SpaceViews
A publication of the Boston chapter of the NSS

Mercury's Competition: Vostok

by Andrew J. LePage
May 15, 2000

All through 1959 and into 1960, America's very public Mercury manned space program was making slow but steady progress (see **Giving Mercury Wings** in the September 1, 1999 issue of *SpaceViews*). While it was quite clear that the Soviet Union also planned to send men into space, it was difficult to sort the facts from the stream of propaganda. That began to change on May 15, 1960 with the launch of Korabl Sputnik 1 (Spaceship Satellite 1) also referred to as "Sputnik 4" in the West.

Carrying a dummy cosmonaut in a 312 by 369 kilometer (194 by 229 mile) orbit inclined 65 degrees to the equator, Korabl Sputnik 1 was the long awaited inaugural flight of Mercury's competition. Although the actual configuration of the spacecraft would remain a state secret for five more years, its weight was announced to be a record 4540 kilograms (9997 pounds). Weighing over three times more than Mercury, the United States would not launch a more massive manned spacecraft until the first Apollo in 1966.

Working Out the Design

When the Council of Chief Designers approved Sergei Korolev's plan to launch a manned orbital spacecraft in November of 1958, its basic design had already been worked out (see **The Start of the Manned Space Race** in the November 1998 issue of *SpaceViews*). The design team at Department No. 9 at Korolev's OKB-1 (Experimental Design Bureau No. 1) had already settled on a two-module spacecraft composed of a service module and a spherical descent module.

The descent module was a sphere 2.3 meters (7.5 feet) in diameter weighing about 2400 kilograms (5300 pounds). It was covered with an ablative heat shield and contained all the equipment needed for returning from orbit. It was designed to carry a single space suit-clad cosmonaut in a semi reclined ejection seat which served a dual purpose: During the early phases of ascent, this seat could safely eject the cosmonaut away from the craft in case of a problem. Because of weight restrictions, the capsule could not carry a large enough parachute to guarantee a soft enough landing for the pilot at the end of a normal mission. Instead a forced landing procedure was developed where, after reentry was done, the cosmonaut ejected from the descent module at an altitude of 7 kilometers (23,000 feet). He then used his own parachute to make a soft landing separate from the more quickly falling descent module.

During the flight, the cabin interior maintained an oxygen-nitrogen atmosphere at a pressure of one bar (15 psi) like on the ground. Since the effects of weightlessness were unknown, the spacecraft was completely automated with the "pilot" only taking control using rudimentary instruments in an emergency. One of the portholes was equipped with a Vzor optical sight built by TsKB-558 (Central Design Bureau No. 558) that allowed the cosmonaut to visually check the spacecraft's attitude. While small, the cabin was roomy enough for the cosmonaut to float out of his seat.

The service module carried all the equipment not needed for the return to Earth. It was a double cone shape about 2.4 meters (7.9 feet) in diameter and about as tall with a mass of 2300 kilograms (5,100 pounds). It was connected to the descent module by straps and an umbilical arm designed to burn away in case they failed to separate before reentry. This module carried various consumables for life support, the attitude control system, batteries, telemetry systems and a liquid propellant TDU-1 retrorocket at its base. Producing 16 kilonewtons (3600 pounds) of thrust for 45 seconds, the TDU-1 was built by OKB-2 under Alexei M. Isayev. Spacecraft attitude was controlled automatically by gas jets using inputs from

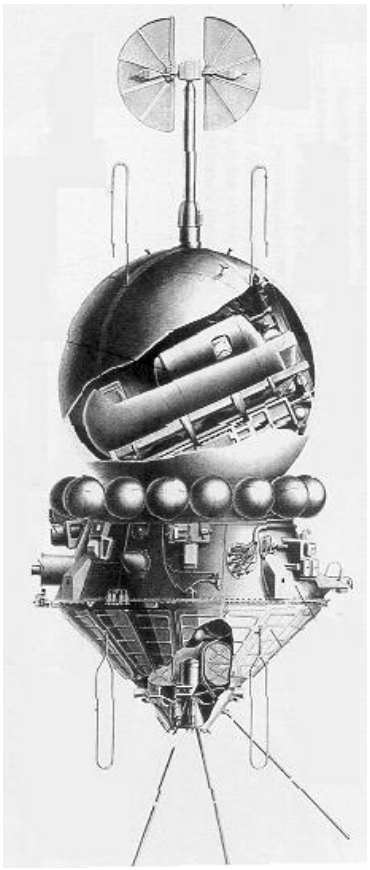
solar and infrared sensors. This system had to orient the spacecraft precisely when the TDU-1 fired in order to make a survivable ballistic reentry. As a backup, the cosmonaut could control the spacecraft's orientation and fire the TDU-1 manually. The descent module had no active attitude control and used aerodynamic forces in conjunction with an offset center of gravity to maintain orientation during reentry.

Since mass restriction did not allow sufficient redundancy in the TDU-1 retrorocket, the spacecraft employed an interesting backup system to return to Earth: Atmospheric drag. The spacecraft would be placed into a orbit that would naturally decay in ten days or less. The Soviet spacecraft was designed from the start with a ten day endurance so that if the TDU-1 failed, the cosmonaut still had a chance to return to Earth alive. While initial plans called for the first manned mission to last a day, this ten-day capability would allow the Soviets to attempt missions an order of magnitude longer than those planned for the much smaller Mercury capsule.

Moving Towards the First Launch

The spacecraft would be launched into orbit under an aerodynamic shroud using an improved, man-rated version of the 8K72 Moon rocket called the 8K72K. Its R-7-based booster would incorporate various engine and systems improvements developed for the newer R-7A ICBM. The Blok E upper stage would also include many upgrades including the replacement of its RO-5 engine with the more reliable and powerful RO-7 built by OKB-154 under Semyin Kosberg. Although work on the 8K72K started in January 1959 and progressed well into 1960, it was decided to use the 8K72 to launch the first unmanned prototypes.

Even as work progressed on the Soviet manned spacecraft, a major debate continued with military interests. In an effort to broaden the appeal for the manned space program, Korolev's engineers also designed a photographic reconnaissance variant of the spacecraft. This unified design, called Vostok, received an official blessing in the form of a government decree on May 22, 1959. But the military wanted priority given to the development of the more useful reconnaissance satellite rather than pouring limited resources into the "stunt" of sending a man into orbit. But Korolev and, more importantly, Soviet Premier Nikita Khrushchev wanted a manned spacecraft to be given priority. Still Korolev argued that much of the development of the two Vostok variants could take place in parallel.



Drawing of the Vostok-1 (or 1K) prototype spacecraft. (Energia RSC)

As the debate raged, work on Vostok continued all through 1959. In March the basic hull drawings were completed. By May design details were available and work started on the fabrication of actual systems. By the end of 1959 a pair of Vostok "electrical analogs", designated 1KP, were being tested in the shops. Ultimately a plan was adopted that allowed for the development of both Vostok variants to continue but with manned flights given priority for political and propaganda purposes. On December 10, 1959 a decree was issued to proceed.

By March of 1960, 20 cosmonaut candidates had started training. Unlike the Mercury 7, their identities remained a secret in some cases for years. Finally in April 1960 a draft project outline, which Korloev had been following for months anyway, was officially accepted. It called for the development of three Vostok variants. Vostok-1 or 1K would be a prototype vehicle meant to test the basic spacecraft design and systems. Next was the Vostok-2 or 2K reconnaissance variant that was later known as Zenit-2. Finally there was the Vostok-3 or 3K which would actually carry a cosmonaut into orbit.

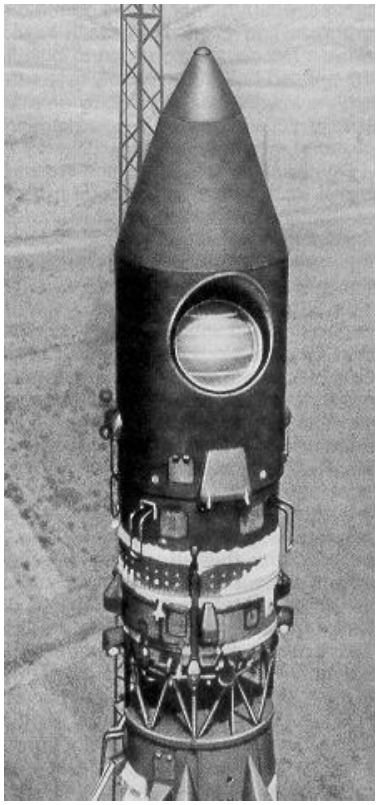
By the spring of 1960 the first 1KP was ready for launch. The 1K incorporated most of the elements of the manned 3K design except the 1K had a mast on top of the descent module carrying a small solar array. Shaped like a pair of half-disks a meter (3.3 feet) across, they carried there own orientation system and would evaluate the use of solar panels for supplying power on future spacecraft. The 1KP prototype contained all the basic systems of the 1K except for life support and a heat shield. This flight would simply evaluate the performance of the basic Vostok design up to and including the firing of the retrorocket. With no heat shield, an actual recovery would not be attempted. The lack of a heat shield also meant that the spacecraft could not accidentally land outside of the Soviet Union in case control was lost.

The first Vostok prototype, called Korabl Sputnik 1, was launched into orbit using an 8K72 on May 15, 1960. Except for a problem with the attitude control system that developed a day into the flight and excessively noisy communication frequencies for the cosmonaut, reportedly all went well. Finally on May 19 after 64 orbits, Korabl Sputnik 1 was commanded to orient itself for retrofire and the end of its mission. While the TDU-1 worked, the fault in the attitude control system caused the engine to fire in the wrong direction. Instead of heading for a destructive reentry, the spacecraft was sent into a higher 307 by 690 kilometer (191 by 429 mile) orbit.

While the Western press took this "mishap" as a mission failure, in reality Korabl Sputnik 1 met almost all of its mission objectives and continued to operate for another four days in its new orbit. On June 4, as the data from the first mission were still being assessed, the launch of the first manned Vostok was officially set for December 1960. While the goal was achievable, there was still much work to be done.

Prototype Test Flights

The next flight would use a fully functional 1K spacecraft for an end to end test of the baseline one-day manned mission. To test the life support systems and obtain more information on the effects of spaceflight, a pair of dogs called Chaika and Lisichka were carried - the first dogs to be orbited since the flight of Sputnik 2 (see **Sputnik 2: The First Animal in Orbit** on the November 1997 issue of *SpaceViews*). A whole team of canine cosmonauts had been assembled for the Vostok test program including some "veterans" from the Soviet's long running suborbital flight program. The dogs would ride in individual compartments attached to the ejection seat. Other biological specimens would also be carried inside the cabin.



The launch of Korabl Sputnik 1 on May 15, 1960. (Author's collection)

On July 28, 1960 the first 1K spacecraft lifted off its pad but the 8K72 rocket quickly experienced problems. Only 17 seconds after liftoff the engine in one of the boosters failed. The damaged booster broke away and the launch vehicle exploded killing both dogs.

With little time to waste, another Vostok-1 and 8K72 were prepared for flight. On August 19, the 4600 kilogram (10,130 pound) Korabl Sputnik 2 was successfully placed into a 306 by 340 kilometer (190 by 211 mile) orbit carrying another pair of dogs: Belka and Strelka. Both did well in space but Belka did suffer from the first known bout of space sickness by the fourth orbit. The next day Korabl Sputnik 2 fired its retrorocket during the eighteenth orbit. This time the orientation system worked and the craft successfully reentered the atmosphere. As planned, the dogs landed separately from the capsule with the ejection seat and survived the flight making them the first living things to successfully return from orbit.

A series of television images of the dog "Belka" orbiting the Earth in Korabl Sputnik 2. Belka has the distinction of being the first known victim of space sickness. (Author's collection)

Inevitable delays in the demanding Vostok development schedule over the following months ultimately doomed a December manned launch. But with Mercury's schedule also slipping, another space first was still within reach. On December 1, 1960 the unmanned Korabl Sputnik 3 was successfully placed into a 180 by 249 kilometer (112 by 155 mile) orbit by the last 8K72 rocket to fly. This spacecraft carried Pchelka and Mushka for a repeat of the baseline mission. Unfortunately this time the TDU-1 failed to operate properly the following day and the descent module reentered the atmosphere at too steep an angle. The capsule was incinerated and the dogs perished.

One last 1K mission was attempted this time using the new 8K72K launch vehicle. On December 22, 1960 1K No. 4 lifted off with the dogs Shutka and Kometa onboard. But the new RO-7 engine in the upgraded upper stage failed upon ignition damaging the spacecraft and forcing an abort. For the unmanned test missions, Vostok carried destruct charges to keep an errant spacecraft from literally falling into foreign hands. But the charges failed to detonate on command and the capsule landed intact in the remote Tunguska region of Siberia. With only 60 hours to find the capsule before a backup timer set off the charges, rescue teams set out in bad winter weather in a desperate recovery attempt. Only 12 hours before time expired, rescuers finally reached the snowbound capsule. Both dogs were still alive inside despite the -45 C (-49 F) temperatures. The damage caused by the Blok E engine failure had not only totally disabled the destruct system but resulted in the ejection seat firing before the hatch blew off leaving both dogs relatively protected inside the cabin.

While the Vostok program experienced much progress and many successes through 1960, the 1K failures in December showed that there were still many engineering problems to solve. With the pressure growing, next would be the critical 3K test flights and the final push to put a man in space before the Americans.

Bibliography

Philip Clark, *The Soviet Manned Space Program*, Orion Books, 1988

James Harford, *Korolev: How One Man Masterminded the Soviet Drive to Beat America to the Moon*, Wiley, 1997

Nicholas L. Johnson, *Handbook of Soviet Manned Space Flight*, Univelt, 1980

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

John Rhea (editor), *Roads to Space: An Oral History of the Soviet Space Program*, Aviation Week Group, 1995

Yuri P. Semenov (editor), *Racketno-Kosmicheskaya Korporatsiya 'Energia' Imeni S P Koroleva*, RKK Energia (Moscow), 1996 (in Russian)

Timothy Varfolomeyev, "Soviet Rocketry That Conquered Space Part 3: Lunar Launchings for Impact and Photography", *Spaceflight*, Vol. 38, No. 6, pp. 206-208, June 1996

Author

Drew LePage is a physicist and freelance writer specializing in astronomy and the history of spaceflight. He can be reached at prometheus1@mediaone.net