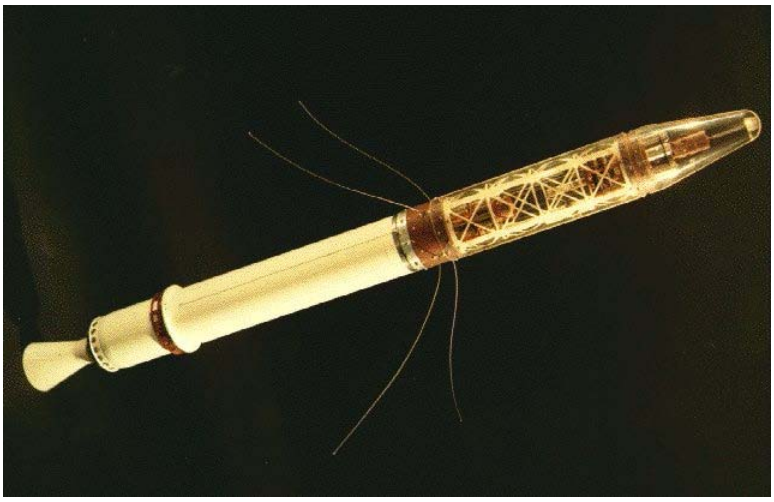
- **Stage Number: 2** - Delta A
    - Mass: 2,164 kg
    - Empty Mass: 694 kg
    - Thrust (vac): 33.8 kN
    - Isp: 271 s (2.7 kN·s/kg)
    - Burn time: 115 s
    - Diameter: 0.84 m
    - Span: 0.84 m
    - Length: 5.36 m
    - Propellants: Nitric acid/UDMH
    - Engines: AJ10-118

- **Stage Number: 3** - Vanguard 3
    - Mass: 210 kg
    - Empty Mass: 31 kg
    - Thrust (vac): 11.6 kN
    - Isp: 230 s (2.3 kN·s/kg)
    - Burn time: 31 s
    - Isp (sea level): 210 s (2.1 kN·s/kg)
    - Diameter: 0.50 m
    - Span: 0.50 m
    - Length: 2.00 m
    - Propellants: Solid
    - Engines: GCRC

Chapter- 4

Explorer 1

Explorer 1
1958 Alpha 1



Operator	Army Ballistic Missile Agency
Major contractors	Jet Propulsion Laboratory
Mission type	Earth science
Satellite of	Earth
Launch date	1958-02-01 03:48 UTC
Carrier rocket	Juno I
Launch site	Cape Canaveral Missile Annex, Florida
Mission duration	111 days
Orbital decay	1970-03-31
COSPAR ID	1958-001A
Homepage	NASA NSSDC Master Catalog

Mass	13.97 kg (30.80 lb)
	Orbital elements
Semimajor axis	7,832.2 km (4,866.6 miles)
Eccentricity	0.139849
Inclination	33.24°
Apoapsis	2,550 km (1,585 miles)
Periapsis	358 km (222 miles)
Orbital period	114.8 minutes

Explorer 1 (1958 Alpha 1) was the first Earth satellite of the United States, launched as part of its participation in the International Geophysical Year. The mission followed the first two Earth satellites the previous year, the Soviet Union's *Sputnik 1* and *2*, beginning the Cold War Space Race between the two nations.

Explorer 1 was launched on January 31, 1958 at 22:48 Eastern Time (this is equal to February 1, 03:48 UTC because the time change goes past midnight) atop the first Juno booster from LC-26 at the Cape Canaveral Missile Annex, Florida. It was the first spacecraft to detect the Van Allen radiation belt, returning data until its batteries were exhausted after nearly four months. It remained in orbit until 1970, and has been followed by more than 90 scientific spacecraft in the Explorer series.

Background

The U.S. Earth satellite program began in 1954 as a joint U.S. Army and U.S. Navy proposal, called Project Orbiter, to put a scientific satellite into orbit during the International Geophysical Year. The proposal, using a military Redstone missile, was rejected in 1955 by the Eisenhower administration in favor of the Navy's Project Vanguard, using a booster produced for civilian space launches. Following the launch of the Soviet satellite *Sputnik 1* on October 4, 1957, the initial Project Orbiter program was revived as the Explorer program to catch up with the Soviet Union.

Explorer 1 was designed and built by the Jet Propulsion Laboratory (JPL), while a Jupiter-C rocket was modified by the Army Ballistic Missile Agency (ABMA) to accommodate a satellite payload; the resulting rocket known as the Juno I. The Jupiter-C design used for the launch had already been flight-tested in nose cone reentry tests for the Jupiter IRBM, and was modified into Juno I. Working closely together, ABMA and JPL completed the job of modifying the Jupiter-C and building *Explorer 1* in 84 days. However, before work was completed, the Soviet Union launched a second satellite, *Sputnik 2*, on November 3, 1957. The U.S. Navy's attempt to put the first U.S. satellite into orbit failed with the launch of the *Vanguard TV3* on December 6, 1957.

Spacecraft design

Explorer 1 is mated to its booster at LC-26

Launch of *Explorer 1* on January 31, 1958

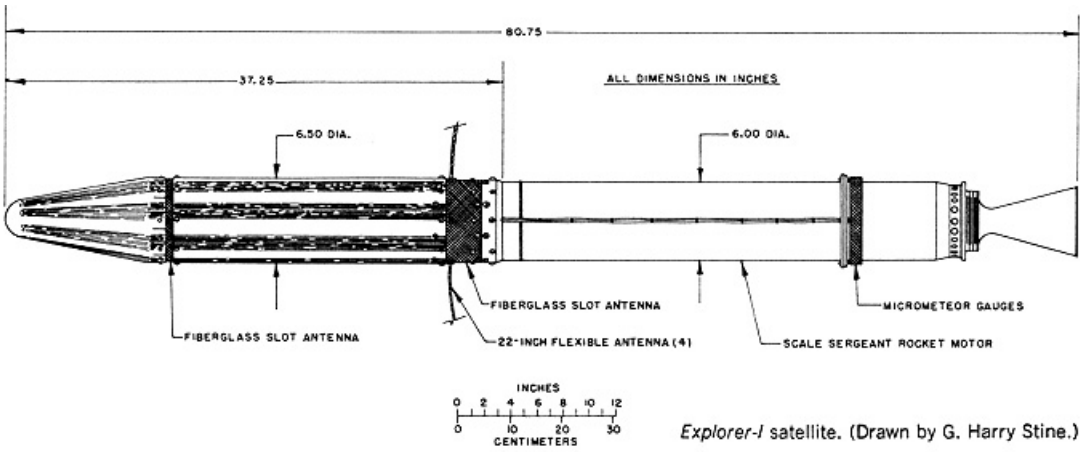
Explorer 1 was designed and built by the California Institute of Technology's JPL under the direction of Dr. William H. Pickering. It was the second satellite to carry a mission payload (*Sputnik 2* was the first).

The total weight of the satellite was 13.97 kilograms (30.80 lb), of which 8.3 kg (18.3 lb) were instrumentation. In comparison the first Soviet satellite *Sputnik 1* weighed 83.6 kg (184 lb). The instrument section at the front end of the satellite and the empty scaled-down fourth-stage rocket casing orbited as a single unit, spinning around its long axis at 750 revolutions per minute.

Data from the scientific instruments was transmitted to the ground by two antennas. A 60 milliwatt dipole antenna consisting of two fiberglass slot antennas in the body of the satellite operating on 108.03 MHz, and four flexible whips forming a 10 milliwatt turnstile antenna operating on 108.00 MHz.

Because of the limited space available and the requirements for low weight, the payload instrumentation was designed and built with simplicity and high reliability in mind, using transistor electronics, consisting of both germanium and silicon devices. This was a very early time frame in the development of transistor technology, and was the first documented use of transistors in the U.S. Earth satellite program. A total of 29 transistors were used in Explorer 1, plus additional ones in the Army's micrometeorite amplifier. Electrical power was provided by mercury chemical batteries that made up approximately 40 percent of the payload weight.

The external skin of the instrument section was painted in alternate strips of white and dark green to provide passive temperature control of the satellite. The proportions of the light and dark strips were determined by studies of shadow-sunlight intervals based on firing time, trajectory, orbit, and inclination.



Explorer 1 schematic

Science payload

The *Explorer 1* payload consisted of the Iowa Cosmic Ray Instrument without a tape data recorder which was not modified in time to make it onto the spacecraft. The real-time data received on the ground was therefore very sparse and puzzling showing normal counting rates and no counts at all. The later *Explorer 3* mission, which included a tape data recorder in the payload, provided the additional data for confirmation of the earlier Explorer 1 data.

The scientific instrumentation of *Explorer 1* was designed and built under the direction of Dr. James Van Allen of the University of Iowa containing:

- Anton 314 omnidirectional Geiger-Müller tube, designed by Dr. George Ludwig of Iowa's Cosmic Ray Laboratory, to detect cosmic rays. It could detect protons with E > 30 MeV and electrons with E > 3 MeV. Most of the time the instrument was saturated;
- Five temperature sensors (one internal, three external and one on the nose cone);
- Acoustic detector (crystal transducer and solid-state amplifier) to detect micrometeorite (cosmic dust) impacts. It responded to micrometeorite impacts on the spacecraft skin in such way that each impact would be a function of mass and velocity. Its effective area was 0.075 m^2 and the average threshold sensitivity was 2.5×10^{-3} g cm/s; and
- Wire grid detector, also to detect micrometeorite impacts. It consisted of 12 parallel connected cards mounted in a fiberglass supporting ring. Each card was wound with two layers of enameled nickel alloy wire with a diameter of 17 µm (21 µm with the enamel insulation included) in such way that a total area of 1 cm by 1 cm was completely covered. If a micrometeorite of about 10 µm impacted, it would fracture the wire, destroy the electrical connection, and thus record the event.

Flight

The Juno I rocket was launched January 31, 1958, putting *Explorer 1* into orbit with a perigee of 358 kilometers (222 mi) and an apogee of 2,550 kilometers (1,585 mi) having a period of 114.8 minutes. At about 1:30 a.m. ET, after confirming that that *Explorer 1* was indeed in orbit, a news conference was held in the Great Hall at the National Academy of Sciences in Washington, DC to announce it to the world.

Mercury batteries powered the high-power transmitter for 31 days and the low-power transmitter for 105 days. *Explorer 1* stopped transmission of data on May 23, 1958 when its batteries died, but remained in orbit for more than 12 years. It reentered the atmosphere over the Pacific Ocean on March 19, 1970 after more than 58,000 orbits.

Results

Pickering, Van Allen, and von Braun display a full-scale model of *Explorer 1* at a crowded news conference in Washington, DC after confirmation the satellite was in orbit.

To the surprise of mission experts, *Explorer 1* changed rotation axis after launch. The elongated body of the spacecraft had been designed to spin about its long (least-inertia) axis but refused to do so, and instead started precessing due to energy dissipation from flexible structural elements. Later it was understood that on general grounds, the body ends up in the spin state that minimizes the kinetic rotational energy (this being the maximal-inertia axis). This motivated the first further development of the Eulerian theory

of rigid body dynamics after nearly 200 years - to address this kind of energy and momentum dissipation.

Sometimes the instrumentation would report the expected cosmic ray count (approximately thirty counts per second) but sometimes it would show a peculiar zero counts per second. The University of Iowa (under Van Allen) noted that all of the zero counts per second reports were from an altitude of 2,000+ km (1,250+ miles) over South America, while passes at 500 km (310 miles) would show the expected level of cosmic rays. Later, after *Explorer 3*, it was concluded that the original Geiger counter had been overwhelmed ("saturated") by strong radiation coming from a belt of charged particles trapped in space by the Earth's magnetic field. This belt of charged particles is now known as the Van Allen radiation belt. The discovery was considered to be one of the outstanding discoveries of the International Geophysical Year.

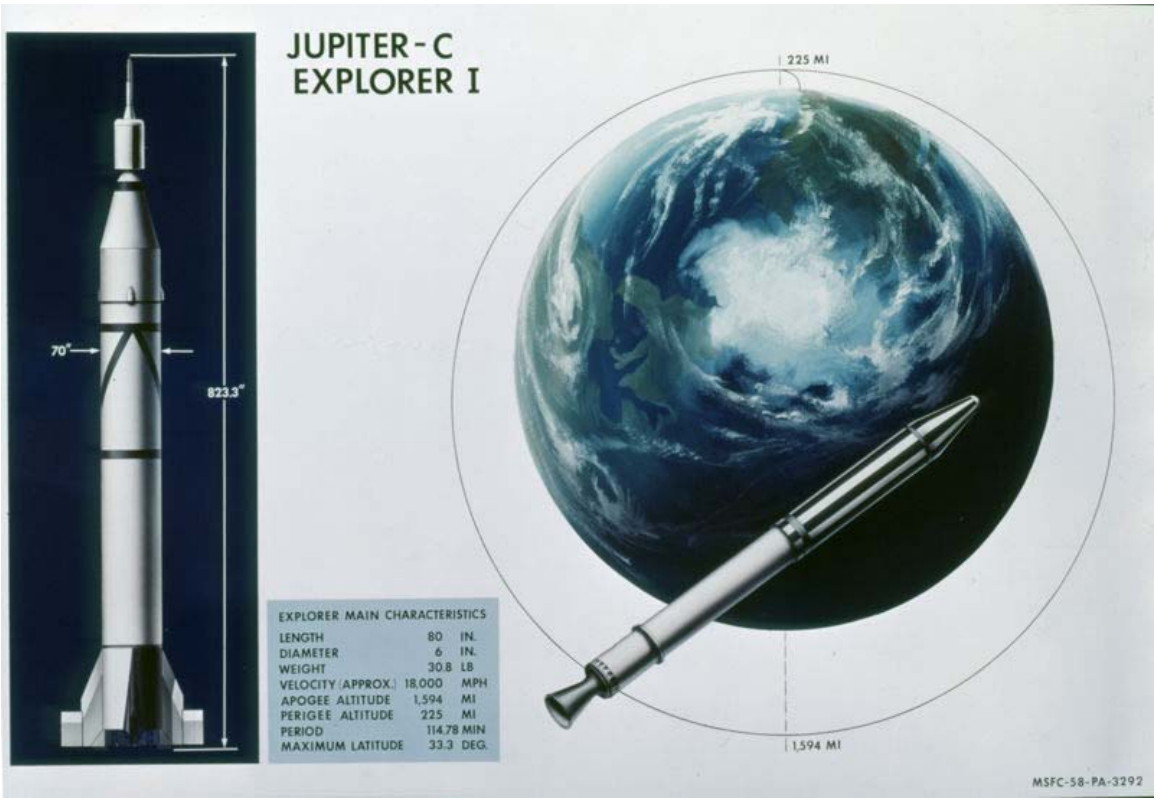
The acoustic micrometeorite detector detected 145 impacts of cosmic dust in 78,750 seconds. This calculates to an average impact rate of 8.0×10^{-3} impacts per m^{-2} s^{-1} over the twelve-day period (29 impacts per hour per square meter).

Legacy

Explorer 1 was the first of the long-running Explorer program. A follow-up to the first mission, Explorer-1 [PRIME], built using modern satellite construction techniques, is scheduled for launch in 2011.

An identically-constructed flight backup of *Explorer 1* is on display in the Smithsonian Institution's National Air and Space Museum, Milestones of Flight Gallery in Washington, DC.

Additional images

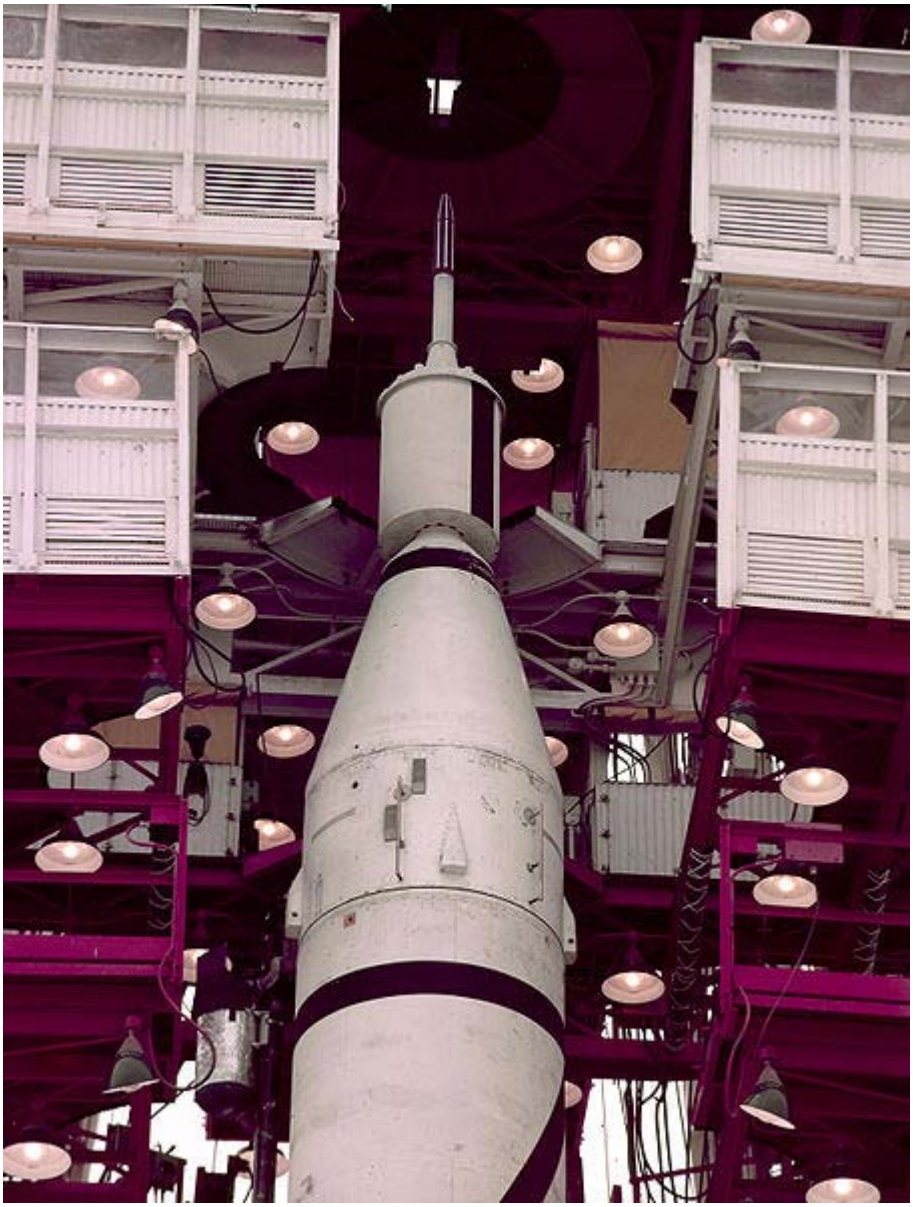


Explorer 1 statistics and orbital diagram

Officials with full-scale *Explorer 1* model at Redstone Arsenal, including Maj. Gen. John Medaris (3rd from left), Walter Haeussermann, Werner von Braun and Ernst Stuhlinger

Explorer 1 mated to Juno I booster

Explorer 1 and Juno I booster in gantry at LC-26



Close-up of *Explorer 1* atop Juno I booster

Juno fueled for launch

Explorer 3

Explorer 3 (international designation **1958 Gamma**) was an artificial satellite of the Earth, nearly identical to the first United States artificial satellite Explorer 1 in its design and mission. It was the second successful launch in the Explorer program.

Mission

The satellite was launched from Cape Canaveral Air Force Station (now Kennedy Space Center) in Florida at 17:31:00 UTC on March 26, 1958, by the Jupiter-C vehicle.

The Jupiter-C has its origins in the United States Army's Project Orbiter in 1954. The project was canceled in 1955, however, when the decision was made to proceed with Project Vanguard.

Following the launch of the Soviet Sputnik 1 on October 4, 1957, ABMA was directed to proceed with the launching of a satellite using the Jupiter-C, which had already been flight-tested in nose-cone re-entry tests for the Jupiter IRBM (intermediate-range ballistic missile). Working closely together, ABMA and JPL completed the job of modifying the Jupiter-C and building the Explorer I in 84 days.

Spacecraft design

Explorer 3 was launched in conjunction with the International Geophysical Year (IGY) by the U.S. Army (Ordinance) into an eccentric orbit. The objective of this spacecraft was a continuation of experiments started with Explorer 1. The payload consisted of a cosmic ray counter (a Geiger-Müller tube), and a micrometeorite detector (a wire grid array and acoustic detector). The Explorer 3 spacecraft was spin-stabilized and had an on-board tape recorder to provide a complete radiation history for each orbit. It was discovered soon after launch that the satellite was in a tumbling motion with a period of about 7 seconds. Explorer 3 decayed from orbit on June 27, 1958, after 93 days of operation.

Mission results

The discovery of the Van Allen radiation belt by the Explorer satellites was considered to be one of the outstanding discoveries of the IGY.

Explorer 3 was placed in an orbit with a perigee of 186 kilometers and an apogee of 2799 kilometers having a period of 115.7 minutes. Its total weight was 14.1 kilograms, of which 8.4 kg was instrumentation. The instrument section at the front end of the satellite and the empty scaled-down fourth-stage rocket casing orbited as a single unit, spinning around its long axis at 750 revolutions per minute.

Instrumentation consisted of a cosmic ray detection package and a ring of micrometeorite erosion gauges. The Explorer 3 spacecraft was spin-stabilized and had an on-board tape recorder to provide a complete radiation history for each orbit. Data from these instruments was transmitted to the ground by a 60 milliwatt transmitter operating on 108.03 MHz and a 10 milliwatt transmitter operating on 108.00 MHz.

Transmitting antennas consisted of two fiberglass slot antennas in the body of the satellite itself and four flexible whips forming a turnstile antenna. The rotation of the satellite about its long axis kept the flexible whips extended.

The external skin of the instrument section was painted in alternate strips of white and dark green to provide passive temperature control of the satellite. The proportions of the

light and dark strips were determined by studies of shadow-sunlight intervals based on firing time, trajectory, orbit, and inclination.

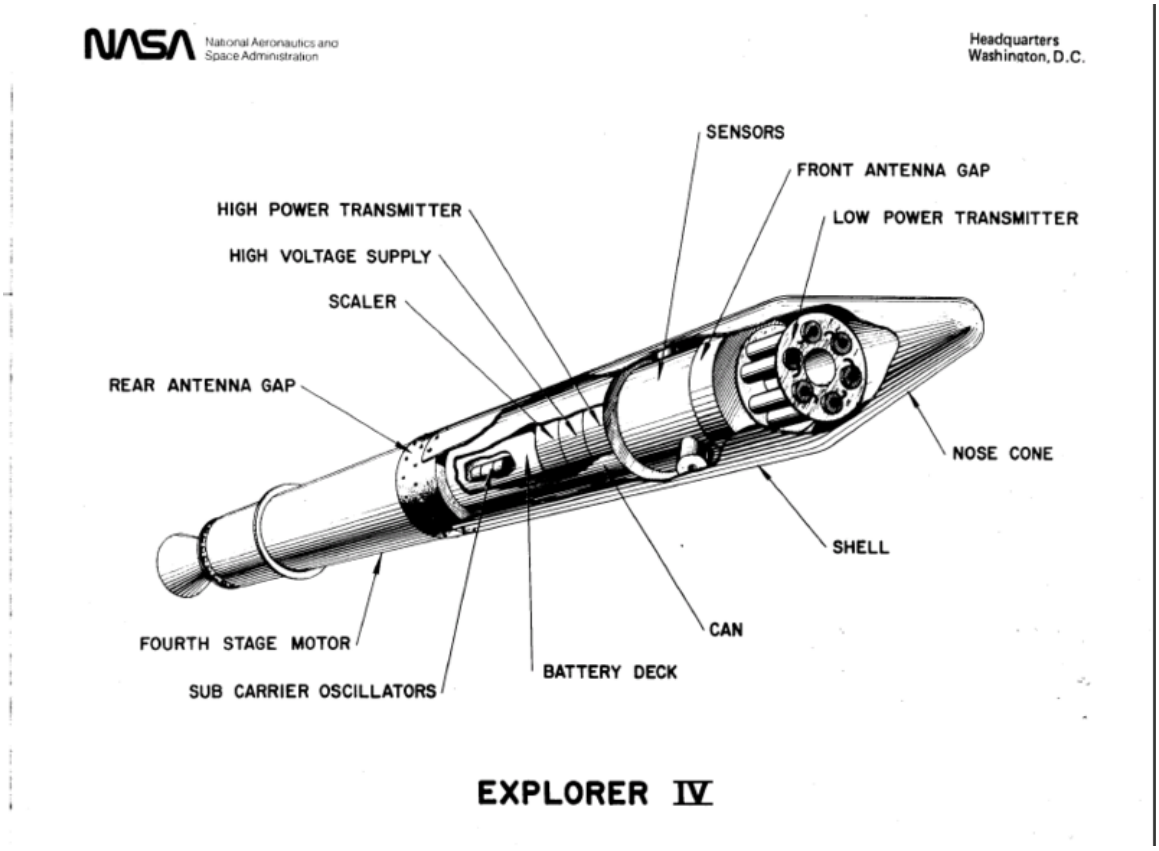
Electrical power was provided by nickel-cadmium chemical batteries that made up approximately 40 percent of the payload weight. These provided power that operated the high power transmitter for 31 days and the low-power transmitter for 105 days.

Because of the limited space available and the requirements for low weight, the Explorer 3 instrumentation was designed and built with simplicity and high reliability in mind. It was completely successful.

Explorer 3 decayed from orbit on June 27, 1958, after 93 days of operation.

A replica of the spacecraft is currently located in the Smithsonian Institution's National Air and Space Museum, Milestones of Flight Gallery.

Explorer 4



Explorer 4 (satellite 1958 epsilon) was a US satellite launched on July 26, 1958. It was instrumented by Dr. James van Allen's group. The Department of Defense's Advanced Research Projects Agency had initially planned two satellites for the purposes of studying the Van Allen radiation belts and the effects of nuclear explosions upon these belts (and

the Earth's magnetosphere in general), however Explorer 4 was the only such satellite launched.

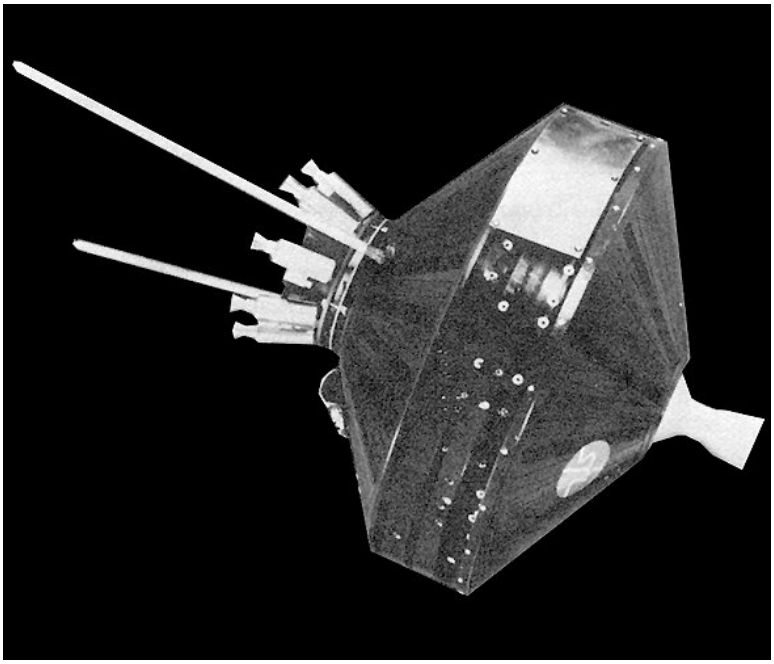
Explorer 4 was a cylindrically shaped satellite instrumented to make the first detailed measurements of charged particles (protons and electrons) trapped in the terrestrial radiation belts. An unexpected tumble motion of the satellite made the interpretation of the detector data very difficult. The low-power transmitter and the plastic scintillator detector failed September 3, 1958. The two Geiger-Müller tubes and the caesium iodide crystal detectors continued to operate normally until September 19, 1958. The high-power transmitter ceased sending signals on October 5, 1958. It is believed that exhaustion of the power batteries caused these failures. The spacecraft decayed from orbit after 454 days on October 23, 1959.

Chapter- 5

Pioneer 0, 1, 2 and 3

Pioneer 0

Pioneer 0



Operator	United States Air Force
Major contractors	Space Technology Laboratories (TRW)
Mission type	Lunar orbiter
Launch date	August 17, 1958
Launch vehicle	Thor-Able
Launch site	Cape Canaveral LC17A
Mission duration	73.6 seconds

COSPAR ID	ABLE1
Homepage	NASA NSSDC Master Catalog
Mass	83.8 pounds (38.0 kg)
	Orbital elements
Apoapsis	16 km
	Instruments
Main instruments	Television camera, magnetometer, micrometeoroid impact detector

Pioneer 0 (also known as **Thor-Able 1**) was a failed United States space probe that was designed to go into orbit around the Moon, carrying a television camera, a micrometeorite detector and a magnetometer, as part of the first International Geophysical Year (IGY) science payload. It was designed by the United States Air Force (USAF) as the first satellite in the Pioneer program and was one of the first attempted launches beyond Earth orbit by any country, but the rocket failed shortly after launch. The probe was intended to be called Pioneer (or Pioneer 1), but the launch failure precluded that name.

Spacecraft design

The spacecraft consisted of a thin cylindrical midsection with a squat truncated cone frustum of 6.5 inches (17 cm) high on each side. The cylinder was 29 inches (74 cm) in diameter and the height from the top of one cone to the top of the opposite cone was 76 cm. Along the axis of the spacecraft and protruding from the end of the lower cone was an 11 kg solid propellant injection rocket and rocket case, which formed the main structural member of the spacecraft. Eight small low-thrust solid propellant velocity adjustment rockets were mounted on the end of the upper cone in a ring assembly which could be jettisoned after use. A magnetic dipole antenna also protruded from the top of the upper cone. The shell was composed of laminated plastic and was painted with a pattern of dark and light stripes to help regulate temperature.

The scientific instrument package had a mass of 11.3 kg and consisted of:

- An image scanning infrared television system of the Naval Ordance Test Station (NOTS) design to study the Moon's surface, particularly the part normally unseen from Earth.
- A diaphragm/microphone assembly to detect micrometeorites. A micrometeorite hitting the diaphragm would generate an acoustic pulse that would travel through the diaphragm to the microphone. The microphone contained a piezoelectrical crystal that rang at 100 kc under influence of the acoustic pulse. A bandpass amplifier would amplify the signal, so it could be detected.

- A search-coil magnetometer with nonlinear amplifier to measure the Earth's, Moon's and interplanetary magnetic field. At the time it was not known whether the Moon had a magnetic field or not.

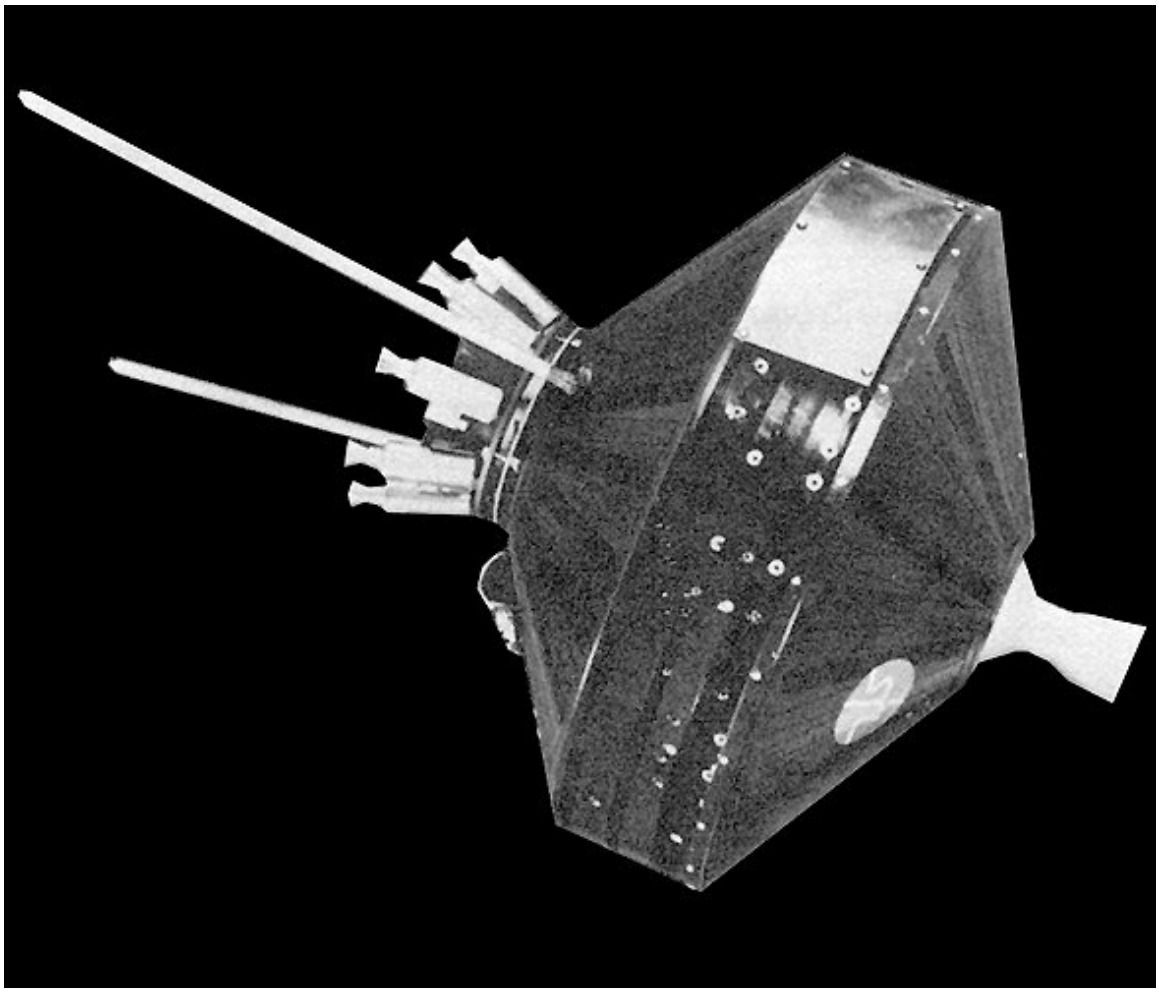
The spacecraft was powered by nickel-cadmium batteries for ignition of the rockets, silver cell batteries for the television system, and mercury batteries for the remaining circuits. Radio transmission was on 108.06 MHz, a standard frequency used by satellites in the International Geophysical Year, through an electric dipole antenna for telemetry and doppler information and a magnetic dipole antenna for the television system. Ground commands were received through the electric dipole antenna at 115 MHz. The spacecraft was to be spin-stabilized at 1.8 rps, the spin direction approximately perpendicular to the geomagnetic meridian planes of the trajectory.

Launch and failure

Pioneer 0 was launched on Thor Missile number 127 at 12:18:00 UTC on August 17, 1958 by the United States Air Force, only 4 minutes after the scheduled launch time. It was destroyed by an explosion of the first stage of the Thor booster, 73.6 seconds after lift-off at 16 km altitude, 16 km downrange over the Atlantic Ocean. The failure was suspected to be due to a failing turbopump bearing, causing the liquid oxygen pump to stop. Erratic telemetry signals were received from the payload and upper stages for 123 seconds after the explosion, and the upper stages were tracked to impact in the ocean. The original plan was for the spacecraft to travel for 2.6 days to the Moon at which time a TX-8-6 solid propellant motor would fire to put it into a 29,000 km lunar orbit which was to nominally last for about two weeks.

It was the only mission in the Pioneer program carried out by the United States Air Force, as subsequent missions were conducted by NASA.

Pioneer 1



On October 11, 1958, **Pioneer 1** became the first spacecraft launched by NASA, the newly formed space agency of the United States. The flight was the second and most successful of the three Thor-Able space probes.

Spacecraft design

Pioneer 1 atop its launcher

Pioneer 1 was fabricated by Ramo-Wooldridge Corp.(TRW), and consisted of a thin cylindrical midsection with a squat truncated cone on each side. The cylinder was 74 cm (29 in) in diameter and the height from the top of one cone to the top of the opposite cone was 76 cm (30 in). Along the axis of the spacecraft and protruding from the end of the lower cone was an 11 kg solid propellant injection rocket and rocket case, which formed the main structural member of the spacecraft. Eight small low-thrust solid propellant velocity adjustment rockets were mounted on the end of the upper cone in a ring assembly which could be jettisoned after use. A magnetic dipole antenna also protruded

from the top of the upper cone. The shell was composed of laminated plastic. The total mass of the spacecraft after vernier separation was 34.2 kg, after injection rocket firing it would have been 23.2 kg.

The scientific instrument package had a mass of 17.8 kg and consisted of an image scanning infrared television system to study the Moon's surface to a resolution of 0.5 degrees, an ionization chamber to measure radiation in space, a diaphragm/microphone assembly to detect micrometeorites, a spin-coil magnetometer to measure magnetic fields to 5 microgauss, and temperature-variable resistors to record the spacecraft's internal conditions. The spacecraft was powered by nickel-cadmium batteries for ignition of the rockets, silver cell batteries for the television system, and mercury batteries for the remaining circuits. Radio transmission was at on 108.06 MHz through an electric dipole antenna for telemetry and doppler information at 300 mW and a magnetic dipole antenna for the television system at 50 W. Ground commands were received through the electric dipole antenna at 115 MHz. The spacecraft was spin-stabilized at 1.8 rps, the spin direction was approximately perpendicular to the geomagnetic meridian planes of the trajectory.

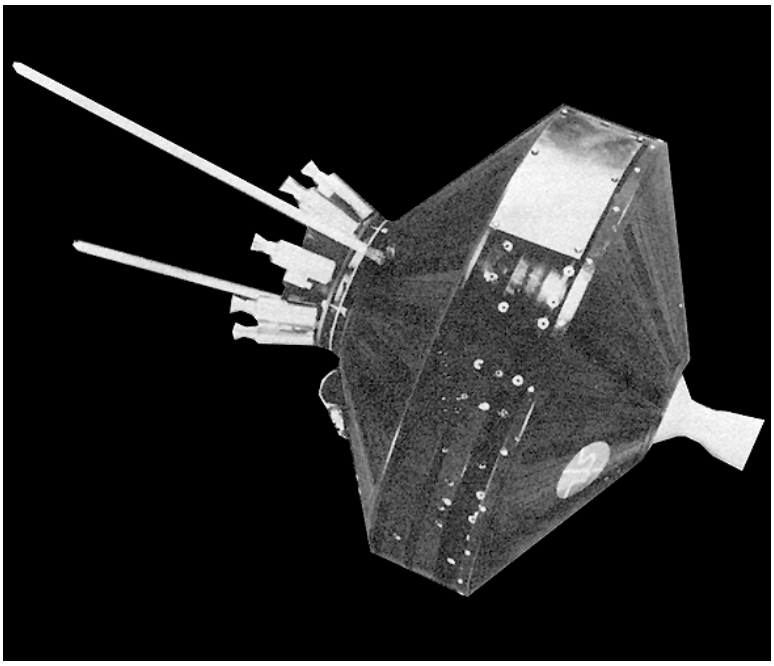
Mission

Due to a launch vehicle malfunction, the spacecraft attained only a ballistic trajectory and never reached the Moon. However, it did return data on the near-Earth space environment.

The spacecraft was launched from LC-17A at 08:42:00 UTC on October 11, 1958 but it did not reach the Moon as planned due to a programming error in the upper stage causing a slight error in burnout velocity and angle (3.5 deg.). This resulted in a ballistic trajectory with a peak altitude of 113,800 km (70,712 mi) around 13:00 local time. The real-time transmission was obtained for about 75% of the flight, but the percentage of data recorded for each experiment was variable. Except for the first hour of flight, the signal-to-noise ratio was good. The spacecraft ended transmission when it reentered the Earth's atmosphere after 43 hours of flight on October 13, 1958 at 03:46 UT over the South Pacific Ocean. A small quantity of useful scientific information was returned, showing the radiation surrounding Earth was in the form of bands and measuring the extent of the bands, mapping the total ionizing flux, making the first observations of hydromagnetic oscillations of the magnetic field, and taking the first measurements of the density of micrometeorites and the Interplanetary Magnetic Field.

Pioneer 2

Pioneer 2



Mission type	Orbiter
Satellite of	Moon
Launch date	November 8, 1958 at 07:30:00 UTC
Mass	87.3 pounds (39.6 kg)

Pioneer 2 was the last of the three project Able space probes designed to probe lunar and cislunar space. Shortly after launch at 07:30:00 UTC on November 8, 1958, the third stage of the launch vehicle separated but failed to ignite, and Pioneer 2 did not achieve its intended lunar orbit. The spacecraft attained a maximum altitude of 1550 km (963 miles) before reentering Earth's atmosphere at 28.7 N, 1.9 E over NW Africa. A small amount of data was obtained during the short flight, including evidence that the equatorial region around Earth has higher flux and higher energy radiation than previously considered and that the micrometeorite density is higher around Earth than in space.

Spacecraft design

Pioneer 2 was nearly identical to Pioneer 1. It consisted of a thin cylindrical midsection with a squat truncated cone frustum on each side. The cylinder was 74 cm in diameter and the height from the top of one cone to the top of the opposite cone was 76 cm. Along the axis of the spacecraft and protruding from the end of the lower cone was an 11 kg

solid propellant injection rocket and rocket case, which formed the main structural member of the spacecraft. Eight small low-thrust solid propellant velocity adjustment rockets were mounted on the end of the upper cone in a ring assembly which could be jettisoned after use. A magnetic dipole antenna also protruded from the top of the upper cone. The shell was composed of laminated plastic. The total mass of the spacecraft after vernier separation but before injection rocket firing was 39.5 kg.

The scientific instrument package had a mass of 15.6 kg (34.4 lb) and consisted of an STL image-scanning television system (which replaced the NOTS image scanning infrared television system on Pioneer 1), a proportional counter for radiation measurements, an ionization chamber to measure radiation in space, a diaphragm/microphone assembly to detect micrometeorites, a spin-coil magnetometer to measure magnetic fields to 5 microgauss, and temperature-variable resistors to record spacecraft internal conditions. The spacecraft was powered by nickel-cadmium batteries for ignition of the rockets, silver cell batteries for the television system, and mercury batteries for the remaining circuits. Radio transmission was at 108.06 MHz through a magnetic dipole antenna for the television system, telemetry, and doppler. Ground commands were received at 115 MHz. The spacecraft was to be spin-stabilized at 1.8 rps, the spin direction approximately perpendicular to the geomagnetic meridian planes of the trajectory.

Pioneer 3

Pioneer 3

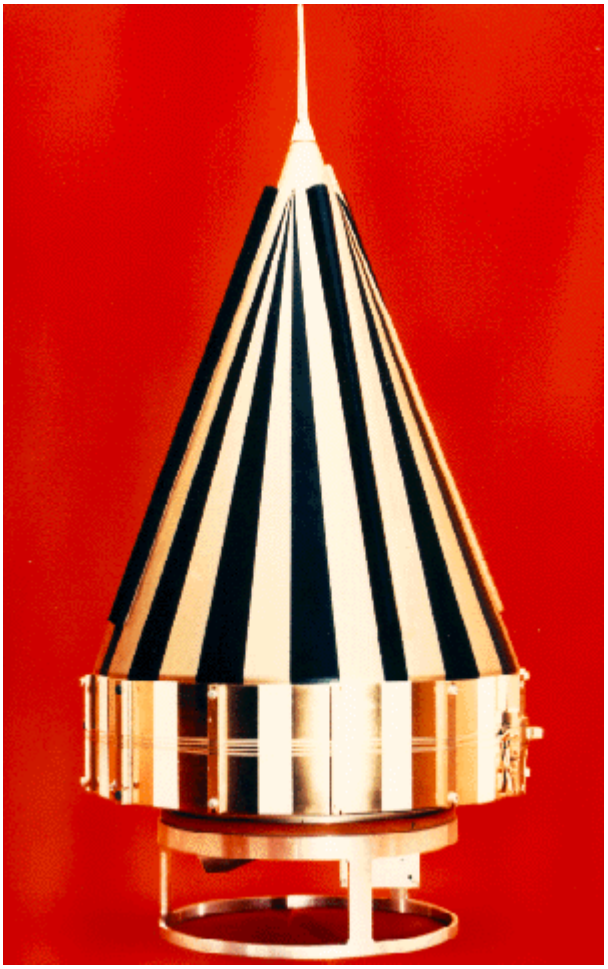
Operator	U.S. Army Ballistic Missile Agency, NASA
Mission type	Fly-by
Flyby of	Moon
Launch date	December 12, 1958

Pioneer 3 was a spin stabilized spacecraft launched at 05:45:12 UTC on 6 December 1958 by the U.S. Army Ballistic Missile Agency in conjunction with the National Aeronautics and Space Administration. This spacecraft was intended as a lunar probe, but failed to go past the Moon and into a heliocentric orbit as planned, but did reach an altitude of 102,360 km before falling back to the Earth. The revised spacecraft objectives were to measure radiation in the outer Van Allen radiation belt using two Geiger-Müller tubes and to test the trigger mechanism for a lunar photographic experiment.

Spacecraft design

Pioneer 3 was a cone-shaped probe 58 cm high and 25 cm diameter at its base. The cone was composed of a thin fiberglass shell coated with a gold wash to make it electrically conducting and painted with white stripes to maintain the temperature between 10 and 50 degrees Celsius. At the tip of the cone was a small probe which combined with the cone itself to act as an antenna. At the base of the cone a ring of mercury batteries provided power. A photoelectric sensor protruded from the center of the ring. The sensor was designed with two photocells which would be triggered by the light of the Moon when the probe was within about 30,000 km of the Moon. At the center of the cone was a voltage supply tube and two Geiger-Müller tubes. A transmitter with a mass of 0.5 kg delivered a phase-modulated signal of 0.1 W at a frequency of 960.05 MHz. The modulated carrier power was 0.08 W and the total effective radiated power 0.18 W. A despin mechanism consisted of two 7 gram weights which could be spooled out to the end of two 150 cm wires when triggered by a hydraulic timer 10 hours after launch. The weights would slow the spacecraft spin from 400 rpm to 6 rpm and then weights and wires would be released.

Mission



Pioneer 3

The flight plan called for the **Pioneer 3** probe to pass close to the Moon after 33.75 hours and then go into solar orbit. However, depletion of propellant caused the first stage engine to shut down 3.7 seconds early preventing the spacecraft from reaching escape velocity. The injection angle was also about 71 degrees instead of the planned 68 degrees. The spacecraft reached an altitude of 102,360 km (109,740 km from the center of the Earth) before falling back to Earth. It re-entered Earth's atmosphere and burned up over Africa on December 7 at approximately 19:51 UT (2:51 p.m. EST) at an estimated location of 16.4 N, 18.6 E. The probe returned telemetry for about 25 hours of its 38 hour 6 minute journey. The other 13 hours were blackout periods due to the location of the two tracking stations. The returned information showed that the internal temperature remained at about 43 °C over most of the period.

While **Pioneer 3** did not meet is primary mission objective of a lunar flyby, the data obtained was of particular value to James Van Allen. The **Pioneer 3** probe data in addition to the data from the previous Explorer 1 and Explorer 3 satellites led to the

discovery of a distinct second radiation belt around the Earth (e.g. characteristics). The trapped radiation starts at an altitude of several hundred miles from Earth (where the outer belt was first observed by Sputnik 2 and Sputnik 3) and extends for several thousand miles into space. These Van Allen radiation belt surrounding the Earth are named for Dr. James Van Allen, in honor of his discovery.

Chapter- 6

Vanguard 1

Vanguard 1

Operator	United States Navy
Major contractors	United States Naval Research Laboratory (NRL)
Mission type	Earth science
Satellite of	Earth
Orbits	~204,000 as of April 1, 2010
Launch date	March 17, 1958 at 12:15:41 UTC
Launch vehicle	Vanguard rocket
Mission duration	May 1964; ~2,200 days
Orbital decay	240 year orbital lifetime

COSPAR ID	1958-002B
Homepage	NSSDC Master Catalog
Mass	1.47 kg (3.2 lb)
	Orbital elements
Semimajor axis	8,689.7 km (5,399.5 mi)
Eccentricity	0.1909
Inclination	34.25°
Apoapsis	3,969 km (2,466 mi)
Periapsis	654 km (406 mi)
Orbital period	134.2 minutes

Vanguard 1 (ID: **1958-Beta 2**) was the fourth artificial Earth satellite launched and the first satellite to be solar powered. Although communication with it was lost in 1964, it remains the oldest manmade satellite still in orbit. It was designed to test the launch capabilities of a three-stage launch vehicle as a part of Project Vanguard, and the effects of the environment on a satellite and its systems in Earth orbit. It also was used to obtain geodetic measurements through orbit analysis.

Spacecraft design

The spacecraft is a 1.47 kg (3.2 lb) aluminum sphere 6.4 inches (165 mm) in diameter. It contains a 10 mW, 108 MHz transmitter powered by a mercury battery and a 5 mW, 108.03 MHz transmitter that was powered by six solar cells mounted on the body of the satellite. Six short antennas protrude from the sphere. The transmitters were used primarily for engineering and tracking data, but were also used to determine the total electron content between the satellite and ground stations. Vanguard also carries two thermistors which measured the interior temperature over sixteen days in order to track the effectiveness of the thermal protection. A backup version of Vanguard 1 is on display at the Kansas Cosmosphere and Space Center.

Mission

The three stage launch vehicle placed Vanguard into a 654×3,969 km (406×2,466 mi.), 134.2 minute elliptical orbit inclined at 34.25 degrees on March 17, 1958. Original estimates had the orbit lasting for 2,000 years, but it was discovered that solar radiation pressure and atmospheric drag during high levels of solar activity produced significant perturbations in the perigee height of the satellite, which caused a significant decrease in its expected lifetime to only about 240 years.

Mission results

Radio beacon

A 10 mW mercury battery powered transmitter on the 108 MHz band used for International Geophysical Year (IGY) scientific satellites, and a 5 mW, 108.03 MHz transmitter powered by six solar cells were used as part of a radio phase-comparison angle-tracking system. The tracking data were used to show that the shape of the Earth has a north-south asymmetry, occasionally described as pear-shaped with the stem at the North Pole. These radio signals were also used to determine the total electron content between the satellite and selected ground-receiving stations. The battery-powered transmitter provided internal package temperature for about sixteen days and sent tracking signals for twenty days. The solar cell powered transmitter operated for more than six years. Signals gradually weakened and were last received at Quito, Ecuador in May 1964 after which the spacecraft was optically tracked from Earth.

Satellite drag atmospheric density

Because of its symmetrical shape, Vanguard 1 was used by experimenters for use in determining upper atmospheric densities as a function of altitude, latitude, season, and solar activity. As the satellite continuously orbited, it would lag its predicted positions slightly, accumulating greater and greater delay due to drag of the residual atmosphere. By measuring the rate and timing of orbital shifts, together with the body's drag properties, the relevant atmosphere's parameters could be back-calculated. It was determined that atmospheric pressures, and thus drag and orbital decay, were higher than anticipated, since Earth's upper atmosphere does taper off into space gradually.

This experiment was extensively planned prior to launch. Initial Naval Research Laboratory (NRL) proposals for the project included conical satellite bodies; this eliminated the need for a separate fairing and ejection mechanisms, and their associated weight and failure modes. Radio tracking would gather data and establish a position. Early in the program, optical tracking (with a Baker-Nunn camera network and human spotters) was added. A panel of scientists proposed changing the design to spheres, at least twenty inches in diameter and hopefully thirty. A sphere would have a constant optical reflection, and constant coefficient of drag, based on size alone, while a cone would have properties that varied with its orientation. James Van Allen of the University of Iowa proposed a cylindrical satellite, which became Explorer 1, the first American satellite. The Naval Research Laboratory finally accepted a sphere with a 6.4-inch diameter as a "test vehicle", with a diameter of twenty inches set for the follow-on satellites. The weight savings, from reduced size as well as decreased instrumentation in the early satellites, was considered to be acceptable.

Since three of the Vanguard satellites are still orbiting, with their drag properties essentially unchanged, they form a baseline data set on the atmospheric that is 50 years old and counting.

50th anniversary

The Vanguard 1 satellite holds the record for being in space longer than any other human-made object. On March 17, 2008 it logged its 50th year in Earth orbit.

A small group of former NRL and NASA workers had been in communication, and a number of government agencies were asked to commemorate the event. The Naval Research Laboratory commemorated the event with a day-long meeting at NRL on March 17, 2008. The meeting concluded with a simulation of the satellite's track as it passed into the orbital area visible from Washington, D.C. (where it is visible from the Earth's surface). The National Academy of Sciences scheduled some seminars to mark the 50th anniversary of the International Geophysical Year, which were the only official observances known.

Chapter- 7

Luna E-1 No.1

Luna E-1 No.1

A replica of a Luna E-1 spacecraft

Major contractors	OKB-1
Bus	Luna E-1
Mission type	Lunar impactor
Launch date	23 September 1958
Carrier rocket	Luna 8K72 s/n B1-3
Launch site	Baikonur Site 1/5

Mass	361 kilograms (800 lb)
Orbital elements	
Regime	Heliocentric (planned) Failed to achieve orbit

Luna E-1 No.1, sometimes identified by NASA as **Luna 1958A**, was a Soviet Luna E-1 spacecraft which was intended to impact the Moon. It did not accomplish this objective as it was lost in a launch failure. It was the first of four E-1 missions to be launched.

Luna E-1 No.1 was a 361-kilogram (800 lb) spacecraft which marked the first Soviet attempt to send a spacecraft to the towards the Moon. It was also the first mission of the Luna programme. The spacecraft was intended to release 1 kilogram (2.2 lb) of sodium, in order to create a "comet" of the metal which could be observed from Earth, allowing the spacecraft to be tracked. Prior to the release of information about its mission, NASA correctly identified that it had been an attempted Lunar impact mission.

Luna E-1 No.1 was launched on 23 September 1958 atop a Luna 8K72 carrier rocket, flying from Site 1/5 at the Baikonur Cosmodrome. Ninety two seconds after launch, longitudinal resonance within the rocket's strap-on booster rockets caused the vehicle to disintegrate.

Luna E-1 No.2

Luna E-1 No.2

A replica of a Luna E-1 spacecraft

Major contractors	OKB-1
Bus	Luna E-1
Mission type	Lunar impactor
Launch date	11 October 1958
Carrier rocket	Luna 8K72 s/n B1-4
Launch site	Baikonur Site 1/5
Mass	361 kilograms (800 lb)
Orbital elements	
Regime	Heliocentric (planned) Failed to achieve orbit

Luna E-1 No.2, sometimes identified by NASA as **Luna 1958B**, was a Soviet spacecraft which was lost in a launch failure in 1958. It was a 361-kilogram (800 lb) Luna E-1 spacecraft, the second of four to be launched, all of which were involved in launch failures. It was intended to impact the surface of the Moon, and in doing so become the first man-made object to reach its surface.

The spacecraft was intended to release 1 kilogram (2.2 lb) of sodium, in order to create a cloud of the metal which could be observed from Earth, allowing the spacecraft to be tracked. Prior to the release of information about its mission, NASA correctly identified that it had been an attempted Lunar impact mission.

Luna E-1 No.2 was launched on 11 October 1958 atop a Luna 8K72 carrier rocket, flying from Site 1/5 at the Baikonur Cosmodrome. One hundred and four seconds after launch, longitudinal resonance within the rocket's strap-on booster rockets caused the vehicle to disintegrate. This was the same problem which had caused the loss of Luna E-1 No.1 three weeks earlier.

Luna E-1 No.3

Luna E-1 No.3

A replica of a Luna E-1 spacecraft

Major contractors	OKB-1
Bus	Luna E-1
Mission type	Lunar impactor
Launch date	4 December 1958
Carrier rocket	Luna 8K72 s/n B1-5
Launch site	Baikonur Site 1/5
Mass	361 kilograms (800 lb)
Orbital elements	
Regime	Heliocentric (planned) Failed to achieve orbit

Luna E-1 No.3, sometimes identified by NASA as **Luna 1958C**, was a Soviet spacecraft which was lost in a launch failure in 1958. It was a 361-kilogram (800 lb) Luna E-1 spacecraft, the third of four to be launched, all of which were involved in launch failures. It was intended to impact the surface of the Moon, and in doing so become the first man-made object to reach its surface.

The spacecraft was intended to release 1 kilogram (2.2 lb) of sodium, in order to create a cloud of the metal which could be observed from Earth, allowing the spacecraft to be tracked. Prior to the release of information about its mission, NASA correctly identified that it had been an attempted Lunar impact mission.

Luna E-1 No.3 was launched on 4 December 1958 atop a Luna 8K72 carrier rocket, flying from Site 1/5 at the Baikonur Cosmodrome. Two hundred and forty five seconds into the flight, a hydrogen peroxide pump seized up due to loss of lubrication, which caused the rocket's core stage engines to fail.

Chapter- 8

Luna 1

Luna 1 (Mechta)

Operator	Soviet Union
Major contractors	OKB-1
Mission type	Planetary Science
Satellite of	Sun
Orbits	37 (as of 2005)
Launch date	2 January 1959 at 16:41:21 UTC

Launch vehicle	SS-6/R-7 (8K72)
Mission highlight	Fly-by of Moon on 4 January 1959 at distance of 5,995 km
COSPAR ID	1959-012A
Homepage	NASA NSSDC Master Catalog
Mass	361 kg
Orbital elements	
Semimajor axis	1.146 AU
Eccentricity	0.14767
Inclination	0.01°
Apoapsis	1.315 AU
Periapsis	0.9766 AU
Orbital period	450 d
Lunar landing	
Date	None
Instruments	
Magnetometer (magnetic fields)	
Geiger counter (radiation environment)	
Micrometeoroid detector	
Scintillation counter (magnetospheric studies)	

Luna 1 (E-1 series), first known as *First Cosmic Ship*, then known as **Mechta** (Russian: Мечта, *lit.*: *Dream*) was the first spacecraft to reach the vicinity of the Moon and the first of the Luna program of Soviet automatic interplanetary stations successfully launched in the direction of the Moon.

While traveling through the outer Van Allen radiation belt, the spacecraft's scintillator made observations indicating that a small number of high energy particles exist in the outer belt. The measurements obtained during this mission provided new data on the Earth's radiation belt and outer space. The Moon was found to have no detectable magnetic field. The first ever direct observations and measurements of the solar wind, a strong flow of ionized plasma emanating from the Sun and streaming through

interplanetary space, were performed. That ionized plasma concentration was measured to be some 700 particles per cm^3 at altitudes 20-25 thousand km and 300 to 400 particles per cm^3 at altitudes 100-150 thousand km. The spacecraft also marked the first instance of radio communication at the half-million-kilometer distance.

A malfunction in the ground-based control system caused an error in the rocket's burntime, and the spacecraft missed the target and flew by the Moon at a distance of 5,900 km at the closest point. Luna 1 then became the first man-made object to reach heliocentric orbit and was then dubbed a "new planet" and renamed *Mechta*. Its orbit lies between those of Earth and Mars. The name "Luna-1" was applied retroactively years later. Luna-1 was originally referred to as the "First Cosmic Rocket", in reference to its achievement of escape velocity.

The spacecraft

The scientific equipment and the satellite's power center were located in the spherical container, combining for a mass of 361.3 kg. Five antennae extended from one hemisphere. Instrument ports also protruded from the surface of the sphere. The spacecraft contained radio equipment, a tracking transmitter, a telemetry system, five different sets of scientific devices for studying interplanetary space (including a magnetometer, Geiger counter, scintillation counter, and micrometeorite detector), and other equipment. The total final (with fuel spent) mass of the third (upper) stage rocket with the spacecraft was 1472 kg.

It was intended that after a completion of its scientific mission of in-flight measurements, Luna-1 would crash into the Moon, delivering two metallic pennants with the Soviet coat of arms that were included into its package.

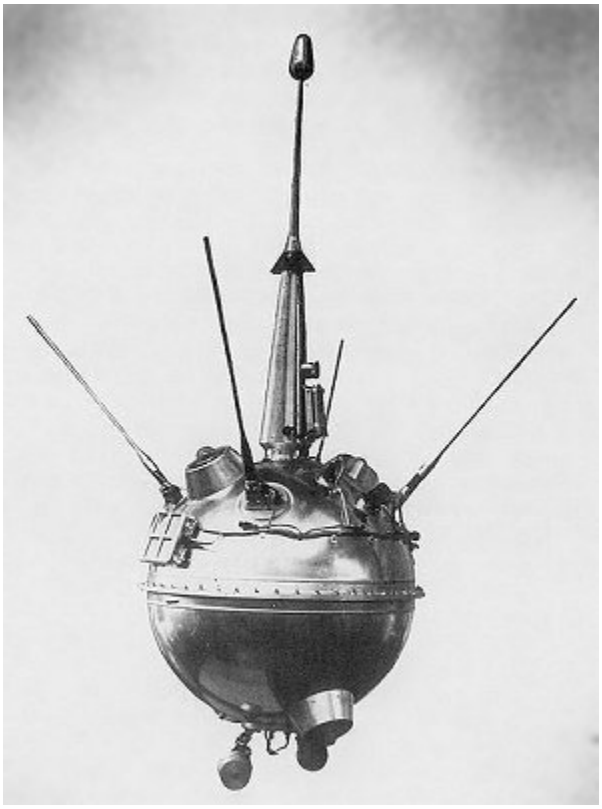
The flight

Luna 1 was launched 2 January 1959 at 16:41 GMT (19:41 Moscow Time) from the Baikonur Cosmodrome by a Luna 8K72 rocket.

Luna 1 became the first ever man-made object to reach the escape velocity of the Earth (what is also known as the *second cosmic velocity*), when it separated from its 1472 kg third stage. The third stage, 5.2m long and 2.4m in diameter, traveled along with Luna 1. On 3 January, 3:56:20 Moscow Time, at a distance of 119,500 km from Earth, a large (1 kg) cloud of sodium gas was released by the spacecraft, thus making this probe also the first artificial comet. This glowing orange trail of gas, visible over the Indian Ocean with the brightness of a sixth-magnitude star for a few minutes, was photographed by Mstislav Gnevyshev at the Mountain Station of the Main Astronomical Observatory of the Academy of Sciences of the USSR near Kislovodsk. It served as an experiment on the behavior of gas in outer space. Luna 1 passed within 5995 km of the Moon's surface on 4 January after 34 hours of flight. It went into orbit around the Sun, between the orbits of Earth and Mars.

Luna 2

Luna 2



Operator	Soviet Union
Major contractors	OKB-1
Mission type	Lunar Science Lunar impact
Satellite of	Moon
Orbits	none
Launch date	September 12, 1959 at 06:39:42 UTC
Launch vehicle	R-7 - (Luna 8K72)
Mission duration	33.5 hours
Mission highlight	Lunar impact (see below)

COSPAR ID	1959-014A
Homepage	NASA NSSDC Master Catalog
Mass	390.2 kg (860.2 lb)
	Lunar landing
Date	Lunar collision September 13, 1959, 21:02:24 UTC
Coordinates	29°06′N 0°00′W / 29.1°N 0°W
	Instruments
	Magnetometer (magnetic fields) Geiger counter (radiation environment) Micrometeoroid detector Scintillation counter (magnetospheric studies)

Luna 2 (E-1A series) was the second of the Soviet Union's Luna programme spacecraft launched to the Moon. It was the first spacecraft to reach the surface of the Moon. It successfully impacted with the lunar surface east of Mare Serenitatis near the craters Aristides, Archimedes, and Autolycus.

Luna 2 was similar in design to Luna 1, a spherical spacecraft with protruding antennae and instrument parts. The instrumentation was also similar, including scintillation counters, geiger counters, a magnetometer, Cherenkov detectors, and micrometeorite detectors. There were no propulsion systems on Luna 2 itself.

Van Allen Radiation Belt

Luna 2 showed time variations in the electron flux and energy spectrum within the outer belt.

Luna 2 was instrumented with a three component fluxgate magnetometer, similar to that used on Luna 1, but with the dynamic range reduced by a factor of 4 to -750 to +750 nanoteslas (gammas) so that the quantization uncertainty was -12 to +12 nT. The spacecraft spin period was 840 seconds about the major axis, and there was a precession with a period of 86 seconds. The sampling rate of the instrument was approximately once per minute. According to the Principal Investigator, the errors associated with the experiment zero levels and spacecraft fields were such that the accuracy was approximately 50 to 100 nT. The spacecraft gave results similar to those of Luna 1 in the Earth's radiation belts and, upon impact, placed an upper limit of 100 nT on the lunar magnetic field at the surface.

USSR pennants

Elements of the USSR pennants, delivered by Luna 2 to the moon

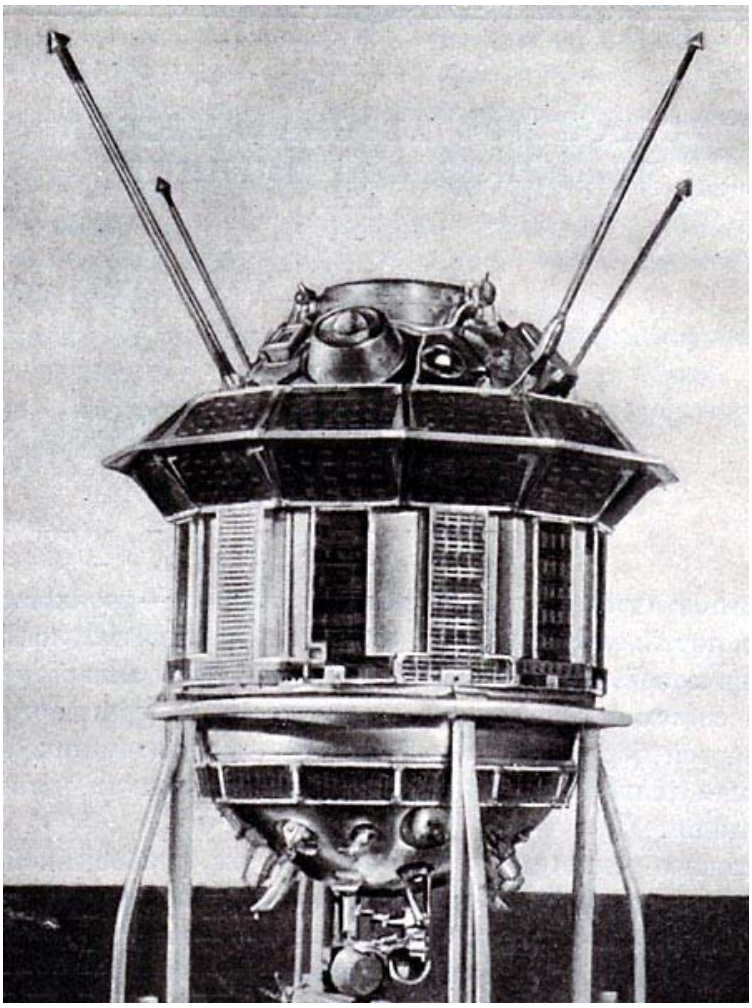
The spacecraft also carried Soviet pennants. Two of them, located in the spacecraft, were sphere-shaped, with the surface covered by identical pentagonal elements. In the center of this sphere was an explosive for the purpose of slowing the huge impact velocity. This was designed as a very simple way to provide the last necessary delta-v for those elements on the retro side of the sphere to not get vaporized. Each pentagonal element was made of stainless steel and had the USSR Coat of Arms and the Cyrillic letters *СССР* (Russian; it translates into English as *USSR*) relief engraved on one side, and the words *СССР СЕНТЯБРЬ 1959* (English: *USSR SEPTEMBER 1959*) relief engraved on the other side. The third pennant was located in the last stage of the Luna 2 rocket, which collided with the moon's surface 30 minutes after the spacecraft did. It was a capsule filled with liquid, with aluminium strips placed into it. On each of these strips the USSR Coat of Arms, the words *1959 СЕНТЯБРЬ* (English: *1959 SEPTEMBER*) and the words *СОЮЗ СОВЕТСКИХ СОЦИАЛИСТИЧЕСКИХ РЕСПУБЛИК* (English: *UNION OF SOVIET SOCIALIST REPUBLICS*) were engraved.

On September 15, 1959, the premier of the USSR, Nikita Khrushchev, presented to the American president Dwight D. Eisenhower a copy of the spherical pennant as a gift. That sphere is located at the Eisenhower Presidential Library and Museum in Abilene Kansas.

The only other known copy of the spherical pennant is located at the Kansas Cosmosphere in Hutchinson, Kansas.

Luna 3

Luna 3



Luna 3

Operator	Soviet Union
Major contractors	OKB-1
Mission type	Planetary Science Lunar Flyby
Satellite of	Earth
Orbits	~14
Launch date	October 4, 1959 at 00:43:39.7 UTC

Launch vehicle	SS-6/R-7 (8K72)
Mission duration	~207 days
Mission highlight	Lunar flyby on 6 October 1959, 14:16 UTC at distance of 6,200 km over the lunar south pole
COSPAR ID	1959-008A
Homepage	NASA NSSDC Master Catalog
Mass	278.5 kg

Orbital elements

Semimajor axis	250,682 km
Eccentricity	0.8379
Inclination	76.8°
Apoapsis	460,725 km
Periapsis	40,638 km
Orbital period	15 days

Instruments

Yenisey-2 Camera/Film processor (Lunar photography)

The Soviet space probe **Luna 3** of 1959 (of the E-3 series) was the third space probe to be sent to the neighborhood of the Moon, and this mission was an early feat in the spaceborne exploration of outer space. Though it returned rather poor pictures by later standards, 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 Far Side of the Moon* was created after image processing improved the pictures. This space probe has been commonly called "Lunik 3", predominantly in the Western world.

These views showed mountainous terrain, very different from the near side, and only two dark, low-lying regions which were named Mare Moscovrae (Sea of Moscow) and Mare Desiderii (Sea of Desire). Mare Luna Desiderii was later found to be composed of a smaller mare, Mare Ingenii (Sea of Ingenuity), and several other dark craters.

Design

The space probe was a cylindric canister with hemispheric ends and a wide flange near the top. The probe was 130 cm long and 120 cm at its maximum diameter at the flange. Most of the cylindric section was roughly 95 cm in diameter. The canister was hermetically-sealed and pressurized to about 0.22 atmosphere (23 kilopascals). 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 celsius. 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.

Mission

After launching on an 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. Initial radio contact showed that the signal from the space probe was only about one-half as strong as expected, and the internal temperature was rising. The spacecraft spin axis was reoriented and some equipment was shut down, resulting in a temperature drop from 40 celsius to about 30 celsius. At a distance of 60,000 to 70,000 km from the moon, the orientation system was turned on and the spacecraft rotation was stopped. The lower end of the craft was pointed at the sun, which was shining on the far side of the moon.

The space probe passed within 6,200 km of the moon near its south pole at the closest lunar approach at 14:16 UT on 6 October 1959, and continued on over the far side. On 7 October, the photocell on the upper end of the space probe detected the sunlit far side of the moon, and the photography sequence was started. The first picture was taken at 03:30 UT at a distance of 63,500 km from the moon, and the last picture was taken 40 minutes later from a distance of 66,700 km.

A total of 29 pictures were taken, covering 70% of the far side. After the photography was complete the spacecraft resumed spinning, passed over the north pole of the moon and returned towards the Earth. Attempts to transmit the pictures to the Soviet Union began on October 8th but the early attempts were unsuccessful due to the low signal strength. As Luna 3 drew closer to the Earth, a total of about 17 viewable but poor quality photographs were transmitted by 18 October. All contact with the probe was lost on 22 October 1959. The space probe was believed to have burned up in the Earth's atmosphere in March or April 1960. Another possibility was that it might have survived in orbit until 1962 or later.

Lunar photography

Luna-3 phototelegraph system at Tsiolkovsky State Museum of the History of Cosmonautics

1959 USSR stamp commemorating first photographs of the Far side of the Moon

The purpose of this experiment was to obtain photographs of the lunar surface as the spacecraft flew by the moon. The imaging system was designated Yenisey-2 and consisted of a dual-lens camera AFA-E1, an automatic film processing unit, and a scanner. The lenses on the camera were a 200 mm focal length, *f*/5.6 aperture objective and a 500 mm, *f*/9.5 objective. The camera carried 40 frames of temperature- and radiation-resistant 35 mm isochrome film. The 200 mm objective could image the full disk of the moon and the 500 mm could take an image of a region on the surface. The camera was fixed in the spacecraft and pointing was achieved by rotating the craft itself.

Luna-3 was the first successful three-axis stabilized spacecraft. During most of the mission, the spacecraft was spin stabilized, but for photography of the moon, the

spacecraft oriented one axis toward the Sun and then a photocell was used to detect the moon and orient the cameras towards it. Detection of the moon signalled the camera cover to open and the photography sequence to start automatically. The images alternated between both cameras during the sequence. After photography was complete, the film was moved to an on-board processor where it was developed, fixed, and dried. Commands from the Earth were then given to move the film into a scanner where a spot produced by a cathode ray tube was projected through the film onto a photoelectric multiplier. The spot was scanned across the film and the photomultiplier converted the intensity of the light passing through the film into an electric signal which was transmitted to the Earth (via frequency-modulated analog video, similar to a facsimile). A frame could be scanned with a resolution of 1000 (horizontal) lines and the transmission could be done at a slow-scan television rate at large distances from the Earth and a faster rate at closer ranges.

The camera took 29 pictures over 40 minutes on 7 October 1959, from 03:30 UT to 04:10 UT at distances ranging from 63,500 km to 66,700 km above the surface, covering 70% of the lunar far side. Seventeen (some say twelve) of these frames were successfully transmitted back to the Earth, and six were published (frames numbered 26, 28, 29, 31, 32, and 35). They were mankind's first views of the far hemisphere of the moon.

The imaging system was developed by P.F. Bratslavets and I.A. Rosselevich at the Leningrad Scientific Research Institute for Television and the returned images were processed and analyzed by Iu.N. Lipskii and his team at the Sternberg Astronomical Institute. The camera AFA-E1 was developed and manufactured by the KMZ factory (Krasnogorskiy Mekhanicheskiy Zavod).