History of Rocketry and Astronautics

Anthony M. Springer, Editor

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Front Cover Illustration:

This still image from archived film footage shows the preparation of PS-1, the first artificial satellite of Earth, launched on 4 October 1957. The "PS" stood for "Prosteyshiy Sputnik" or "The Simplest Satellite." It is unclear whether the model shown is the actual one launched or a backup. The picture does, however, give an excellent sense of the scale of the first satellite. Photo Credit: Donald Mitchell.

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Chapter 1

Sputnik 1—The First Artificial Earth Satellite*

Victor P. Legostaev†

The launch of the first artificial Earth satellite is one of the most significant events in the history of humanity. The satellite was designed, manufactured, and launched in the Soviet Union by Design Bureau-1 (known as OKB-1, now the S. P. Korolev Rocket Space Corporation Energia) under the leadership of S. P. Korolev, whose role in space exploration is now acknowledged all over the world. In January 1956, on S. P. Korolev's insistence, a decision on the development of the Earth artificial satellite that would be launched using the R-7 launch vehicle was made. The successful flight of this missile to the intercontinental range was performed on 21 August 1957. The *Sputnik* launch was to be recognized by all the world's countries, so radio equipment was installed on the satellite. The world's first Earth satellite was injected into near-Earth orbit on 4 October 1957. This event marked the beginning of a new era in the history of civilization—the space era. The satellite PS-1‡ mass was 83.6 kilograms, and it stayed in orbit for 92 days. The first Earth satellite resulted in data on the satellite's lifetime in near-Earth orbit, radio waves propagation through the ionosphere, and the effect of spaceflight conditions on satellite equipment operation. This chapter is dedicated to the history of the *Sputnik* development and launch.

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† S. P. Korolev Rocket Space Corporation Energia, Moscow, Russia.

‡ *Sputnik 1* (Russian: *Спутник-1*, "Satellite-1," byname *ПС-1* (PS-1, *Простейший Спутник-1*, or Elementary Satellite-1).

The date of 4 October 1957 marked the beginning of a technological, social, economical, and overall global revolution. The launch of the first artificial satellite had dramatically changed the whole world and me also. At that time, I had little experience in the capacity of an engineer, and I still believed that Earth was flat. I was occupied with the control systems of large winged missiles with some placidity. My boss had been acquainted with S. Korolev, and the next day my boss came to see me and proposed that I set to work on the control system of a spacecraft that was to take pictures of the Moon's far side. A boss being a boss, so for the rest of my life, I could not get out of space-related activities. Then we worked under the lead of the President of the USSR Academy of Sciences (academician M. Keldysh) but shortly after we had been transferred to S. Korolev. It was not easy to work with S. Korolev, but, however, it was a nice job. Whenever we met, it was like playing with fire. I have never met before and after such an energetic and purposeful person. On 18 January this year (2007) we celebrated his centenary. The idea of developing the first satellite was not generated by him spontaneously. Initially, the rocket named R-7 and having a flight range of 10,000 km with a five-tonnage payload was developed and manufactured for quite different purposes. But shortly before the successful launch of the two pioneer rockets, the proposal had been made to develop an artificial Earth's satellite. S. P. Korolev submitted a proposal to D. F. Ustinov to develop an artificial satellite of Earth. After detailed discussions in the USSR Academy of Sciences and the government, on 30 January 1956, the resolution to develop the artificial satellite was adopted. That document called for developing in 1957–1958 a 1,000–1,400 kg artificial satellite (Object D) without any attitude control system, which would carry 200–300 kg of scientific payloads.

The first satellite prototype was multifunctional, bulky, and sophisticated, that is why it was behind schedule. Later this satellite would be destroyed during the launch. Meanwhile, S. Korolev proposed a great concept of a satellite, relatively simple in design, which could be developed and manufactured quickly and on time. "On time" implied faster than the United States. On 15 February 1957, a resolution was adopted, which called for putting into orbit such an object (Object PS), checking the feasibility of its observation, and receiving signals transmitted from PS. Because of the very tight schedules, the designers and production personnel had to work in parallel. You should understand, that many years we have been rivals with the United States, although our engineers and scientists met and made friends with each other. The first man-made Earth satellite, launched at 22 hr 28 min, Moscow time, on 4 October 1957, was put into orbit with these parameters: altitude in perigee—228 km, altitude in apogee—947 km, and with inclination—65.1°.

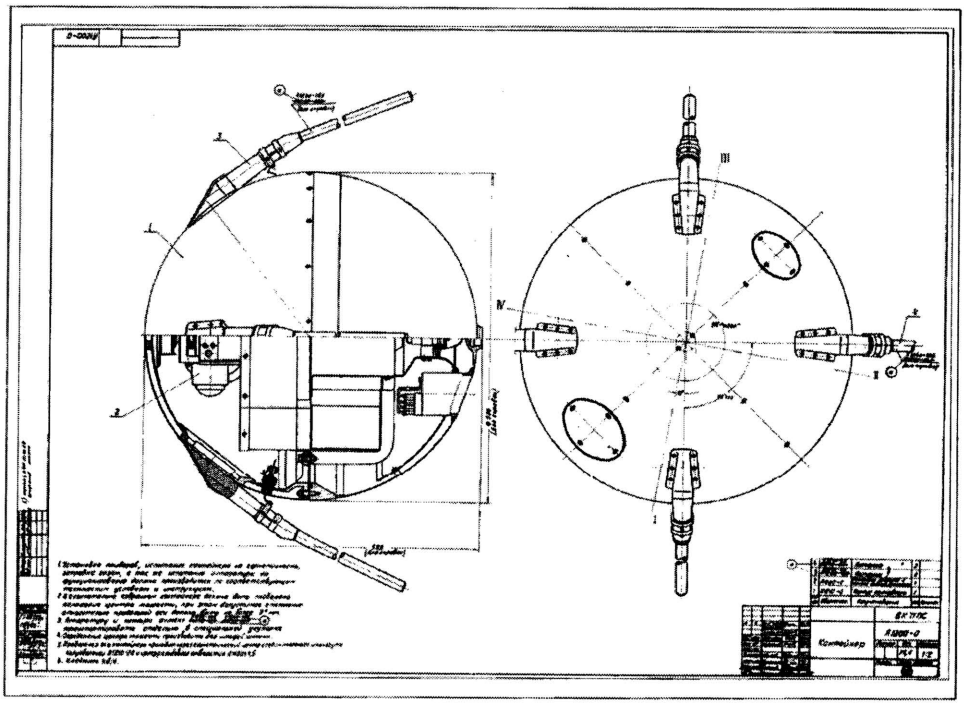

Figure 1–1: The original assembly drawing of *Sputnik* (1956).

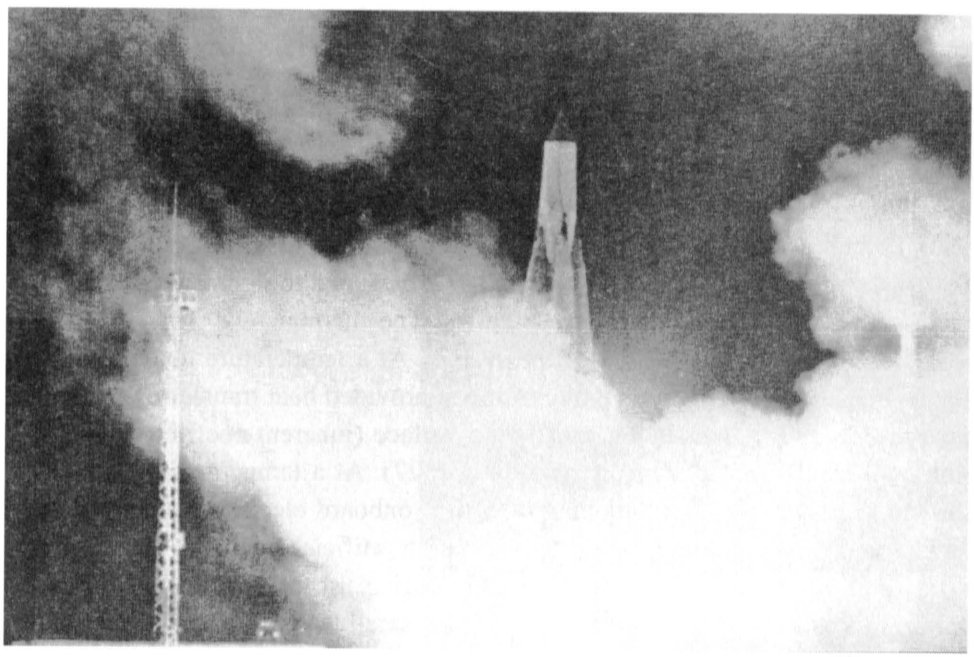

Figure 1–2: Launch of *Sputnik 1*, 4 October 1957.

At 315 seconds into the flight, the satellite separated from the second stage of the launch vehicle and its signals were heard by the entire world. The first artificial satellite of Earth, PS-1 (*Sputnik 1*), was a pressurized 580-mm spherical container with four whip antennas, 2.4 and 2.9 meters long, attached to the upper hemisphere with a mass of 83.6 kg. Inside the sealed body the following systems were accommodated: a transmitting device; a fan; a thermal relay and air duct of the thermal control system; a switching device of the onboard electrics, temperature, and pressure sensors; and onboard cable system. The hull was manufactured of an aluminum alloy and consisted of two shells. The internal volume was filled with dry nitrogen (pressure of 1.3 atmospheres). Pressure integrity was provided by a sealing vacuum rubber ring of a rectangular cross-section gasket between two hemispheres tightened along their periphery with 36 bolts. The assembly of electric-chemical generators (mass of 51 kg) consisted of three batteries of silver–zinc accumulators; two batteries provided power supply for the transmitting device, the third battery provided power for the thermal control system. The transmission system (mass of 3.5 kg) included two transmitters operating at frequencies of 20.005 and 40.002 MHz, the output power of each transmitter was ~ 1W. The transmitters generated signals as telegraph messages of 0.2–0.3 s in duration; one transmitter operated during intervals in operation of the other one. Telemetry information (temperature, pressure) was transmitted through changes of the sampling frequencies and intervals between them. Whenever temperature inside the satellite went above +50°C or below 0°C, and in case the pressure inside the satellite fell below 0.35 atm, one of the control switches (thermostatic or pressure switch) was to be triggered causing a change in the duration of periodic signals emitted by the radio transmitter. Each transmitter had two whip antennas (with an angle of 70° between them), the pattern of each pair was chosen to provide omnidirectional coverage. The thermal control system included a radiator and gaseous heat exchange circuit; forced circulation of the gas in the pressure hull was provided by the fan. The system was designed to maintain a stable temperature under variable external heat flows. The thermal relay (based on a bimetal) was a sensitive element of the system. At a temperature above 36°C the fan switched on, and the circulating nitrogen provided heat transfer of one of the pressure hull half shells being a radiating surface (inherent coefficient of radiation of 0.35–0.4; solar absorbance of 0.23–0.27). At a temperature below 20°C the fan switched off. The switching device of onboard electrics was designed to switch on the power supply of devices on Earth artificial satellite's insertion into orbit (on separation from launch vehicle). During ascent, to provide protection against aerodynamic and thermal effects, the satellite was placed under a nose fairing to be separated simultaneously with the Earth artificial satellite.

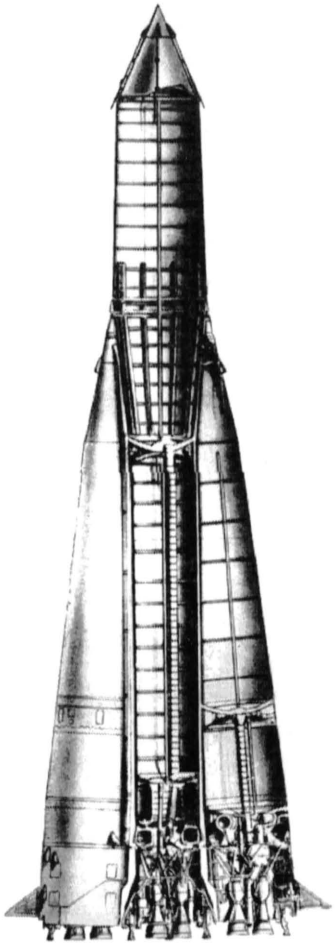

Figure 1–3: The *Sputnik* launch vehicle was designed on the basis of the R-7 rocket.

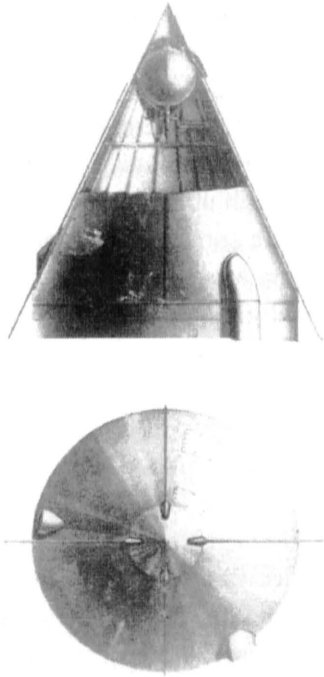

Figure 1–4: Accommodation of *Sputnik* under the launcher payload shroud.

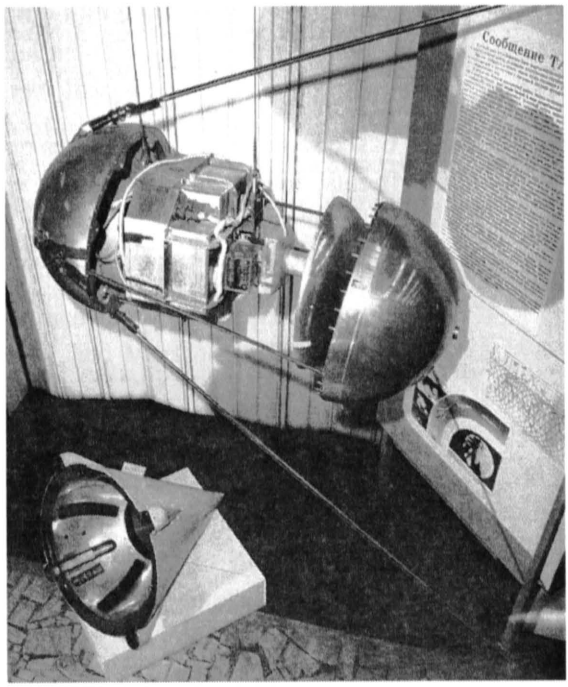

Figure 1–5: The engineering model of *Sputnik* and its shroud in the RSC Energia Museum.

The electric-chemical generators provided equipment operation in flight for three weeks. Earth artificial satellite was in existence for 92 days, having performed about 1,400 orbits around Earth. On 4 January 1958 it entered the upper atmosphere and burnt up during entry. The first satellite was indeed very simple. But that event found a broad response worldwide. For the first time an object thrown high up had not returned to Earth. It was a "beep-beep" known to everybody. The human-made pioneer star was the first to have flown over our heads. It had been a tremendous success of all humanity and (just between ourselves) a personal great contribution of Chief Designer S. P. Korolev. For the rest of his life (nine years) he had been able to make as many achievements as would be sufficient for all of us taken together. Those were:

- intercontinental multistage rockets;
- first submarine launch of missile;
- first animal launch into space; on 10 October 1957, following the instructions given in person by the head of the government, N. S. Khrushchev, a decision was made to prepare on short notice and launch a second artificial satellite (PS-2). The satellite was represented by the last stage of the launch vehicle, which carried a number of containers with scientific equipment and instrumentation and, in a special pressurized cabin, a test animal, a dog named Laika. The cabin had a life support system. The satellite was designed and built in less than a month. The total mass of the equipment, the animal and the power supply units was 508.3 kg. The launch of the second artificial satellite took place on 3 November 1957. For the first time the scientists got an opportunity to study the physiological state of an animal exposed to orbital environment.
- launch of the satellite to take pictures of Earth's surface;
- Moon flights; interplanetary probe *Luna-2* was the first in the world to reach the lunar surface and it delivered to the surface of the Moon an ensign with the Soviet Union state emblem. For the first time in the world's history, the photographs of the far side of the Moon were taken and transmitted to Earth.
- soft automatic lunar landing; after landing on the Moon, the unmanned lunar lander switched its television (TV) camera on six times, permitting for the first time to take panoramic pictures of the lunar surface in the landing area.
- first human launch into space; on 12 April 1961 spacecraft 3KA No. 3, with a mass of 4,725 kg, was launched, which became known in the mass media under the name of *Vostok*, carrying aboard pilot-cosmonaut Yu. A. Gagarin. That was the world's first mission into space.

- spaceflights to Mars and Venus;
- first communications satellite; for its operational orbit, a high elliptical orbit was adopted, with an orbital period of 12 hours and apogee altitude of 40,000 km above the northern hemisphere. Using three satellites that pass over our country one after another, it was possible to construct a 24-hour communications system;
- first human extravehicular activity; today cosmonauts can stay in outer space for hours, but the first egress into space will always survive in Alexey Leonov's memory;
- developed multi-set space vehicles for long-duration stay in space; on 12 October 1964 a three-seater spacecraft, *Voskhod*, was launched, carrying aboard cosmonauts V. M. Komarov, K. P. Feoktistov, and B. B. Yegorov.

The pace of works was impressive. It took 2.5 years to develop a rocket, 2.5 years to develop the ground infrastructure, including Baikonur Cosmodrome, and 0.5 year to develop the first satellite. We could not keep up with that pace of works today.

Forthcoming events were *Soyuz* space vehicle; the H-1 rocket capable of delivering 100 tons of cargo into orbit; in-orbit automated docking of space vehicles, and the first orbital station. In the Soviet Union a common powerful system was created for providing long-term operation of the orbit, crew change, and necessary payload recovery back to Earth.

Today we work in cooperation with many countries. We have the International Space Station, Sea Launch, and many other projects behind us. Nowadays, most of us are not aware of the fact that space-related progress products are available at our homes. Nearly each of us has a mobile phone, we have access to virtually any location on Earth; we can receive TV and musical programs; establish communications via Internet; locate our position onsite. Satellite images of Earth allow people to estimate harvests, facilitate search of minerals, and see the scope of disasters caused by floods and fires. Space research enabled us to determine the electromagnetic environment around Earth; investigate interstellar space, the surface of the Moon, Venus, and Mars; as well as the satellites of the other planets. These investigations make us closer to a discovery that we are not alone in this world. Investigation of the space environment gives rise to new hypotheses concerning the origin of worlds.