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A disassembled model of the PS-1 satellite at the Memorial Museum of Cosmonautics in Moscow. (credit: Asif Siddiqi)

Sputnik remembered: The first race to space (part 2)

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Success with the R-7?

Although Korolev had obtained permission to launch PS-1 back in February, the launch was *not* a foregone event. In his letter to the government in January, he had noted that a satellite could be "launched immediately after the first successful launches of the intercontinental missile."[1] A government document specified this as "one or two" successful launches.[2] As is well-known, there were several consecutive failures of the R-7 missile in the summer of 1957: one on May 15 exploded 104 seconds into its ascent; a second rocket never left the pad despite three consecutive attempts on June 9, 10, and 11; and a third R-7 was destroyed 33 seconds after launch on July 12. If there had been hope of launching two PS-1-type satellites in the summer, that hope was lost. The mood at Tiura-Tam was hitting bottom by the time that a fourth R-7 was brought out to the pad. Engineers, soldiers, and even government bureaucrats were all desperate for a success.

Luck favored them in this dark hour. An R-7 lifted off on its first (relatively) successful flight on August 21. To the delight of thousands of engineers, the R-7's engines, combustion chambers, strapon boosters, hybrid guidance system, and launch complex worked with clockwork precision. The missile flew 6,500 kilometers, and its warhead entered the atmosphere over the

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Kamchatka peninsula in the far eastern coast of the Soviet landmass. Although the actual warhead container disintegrated about 10 kilometers above the target, the flight was considered a major step forward in the program.[3] Korolev was so animated by the event that he kept his deputies awake until three in the morning, talking without end about all the doors opened by this success.

The R-7 flight in August helped Korolev's reputation, which had come under attack with the repeated failures in the summer. With a success under his belt, Korolev now needed final permission from an ad hoc body known as the "State Commission" to proceed with an orbital launch. In the Byzantine organizational world of the Soviet missile program, such commissions were temporary bodies that brought together individuals from many different sectors to oversee the process of testing and acceptance of new weapons. The chairman of the State Commission for both the R-7 (and thus, of Sputnik) was one Vasilii Riabikov (1907–74), who arguably played as important a role in the birth of Sputnik as Korolev, Tikhonravov, and Keldysh, the other three big players. Yet ironically, Riabikov is almost absent from the many stories on the history of the world's first satellite. Without the existence of any formal and detailed biography of the man, it remains difficult to discern any sense of his personality—he remains in some sense, one of the "gray cardinals" of the Soviet military-industrial complex, devoid of color and character. According to one source, back in February 1957, it was Riabikov who supported Korolev's argument to switch the satellites from the big Object D to the small PS-1.[4] As it got closer to commit to a satellite launch, it may have been Riabikov who played the deciding role to push ahead.

Soon after the first ICBM launch success, the State Commission convened at Tyura-Tam to review the state of the R-7 test series. After a discussion of the results of the August 21 launch, Korolev, to everyone's surprise, proposed that they should immediately start preparations for the launch of the satellite. He claimed that he would require a month and a half to two months to get everything ready for the launch. The Tiura-Tam launch range's chief of staff at the time, Konstantin Gerchik (1918–2001), later remembered that for many members of the Commission this was a total surprise. Several had not even *heard* of the PS-1 option; they had assumed that the plan was still to wait for the Object D satellite to be ready next year. The response to Korolev's request was "uproarious." Some members objected to the new plan, citing the more compressed and intense regime of work that many industrial enterprises were about to transition to because of numerous planned rocket launches—there would hardly be time to *also* work on a satellite launch. Korolev persistently continued to press his case, but there was no unanimous support at the meeting.

Perhaps sensing that he needed to try a different approach, he switched gears. Gerchik recalled that "The fate of the launch of the [satellite] was determined by … Korolev's *second* suggestion. [Korolev said] 'I propose sending the question of national priority in the launch of the world's first [satellite] up to a meeting of the [Politburo]…'. Let them settle it!"[5] The notion that Korolev's idea be sent up to the Politburo completely changed the tenor of the meeting. No one on the Commission wanted this question to be passed up that high, and certainly no member wanted to be the one whose stubbornness had dragged the Politburo into this discussion. But for Korolev, the most powerful argument was the specter of "national priority"; what bureaucrat would want to take a misstep and end up undercutting "national priority"? Perhaps Korolev was right? Maybe there was something to this satellite launch? In the end, the Commission unanimously approved Korolev's proposal, with the caveat that there be a second R-7 success. The satellite launch was on. (It's worth noting that the Politburo *did* actually discuss the impending launch, on September 26, but had no objection).

Korolev returned briefly to Moscow on August 31 before heading back to Tiura-Tam on September 5 for his fourth trip that year to the launch range. The subsequent launch of the R-7 two days later was as successful as its predecessor, and the missile flew across the Soviet Union before depositing its dummy warhead over the skies of Kamchatka. Like the previous time, the warhead container disintegrated.[6] It was clear that while the rocket itself was performing without fault, it could still not effectively deliver a warhead to any target. The problem required some serious research on the dynamics (shape, angle of entry, materials, aerodynamic quality) of the warhead container. Yet, the second failure of the warhead container actually helped Korolev's case in launching a satellite. Korolev's "first deputy" Vasilii Mishin (1917–2001) later wrote that "[t]o determine the reasons for the destruction [of the warhead containers] required time, and on … Korolev's suggestion, a decision was taken on launching [PS-1] in the course of flight-design testing of the R-7 missile and gather statistic[al data] on the flight of this rocket on the powered portion of its trajectory."[7]

In other words, it would take weeks, perhaps months, to determine the precise cause for the destruction of the warhead containers. Engineers might have to produce an entirely new container (which is what they did.) In the meantime, might not Korolev and his engineers continue fly R-7 missiles to gain more data on its other systems? Launching a satellite would be an ideal test in that sense, for the warhead would be replaced by the satellite, but everything else would largely be the same. For this reason, military representatives allowed Korolev to indulge his space dreams and handed over a perfectly "good" ICBM to launch a space satellite.

A rare photo of Korolev taken less than a month before the launch of Sputnik during celebrations for the 100th birthday of Konstantin Tsiolkovskii, the founding theorist of Soviet and Russian space exploration. Here we see (from the left) Mikhail Riazanskii, Mikhail Tikhonravov, Sergei Korolev, his wife Nina Koroleva, and Konstantin Trunov, during a light moment after the function in Kaluga on September 15, 1957. Soon after this, Riazanskii and Korolev flew back to the launch range in Kazakhstan to direct the Sputnik launch. This was Korolev's last public appearance. After Sputnik, he disappeared from view completely in the secret world of the Soviet military-industrial complex. (credit: Asif Siddiqi)

Getting ready for launch

On September 20, Korolev attended a meeting of the State Commission for the launch of PS-1. Based on the current rate of preparations of the launch vehicle and the satellite, the attendees set the provisional date for the launch of the satellite as October 7. They decided that the Soviet press would be officially informed about the launch of PS-1 only after it had completed its first complete orbit. The members also agreed to have ready within three days a draft of the announcement that would be sent to TASS.[8] Meanwhile in Moscow, on September 26, at a Politburo meeting, the final document approving the Sputnik launch was circulated. It was one among many topics discussed at the meeting, and there is no indication that anyone present gave it more than a passing thought as they signed off on it. For most of the attendees, it was just another ICBM launch.[9]

Stubborn to the core, Korolev refused to take a chance. Now panicked about being preempted by Americans at the last minute, he insisted that the PS-1 launch be brought forward by two days, from early morning October 7 to late night October 4.

On September 24, Tikhonravov finally readied the internal design bureau document detailing all aspects of the launch and mission of PS-1. It was modestly titled "Technical Account on the Possibility of Launching PS-1." Korolev signed the cover and scribbled in bold "Keep Forever!"[10] A more general document for the core State Commission members was also drawn up for everybody to sign. In the typical bureaucratic and dry language of the Soviet era, reading the title, one would never know that the five men who signed it basically signed one of the most historic documents of the space age. The title was: "The Program for Carrying Out a Test Launch of a Simple Unoriented ISZ (the Object PS) Using the Article 8K71PS."[11]

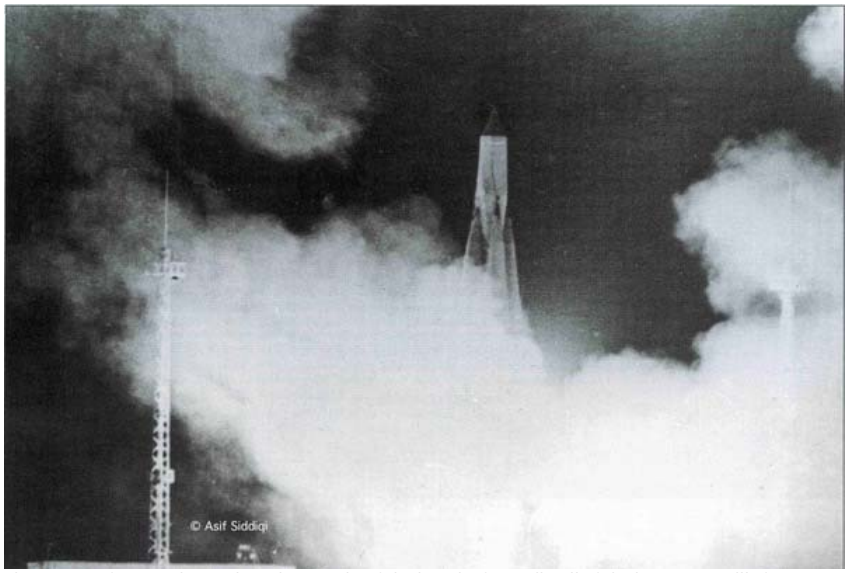
On September 26, Korolev flew to Tiura-Tam via Tashkent to supervise the launch. Once there, he stayed in a small cottage close to the main area of activity at the range, Site 2. Activity at the Assembly-Testing Building nearby was quickly accelerating as a mere 11 days remained until the planned launch. All operations with PS-1 were carried out in a hall room on the second floor adjacent to the main (and massive) assembly hall for R-7. This room later became the testing station for future spacecraft payloads, including the Vostoks that carried cosmonauts into orbit.

Sputnik's deputy lead designer Ivanovskii remembers a few glitches in the preparations. Before stacking the PS-1 with the R-7 booster, the designers carried out a final test of all of the satellite's systems. Viacheslav Lappo, the young designer of the radio transmitter repeatedly—and some would say obsessively—checked and rechecked his handiwork, making sure that the transmissions correctly communicated information about internal temperature and pressure. The last separate item to be checked was the heavy battery installed in the metal ball. The flight model was brought in and hooked up to a voltmeter. There was dead silence when it showed zero volts. There was suspicion that electrolyte was leaking from the battery but no one could figure out the precise source of the problem. Everyone present knew that the stakes were high, especially since both Korolev and State Commission Chairman Riabikov were already at Tiura-Tam.

Quickly, the testers formed a group to debug the problem. They put the battery on a work station, and "with the gravitas of doctors doing a heart operation," technicians began dismantling the battery under the supervision of Vladimir Bogotskii, the man responsible for the system, who currently looked like his world had caved in.

Finally, a technician found that some wires had come off due to bad soldering. A plug socket had come undone. Rimmochka Kolomenskaia, a young mechanic, quickly repaired the problem on the spot. By this time, Riabikov had apparently showed up wanting accountability. He railed at Bogotskii who desperately tried to defend himself by explaining that the problem would not occur again, that they had applied a new coating of epoxy. Korolev, standing next to Riabikov, kept silent the whole time.[12]

After the debacle with the battery, all the systems were retested, the satellite components were reintegrated into a whole, and, using pullies and cranes, the payload was attached to the top of the horizontally stacked launch vehicle. The "long moustaches"—as the engineers called Sputnik's four aerials—were fixed adjacent to the payload fairing atop the rocket. Once the satellite was stacked completely, Korolev insisted on a final test of the radio transmitter. All the members of the State Commission were there to witness this. Lappo gingerly turned on the switch to the transmitter, and the "beep-beep-beep" of Sputnik eerily echoed throughout the big hallroom of the assembly building. Once the transmitter was switched off, Ivanovskii climbed up a stepladder to the satellite and removed a protective plate from the contact point that would supply power to the transmitter. According to the flight program, at the moment of separation from the launch vehicle, the commutator (basically an electrical switch) would switch on the power in the satellite.[13]



There are, unfortunately, no clear photographs of the launch of Sputnik. All of the images are stills from a movie camera which captured the moment of launch. Because of the time of the launch, close to midnight local time, the quality of the film was, unfortunately, rather poor. (credit: Asif Siddiqi)

The launch

On September 30, a six-day conference opened at the National Academy of Sciences in Washington, DC focusing on rocket and satellite research during IGY. Representatives from six countries, including the Soviet Union, attended. Korolev kept tabs on the proceedings via cables from the Soviet Embassy in Washington. Seeing that the title of one of the papers was "A Satellite Over the Planet [sic]," he concluded that this meant only one thing: that the Americans were timing a secret launch during the conference and that the paper would essentially be an announcement of the event. The fact that the paper was by John P. Hagen, the Vanguard satellite program's manager, seemed to confirm his worst fears. Hagen was apparently familiar to Korolev. Golovanov notes that Korolev "read [Hagen's papers] attentively."[14] Korolev contacted KGB representatives to verify if the Americans were planning a launch but the security agency reported back that there was no evidence to suggest a launch was in the offing.

Stubborn to the core, Korolev refused to take a chance. Now panicked about being preempted by Americans at the last minute, he insisted that the PS-1 launch be brought forward by two days, from early morning October 7 to late night October 4. As a result, at 4 pm on the afternoon of October 2, he signed an order for the *new* launch date and sent it to Moscow for final approval. Launch would be in two days. True to Korolev's headstrong character, he didn't bother to wait for official confirmation to begin the ball rolling on the launch. In the pre-dawn twilight of October 3, a diesel train carrying the rocket and its delicate payload emerged out of the assembly building and slowly headed for the launch pad at Site 1. Witnesses remember Korolev saying "Well, have a good trip…let's accompany our first-born."[15] Scores of people lined the railway track all the way to the pad; with Korolev at the front, others slowly escorted the vehicle all the way to its launch site.

It was warm at the time, unusual for October at Tiura-Tam. On the morning of the launch, a Friday, testers at the pad were concerned that the high temperatures might overheat the tiny satellite,

Korolev told his engineers, "Nobody will hurry us. If you have even the tiniest doubt, we will stop the testing and

rendering its systems useless. A quick test seemed to indicate that temperatures were in fact rising underneath the payload fairing. A young military officer, Vladimir Kobelev, assigned to work with the designers at the firing range, took the initiative to go up the service platform and cover the payload fairing with a large white fabric while other tests were going on. This proved ineffective. Eventually, Kobelev set up a hose that released cold air into the fairing, which evidently reduced temperatures down to tolerable levels.[16]

make the corrections on the satellite. There is still time…"

Fueling of the rocket had already begun at 0545 hours local time. Korolev, although under pressure, remained cautious throughout the proceedings. He told his engineers, "Nobody will hurry us. If you have even the tiniest doubt, we will stop the testing and make the corrections on the satellite. There is still time…"[17] Evgeniy Shabarov (1922–2003), one of Korolev's deputies in charge of flight-testing, remembered that the launch preparations for the satellite were conducted at "a slower pace" than was usual.[18] Most personnel at the launch range, understandably enough, did not have time to ponder over the historical value or importance of the upcoming event. Ivanovskii wrote, "…Nobody back then was thinking about the magnitude of what was going on: everyone did his own job, living through its disappointments and joys."[19]

Although many people from Korolev's design bureau were on hand at Tiura-Tam, most of the personnel involved in carrying out the launch were young men from various rocket and artillery divisions of the Soviet armed forces. On behalf of Korolev, the launch preparations were directed by his deputy, Leonid Voskresenskii (1913–65), a legend already in his own time, known for his fearlessness and colorful personality. For most of Korolev's time as Chief Designer, he relied on the trustworthy Voskresenskii to fix any situation at the pad, who sometimes disregarded pretty much every rule in the book. Commanding the launch with Voskresenskii was Lieutenant Colonel Aleksandr Nosov (1913–60), the same age as his colleague, whose official title was deputy commander of the launch range, which in effect meant that he was personally responsible for all missiles that took off from any pad. A World War II veteran, Nosov had gained considerable experience with firing rockets during long tours of duty at Kapustin Iar near the Volga river where the Soviets had tested their first German V-2s back in the late 1940s.

For the satellite launch, a young artillery captain, Vladimir Nikulin, was put in charge of maintaining the paperwork—filling out the mission goals and flight logs. Unsure of what to fill in for "goal of the launch," Nikulin turned to Korolev's first deputy Vasilii Mishin who told him to dispense with such entries as "target," and instead write out the launch azimuth (the angle between "true north" and the direction of the launch) as 34° 37' 59.2".[20] The launch azimuth was calculated based on the desired orbital inclination of 65.1°, which would ensure that the satellite would pass over almost all inhabited areas of the globe, including, most importantly, both the eastern portion of the Soviet Union and the United States.

Nikulin's job was to get the key military testers responsible for each system of the launch vehicle and the satellite to sign off that "their" system was ready for launch. This was a long tradition with military rocket launches in the Soviet Union, made doubly important with the test flights of the R-7 earlier in the year. Unlike all earlier missiles, the R-7 was an expensive and massive piece of machinery. To lose one of these due to a junior army officer's negligence was unacceptable. There was one novelty and tradition introduced with the launch of Sputnik—there was now an individual responsible for signing off on a spaceship. One by one, Nikulin got his signatures: Senior Lieutenant Iurii Chalykh in charge of programming the rocket's launch azimuth, Lieutenant Colonel Aleksei Dolinin on the readiness of all the engines of the rocket, and Captain Semen Grafskii and Lieutenant Vladimir Ganushkin for the propellants. All the chief designers involved in the operation—in particular, the "big six" from the famed Council of Chief Designers of the 1940s, signed off on the launch: Korolev, Valentin Glushko (1908–89), Nikolai Piliugin (1908–82), Mikhail Riazanskiy (1909–87), Vladimir Barmin (1909–93), and Viktor Kuznetsov (1913–91). Another chief designer, Aleksei Bogomolov (1913-2009) —responsible for the R-7's telemetry systems—was listed as a "technical supervisor" rather than a chief designer since historically he had not been part of the original "big six" but was a new entrant to the big leagues. As for Korolev, Nikulin remembers finding him loitering very close to the rocket; he signed off on the launch log pensively, in silence.[21]

On the night of the 4th, huge floodlights illuminated the launch pad as servicemen crowded around the rocket completing their various tasks. Korolev was clearly anxious. About an hour before launch, Korolev abruptly ordered the satellite's lead designer Khomiakov and a military tester from the launch team to go up to the very top platform and check everything out. This was highly unusual and probably quite dangerous, but Khomiakov obliged without resistance.[22] Khomiakov had been preceded up to the top earlier in the day by Konstantin Gringauz, the designer of the satellite's radio transmitter system. He later recalled, "I had to do the final check to make sure that the transmitter was going to work . . . there was a special cover [hatch] in the nosecone, so I reached inside, checked the 'beep… beep… beep' signal, and I knew everything was all right… Then the cone was sealed for the last time."[23] By his own admission, Gringauz was the last person to "touch" Sputnik.

Ivanovskii, in his memoirs and in various interviews, has described an anonymous serviceman, stepping out into the launch area after dusk, and blowing a bugle, as if to mark the solemnity of the event. "The name of this solder remains unknown to history," according to Ivanovskii.[24] Yet, no other witnesses who were during the launch preparations have spoken of this lone bugler, and, as good a story as it sounds, it may be closer to myth than memory in the history of Sputnik.

At T-15 minutes, the whole area around the pad was evacuated. Five minutes later, Korolev, Voskresenskii, Nosov, and a few others joined the rest of the command crew in the bunker. Voskresenskii and Nosov, in charge of the launch, took their places at periscopic sights. A loud speaker echoed the announcements in the now-deserted and dark area around the launch pad: "T-10 minutes!" Voskresenskii's deputy Shabarov, also in the bunker, had a vivid memory:

> With the exception of the operators, everybody was standing. Only N. A. Piliugin and S. P. Korolev were allowed to sit down. The launch director [Nosov] began issuing commands. I kept an eye on ... Korolev. He seemed nervous although he tried to conceal it. He was carefully examining the readings of the various instruments without missing any nuance of our body language and tone of voice. If anybody raised their voice or showed signs of nervousness, Korolev was instantly on the alert to see what was going on.[25]

At T-5 minutes, the "Auxiliary System" indicator suddenly turned on, indicating that a system was delayed in their preparedness. A sensor was showing an instability in the level of liquid oxygen, apparently due to natural evaporation. Operators quickly concluded that this was not a serious problem and blocked the sensor signal manually by turning a key on a panel. The launch program continued.[26]

Boris Chekunov, the 24-year old lieutenant in charge of pushing the ignition button for the central core booster, later described the final moments as the clock ticked down to liftoff: "When only a few minutes remained until liftoff, Korolev nodded to his deputy Voskresenskii. The operators froze, awaiting the final order. Aleksandr Nosov, the chief of the launch control team, stood at the periscope. He could see the whole pad. 'One minute to go!,' he called."[27] As the seconds counted down to zero, an operator announced "Key to launch!" (*Kliuch na start!*). Chekunov turned a key on his panel clockwise from left to right. He would do this nearly 600 more times in a career spread over thirty years, but this was the very first time for a launch into space.[28]

First slowly, but then quickly—almost too quickly—the nearly 273 ton mass of metal, oxygen, and kerosene, gathered speed and shot up into the warm night sky.

For Soviet launches, there was no countdown, only an occasional voice announcing "X minutes readiness" punctuated by the announcement of sudden commands. The next command—"Key to drainage!" (*Kliuch na drenazh!*)—meant that the drainage valves were closed after disconnecting from the rocket's propellant tanks. Operators then waited the few seconds until the second hand of the clock approached the precise time for engine ignition indicated on their launch cards. As the word "Launch!" (*Pusk!*) rang out, Chekunov decisively pressed the launch button on his panel (known as V-347) to begin the engine firing cyclogram. There was a little over a minute now left to the actual departure of the rocket from the pad, perhaps the most anxiety-inducing seconds of the whole launch. Voskresenskii and Nosov's eyes were glued to their periscopes as they watched the launch vehicle vent steam around it. A panel indicator lit up: "Preliminary" (*Predvaritel'naia*), meaning that the engines had ignited and were revving up to their preliminary thrust regime. All in the bunker began to sense the growing rumbling vibrations. An operator yelled: "Main!" (*Est' glavnaia!*) and almost immediately "Contact of Liftoff! (*Est' kontakt pod'ema!*), Liftoff!"[29]

It was exactly 2228 hours 34 seconds Moscow Time, about an hour and a half after midnight local time. One participant remembered, "At the moment [of liftoff] it seemed to onlookers that the rocket would burn where it was, on the launch pad, without taking off."[30] This was a feature of early R-7 launches where it would seem that the rocket itself appeared engulfed in flames. Subsequent modifications to the pad diverted the flames away from the rocket. In Sputnik's case, the flames from the base of the rocket cut through the darkness of the Kazakhstan desert steppes as the arms of the launch complex pulled back, allowing the graceful rocket to lift off from its pad. First slowly, but then quickly—almost too quickly—the nearly 273 ton mass of metal, oxygen, and kerosene, gathered speed and shot up into the warm night sky. The five engines, the children of Valentin Glushko's genius, generated a total of nearly 400 tons of thrust.[31]

There were problems on the outbound flight, in both the engines and in the inertial guidance system. At liftoff, telemetry noted that the engine in one of the strapon boosters (Block G) reached its "intermediate" stage late, i.e., it took longer than usual to reach the desired level of thrust. Because of this, there was a brief threat of the rocket flying off-kilter at a dangerous angle since there was unequal thrust spread across the bottom, but fortunately, at the very last moment, the engine completed its thrust buildup, and the rocket "returned" to its correct attitude within 18 to 20 seconds.[32] A more serious problem occurred soon after, at T+16 seconds, when the Tank Depletion System, which regulated how much propellant was being used for each engine, failed. The malfunction led to a higher consumption of kerosene than planned, and as a result, the booster did not have

enough propellant to reach the original burnout point at T+296.4 seconds. The main core engine, in fact, shut down one second earlier than planned, i.e., at T+295.4 seconds.[33]

These details were not known at the time of the launch. In the bunker, only the major events were reported back. At T+116.38 seconds, the four strapon boosters separated as planned, as the rocket made its way across the Soviet landmass, gaining altitude and velocity. At main core engine burnout—which was reported back in the bunker with an exclamation of "Main Command!"—the core and its satellite payload were traveling at 7,780 meters per second at a height of 228.6 kilometers above the Earth. As planned, 19.9 seconds later, at T+314.5 seconds, the PS-1 satellite successfully separated from the core booster. The separation was effected by mechanical "pressure" at a speed of 2.73 meters per second. Simultaneously, the nose fairing over the satellite was discarded (using a spring system) at a relative speed of 0.643 meters per second. At the moment of separation, PS-1's commutator switched on the satellite's power supply system and pressurization system. Less than 11 seconds later, the angular reflectors on the core deployed.[34]

From the data streaming into the bunker—principally a signal from the booster core's Tral telemetry system that indicated engine shutdown, which was received by the IP-1 tracking station at Tiura-Tam—it seemed that Earth orbit had been achieved. Shabarov recalled that "everyone breathed a sigh of relief, and there was [finally] a minute of silence. And suddenly, everyone began talking to each other, and people began to go up. The launch chief and I were even allowed to smoke inside the bunker."[35]

While Korolev was in the bunker, another group of people had begun crowding around a van stationed near a house at Site 2, the main living area of the launch range. Inside, Viacheslav Lappo and Konstantin Gringauz, the men who had built the radio transmitters, were sitting with headphones to their ears, waiting for a sign from the heavens.[36] People were constantly trying to shove their way into the van, to the irritation of the two, who had to repeatedly tell people to be quiet. Suddenly, there was a weak "beep-beep-beep" that slowly grew in volume, becoming louder and louder each second. There was a round of "hurrahs" outside the van. Riazanskii, who was Lappo and Gringauz' boss, immediately got on the phone and called Korolev, who was still back at the bunker: "There it is! There's a signal!"[37] This apparently was a tape recording, transmitted from one of the Kamchatka tracking stations back to the launch site.[38] Korolev was not impressed. He dryly commented, "This could be a mistake. Until we hear the signals after the satellite comes back after its first orbit . . . it's too early to celebrate."[39]

In general, people urged caution. There was, after all, a chance that the satellite was heading on a ballistic trajectory into the Pacific Ocean, helplessly transmitting its beep-beep-beeps for all to hear. There was only one thing to do now: wait an hour or so for the satellite to come around again. Korolev, Riabikov, Keldysh, Glushko, Barmin, Voskresenskii, Nosov—all of them made their way out of the bunker and headed to van of the radio operators. It took a little over an hour for the satellite to return back around the Earth. Once again, Lappo picked up the signals, the insistent "beep-beep-beep." He screamed: "It's there! It's there! Turn on the tape recorders!"[40] Ballistics experts brought in their data: according to their calculations, the satellite was in an orbit with an apogee of 939 kilometers and a perigee of 215 kilometers.[41] These figures would be adjusted later, but at the time, the numbers must have seemed like a revelation—even if the apogee was lower than hoped. According to the memoirs of Korolev's deputy Boris Chertok (1912–2011), the apogee was about 80 to 90 kilometers too low, which squares somewhat with the numbers listed in the final planning document Korolev sent to the government a few days before launch (225 by 1,000 kilometers).[42]

These were minor considerations, since the first object made by humans was in a freefall trajectory—an orbit—around the Earth. The space age had arrived. According to calculations revised over the night—sharpened by scientists back at the Computation Center at the NII-4 institute near Moscow—PS-1 was in an orbit of 947 by 228 kilometers. The orbital period, i.e., the time it took to make one complete circuit around the Earth, was a little over an hour and a half; more precisely, 96 minutes 10.2 seconds. The satellite was circling at an angle of 65.1B° to equator, giving it surface coverage over an enormous portion of the Earth's inhabited surface.[43]

For the engineers, scientists, soldiers, and bureaucrats responsible for the achievement—in Moscow, in Bolshevo, at Kaliningrad, at Tiura-Tam, and at tracking stations all over the country—the feeling was one of elation and exhaustion.

Earlier, the State Commission had planned to inform Khrushchev after the first orbit, but exercising more than usual caution, Commission Chairman Riabikov waited until the *second* orbit before calling the Soviet leader.[44] According to conventional wisdom, Khrushchev's reaction to the launch was unusually subdued for an event of such magnitude, indicating that he, like many others, did not immediately grasp the true propaganda effect of such a historic moment. He told the press at the time that "[w]hen the satellite was launched, they phoned me that the rocket had taken the right course and that the satellite was already revolving around the earth. I congratulated the entire group of engineers and technicians on this outstanding achievement and calmly went to bed."[45]

Khrushchev's son, Sergei, however, recalls his father's reaction was a little more enthused. The older Khrushchev at the time was on visit to Kiev to discuss economic issues with the Ukrainian Party leadership. Around 11 pm—it was already past 2 am at Tiura-Tam—these negotiations were interrupted by a telephone call. Khrushchev left the meeting room to take the call, then returned without saying anything—at least at first. His son described the scene:

> He finally couldn't resist saying [to the Ukrainian officials]: "I can tell you some very pleasant and important news. Korolev [sic] just called (at this point he acquired a secretive look). He's one of our missile designers. Remember not to mention his name—it's classified. Korolev has just reported that today, a little while ago, an artificial satellite of the Earth was launched."[46]

The Ukrainian Party leaders were not a bit bewildered as Khrushchev continued to ramble on about the satellite. They after all, had important economic issues, to discuss. Yet, the Soviet leader was animated the rest of the evening, speaking in glowing terms about the new era of missiles which could "demonstrate the advantages of socialism in actual practice" to the Americans.

For the engineers, scientists, soldiers, and bureaucrats responsible for the achievement—in Moscow, in Bolshevo, at Kaliningrad, at Tiura-Tam, and at tracking stations all over the country—the feeling was one of elation and exhaustion. As night turned to day—the first daylight of the space age—people arranged an impromptu meeting where Korolev climbed onto an improvised rostrum and gave a speech that was unusually flowery, even for him:

> Dear comrades! Today, that which the best human minds have dreamed of has taken place! The prophetic words of Konstantin Eduardovich Tsiolkovskii that mankind would not always remain on the Earth have come to pass. Today the first artificial satellite in the world has been injected into orbit around the Earth. With its injection into orbit, the conquest of space has begun. And the first country to open the road to outer space has been our country—the land of the Soviets! Allow me to congratulate all of you on this historic occasion. And allow me to especially thank all the junior specialists, technicians, engineers, and designers who took part in the preparation of the [rocket] and the satellite, for their titanic labor... Once more I give to you a hearty Russian thanks![47]

Soon, Voskresenskii's deputy Shabarov ordered the chief of the mission at Tiura-Tam to express thanks in a different way, by handing out alcohol. So that people would not come back for more, he stipulated that each man would get a whole teapot of spirits. Meanwhile, radio transmitter designer Lappo extended one of his speakers right out into the street and set it at full volume; all over Site 2, one could hear the enigmatic "beep-beep-beep"—a tape that ran over and over again. Later in the day, there was a celebration in a small movie theater in at Site 10, the main living area at the launch range; Riabikov made a speech congratulating all, followed by Korolev and Keldysh.

After nightfall, Korolev and a small group of his co-workers took off in an Il'iushin Il-14 aircraft from Tiura-Tam to head for Moscow. Despite the two massive piston engines that roared through the flight, most were exhausted and slept through the trip—some, after all, were sleeping the alcohol off. Soon after takeoff, the pilot of the airplane, Tolia Esenin, came out of the cockpit and bent over Korolev's seat to tell him that "the whole world was abuzz" with the launch—"in all languages you can hear, 'Russia' and 'satellite'." Korolev quickly got up and went into the pilot's cabin. Returning back to the passenger's area, he announced gleefully to everybody, "Well comrades, you can't imagine—the whole world is talking about our satellite," adding with a huge smile, "It seems that we have caused quite a stir..."[48]

At about 1:30 am Moscow Time on the early morning of October 5—just after 7:30 pm in Washington DC, the night before—the official Soviet news agency TASS released the communiqué on the launch that the State Commission had authored in late September. Published in the morning edition of *Pravda*, it was exceptionally low-key and was not even the headline of the day—the main headline "above the fold" on October 5 was "Preparation for Winter is an Urgent Task." Even the text of the satellite launch was understated. When the authors wrote the original text, they clearly did not play up the event:

> For several years scientific research and experimental design work have been conducted in the Soviet Union on the creation of artificial satellites. As has already been reported in the press, the first launching of the satellites in the USSR were planned for realization in accordance with the scientific research program of the International Geophysical Year. As a result of very intensive work by scientific research institutes and design bureaus the first artificial satellite in the world has been created. On October 4, 1957, this first satellite was successfully launched in the USSR. According to preliminary data, the carrier rocket has imparted to the satellite the required orbital velocity of about 8,000 meters per second. At the present time the satellite is describing elliptical trajectories around the Earth, and its flight can be observed in the rays of the rising and setting Sun with the aid of very simple optical instruments (binoculars, telescopes, etc.).[49]

In the announcement, there was no detail on the actual orbit of the satellite, just a general comment that it was traveling at "altitudes of up to 900 kilometers above the Earth's surface."

As the media tumult over Sputnik began to mount in the West, the Soviet

The communiqué nor the Soviet media ascribed a specific name for the satellite (like the Americans would with Explorer I), but generically and simply called it "the artificial satellite of the Earth" (*iskusstvennyi sputnik zemli*). Since the word for "satellite" in Russian was *sputnik*, that word acquired a greater resonance than perhaps intended. In the West, *Sputnik* became a synonym for the satellite, although in Russia even to this day, the satellite is still simply called "the first Soviet artificial satellite of the Earth" (*Pervyi sovetskii iskusstvennyi sputnik zemli* or *Pervyi sovetskii ISZ*).

leadership began to capitalize on the utter pandemonium surrounding the event in the United States.

As the media tumult over Sputnik began to mount in the West, the Soviet leadership began to capitalize on the utter pandemonium surrounding the event in the United States. After everybody's return to Moscow, on October 6, one of Keldysh's assistants at the Academy of Sciences, Gennadii Skuridin (1926–1991), met with a small group to hammer out a more dramatic and informative announcement. They included the young scientists led by Dmitrii Okhotsimskii (1921–2005) from the Department of Applied Mathematics who had developed the basic equations for orbital flight earlier in the decade and a number of Korolev's representatives. Their draft was passed around to Korolev, Glushko, Keldysh, and others before being sent to *Pravda*, where Skuridin and *Pravda*'s science editor, A. G. Azizian, smoothed out any sensitive information. The article was typeset and then published as a major page one story in *Pravda* on the morning of October 9. Given the constraints that its authors were working with, the article was actually rather informative, especially about the satellite itself, and included a photograph of the satellite as well drawings of its ground track.[50] The parties responsible for this great deed were, of course, not named.

page 2: Sputnik in orbit >>

A disassembled model of the PS-1 satellite at the Memorial Museum of Cosmonautics in Moscow. (credit: Asif Siddiqi)

Sputnik remembered: The first race to space (part 2)

<< page 1: the launch

Sputnik in orbit

Hundreds of thousands of people all over the world visually saw Sputnik (or more likely, the core stage of the R-7, which was more reflective) in orbit. Many heard the famous "beep-beep-beeps." The duo of orbital payloads was tracked relatively easily through mid-November. After November 15, according to Tikhonravov, it became much harder to identify the payloads, apparently due to "destruction of [material on the] angular reflector" on the core. For a while ionized trails from the core (from venting residual propellants) was visible in the night sky. Newspapers all over the world published the ground track of the satellites so that people could plan optical observations.

The Sputnik satellite meanwhile circled the Earth for 1,440 orbits before reentering the Earth's atmosphere on January 4, 1958. Thus ended the life of the world's first artificial satellite.

Although the Sputnik launch had no scientific goals per se, it did contribute to certain fields. Soviet scientists used observational data to try and determine the coefficient of absorption of radio waves in the ionosphere and to develop a model of the ionosphere's effect on the diffusion of radio waves. There were also attempts to develop methods to determine electron concentrations above the maximum layer F2 (The F layer has the highest concentration of electrons and ions in the atmosphere). The satellite's radio transmitters provided useful information during the three weeks that

they successfully sent out their “beep-beep-beeps.” According to the “data” that they transmitted, it was determined that while the radio transmitters were working, the temperature and pressure inside the satellite remained within design limits. Engineers could confidently say that there had been no damage due to micro-meteoroids. According to Tikhonravov, Sputnik’s radio beeps were tracked at distances of six to eight thousand kilometers and at some points as far as 16,000 to 17,000 kilometers from the source.

The satellite was not the only object transmitting information: there was a working telemetry system known as *Tral* on board the orbiting core booster. *Tral* was originally designed for monitoring various systems of the rocket during ballistic flight, but was included on this launch, partly to verify whether it could be used on future orbital missions. (It was later used on *Sputnik 2*). Concern that *Tral*’s operation would interfere with the radio transmitters on *Sputnik* proved unfounded.

Observations from the dozens of DOSAAF amateur radio clubs were useful. Their monitoring equipment had two antennas: when the satellite entered or exited the zone of radio visibility, the signal received on one of the antennas was more powerful than the other. When the satellite was equidistant from the two antennas, then the signals were of equal strength. By knowing the exact time of the signal reception, amateurs were able to very roughly map the location of the satellite. Besides radio reception, optical observations were carried out not only by DOSAAF clubs all but also by other amateurs, university students, and laypeople. Because the core was the brighter of the two objects—it was at magnitude 2 while the satellite was at magnitude 5 to 6—it was more likely to be visible by the naked eye. Soviet AT-1 telescopes were made available at select urban settings for regular people to observe the satellites.[51]

The Sputnik core booster, given its larger dimensions, had a faster rate of orbital decay. On December 2, the booster was tracked slowly falling over a trajectory that took it over Irkutsk (in western Siberia north of Mongolia), the Chukotka peninsula, and Alaska, before coming down off the western coast of the North America. According to Soviet information, the core circled the Earth 882 times before its untimely demise.[52] The Sputnik satellite meanwhile circled the Earth for 1,440 orbits before reentering the Earth’s atmosphere on January 4, 1958. Thus ended the life of the world’s first artificial satellite.

A model of Sputnik at the Memorial Museum of Cosmonautics in Moscow. (credit: Asif Siddiqi)

Epilogue

PS-1's lead designer Mikhail Khomiakov underscored that "frankly speaking, many of us did not understand the full significance of this event."[53] Not one of the Soviet engineers or scientists or politicians truly anticipated the global response. They had expected something, but not on the scale that they saw. Before Korolev left Tiura-Tam, he had asked Khomiakov to stay back to pack up and bring back the entire set of the spare PS-1 model, "an exact copy of the one which was now in orbit around the Earth." When Khomiakov returned to the design bureau near Moscow, he checked in with Korolev, saying that he was back from his "business trip." This was the usual way engineers spoke about going to the launch range—an assignment to Tiura-Tam was a "business trip," a strange euphemism that was accepted as part of the culture of intense secrecy around the missile industry. Korolev responded with "what business trip?" confusing Khomiakov. The Chief Designer raised his voice: "What's this you say, a business trip, a business trip... Tell your comrades that you have participated in the preparation and launch of the world's first artificial satellite of the Earth!"[54]

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There was, of course, the political and economic dimensions to be considered, which journalists wrote widely about in the days after the launch. Sputnik punctuated the Cold War in a way that was not unlike another earlier strike to American self-confidence—some called it a "technological Pearl Harbor." Historians have written many volumes about the effect Sputnik had upon the American psyche, how it led to the formation of NASA, how it increased funding for scientific research and education, and even how it led to the creation of the organization (ARPA) that would

later create the seed of the Internet. But there was also a philosophical import to Sputnik. It was the first time in the history of the human race that our handiwork had managed to breach the heavens around us and stay there. The late Soviet journalist Iaroslav Golovanov eloquently summed up this notion in his biography of Korolev: "For the first time on Earth something that had been thrown upwards had not come down again."[55]

Endnotes

1. Korolev, "Predlozheniia o pervykh zapuskakh."
2. "Postanovlenie Prezidiuma TsK KPSS o zapuske ISZ s pomoshch'iu rakety R-7 v nachale Mezhdunarodnogo geofizicheskogo goda" (February 15, 1957) in *Pervyi pilotiruemyi polet*, 87-88.
3. Poroshkov, "Khronika vazhneishikh sobytii," 108-109.
4. Maksimov, "Iz istorii sozdaniya komandno-izmeritel'nogo kompleksa."
5. K. V. Gerchik, "Triumf otechestvennoi nauki" in *Proryv v kosmos: ocherk ob ispytatelyakh spetsialistakh i stroiteliakh kosmodroma Baikonur*, ed., K. V. Gerchik (Moscow: SVKB, 1994), 29-30.
6. Poroshkov, "Khronika vazhneishikh sobytiy," 109.
7. V. P. Mishin, "Nekotorye stanitsy istorii raketno-kosmicheskoy nauki i tekhniki v poslevoennyi period" in *Issledovaniia po istorii i teorii razvitiia aviatsionnoi i raketno-kosmicheskoi nauki i tekhniki, vyp. 8-10*, ed., B. V. Raushenbakh (Moscow: Nauka, 2001), 50-66.
8. Memoirs of Tikhonravov in *Akademik S. P. Korolev*, 447.
9. The signed document was a Presidium (or Politburo, as it was called at the time) decree no. P114/XXXIII entitled "On the Launch of an Artificial Satellite of the Earth" issued on September 26, 1957. A similarly titled decree of the Council of Ministers (no. 1181-535) was also issued on the same day.
10. Golovanov, *Korolev*, 534.
11. Semenov, *Raketno-Kosmicheskaia Korporatsiia*, 90. "ISZ" is the Russian abbreviation for "Artificial Satellite of the Earth." The men who signed it were V. M. Riabikov, M. I. Nedelin, D. F. Ustinov, V. D. Kalmykov, and A. N. Nesmeianov.
12. Ivanovskii, *Rakety v kosmos v sssr*, 31-32.
13. Ivanovskii, *Rakety v kosmos v sssr*, 31-32.
14. Golovanov, *Korolev*, 537-538. The specific paper that caused so much alarm to Korolev was probably Hagen's "The Satellite Launching Vehicle; Placing the Satellite in Orbit," which he presented on September 30. See M. Nicolet, ed., *Annals of the International Geophysical Year, Vol. IIB: The International Geophysical Year Meetings* (Pergamon Press: London, 1959), 640-665.
15. Golovanov, *Korolev*, 538; Memoirs of Tikhonravov in *Akademik S. P. Korolev*, 447-448.
16. Ivanovskii, *rakety i kosmos v sssr*, 33.
17. Golovanov, Korolev, 538; Memoirs of Shabarov in *Nachalo kosmicheskoi ery: vospominaniia veteranov raketno-kosmicheskoi tekhniki i kosmonavtiki: vypusk vtoroi*, ed., Iu. A. Mozzhorin (Moscow: RNITsKD, 1994), 63
18. Memoirs of E. V. Shabarov in *Nachalo kosmicheskoi ery*, 63.
19. Aleksei Ivanov [Oleg Ivanovskii], *Vpervye: zapiski vedushchego konstruktora* (Moscow: Moskovskii rabochii, 1982), 35.
20. Semenov, "Kak zapuskali pervyi sputnik."
21. Semenov, "Kak zapuskali pervyi sputnik."
22. Memoirs of Kavyzin [Khomiakov] in *Akademik S. P. Korolev*, 451.
23. M. I. Verigin and G. A. Kotova, "The Contribution of K. I. Gringauz to Space Research," *Acta Astronautica* 43, nos. 1-2 (1998): 23-25; Tamara K. Breus, "An Unforgettable Personality," *Journal of Geophysical Research* 102, no. A2 (February 1, 1997): 2027-2034.
24. Ivanovskii, *Rakety i kosmos v sssr*, 34.
25. Memoirs of Shabarov in *Nachalo kosmicheskoi ery*, 63.
26. The oxygen level problem at T-5 minutes is from the Memoirs of V. Ia. Khil'chenko in *Nachalo kosmicheskoi ery*, 230. The official post-flight launch report on Sputnik, however, notes that the one major glitch during launch preparations was related to a faulty sensor measuring propellant loading in the Block B strapon, which was apparently drained of kerosene and then refueled again. See "Osnovnye rezul'taty puska rakety-nositelia...," 239-242.
27. Ivan Borisenko and Alexander Romanov, *Where All Roads Lead to Space Begin* (Moscow: Progress Publishers, 1982), 66.
28. By July 1995, Chekunov had "launched" 583 rockets from Tiura-Tam (Baikonur). See Mikhail Rebrov, "Kliuch—na start!," *Krasnaia zvezda*, July 2, 1995, 2.
29. Semenov, "Kak zapuskali pervyi sputnik."
30. Golovanov, *Korolev*, 540.
31. The precise launch mass of the rocket and PS-1 was 272,830 kilograms. See Memoirs of Tikhonravov in *Akademik S. P. Korolev*, 448.
32. "Osnovnye rezul'taty puska."

33. Poroshkov, “Khronika vazhneishikh sobytii,” 111-112; Boris Chertok, *Rockets and People, Vol. II: Creating a Rocket Industry*, ed., Asif A. Siddiqi (Washington, DC: NASA, 2006), 386-387.
34. “Pervyi iskusstvennyi sputnik zemli.”
35. Memoir of Shabarov in *Nachalo kosmicheskoi ery*, 64.
36. Sources differ on the location and personnel involved. Ivanovskii (echoed by Golovanov) refers to Lappo and Gringauz at Site 2 while Semenov refers to Junior Lieutenant V. G. Borisov who was stationed in of the Finnish houses at IP-1. For the latter, see Semenov, “Kak zapuskali pervyi sputnik.”
37. Golovanov, *Korolev*, 540.
38. Ivanovskii, *Rakety i kosmos v sssr*, 35. Semenov makes no mention of the signal being a recording.
39. Memoir of Shabarov in *Nachalo kosmicheskoi ery*, 64.
40. Ivanovskii, *Rakety i kosmos v sssr*, 35.
41. Golovanov, *Korolev*, 541.
42. Chertok, *Rockets and People, Vol. II*, 386-387. The planning document was a letter from Korolev (co-authored with Riabikov, etc.) sent to the Central Committee on September 24, 1957. See Baturin, *Sovetskaia kosmicheskaia initsiativa v gosudarstvennykh dokumentakh*, 72-74. An internal OKB-1 document suggests the plan was to achieve 223 X 1,450 kilometers.
43. These data are according to the TASS announcement of October 5. An internal OKB-1 report issued on November 1 states parameters at orbital insertion as 223 X 950 kilometers with an orbital period of 96.2 minutes, but these refer to the core stage of the booster. See “Osnovnye rezul’taty puska”; “Pervyi iskusstvennyi sputnik zemli.”
44. Golovanov, *Korolev*, 541.
45. Nicholas Daniloff, *The Kremlin and the Cosmos* (New York: Alfred A. Knopf, 1972), 65-66.
46. Sergey N. Khrushchev, *Nikita Khrushchev and the Creation of a Superpower* (University Park, PA: Penn State University Press, 2000), 260.
47. Golovanov, *Korolev*, 541.
48. Memoirs of Skuridin in *Akademik S. P. Korolev*, 457-458.
49. “Soobschenie TASS o zapuske pervogo iskusstvennogo sputnika zemli,” *Pravda*, October 5, 1957, 1. For the English news translation, see “Text of Satellite Report,” *New York Times*, October 5, 1957, 3.
50. “Sovetskii iskusstvennyi sputnik zemli,” *Pravda*, October 9, 1957; Memoirs of Skuridin in *Akademik S. P. Korolev*, 458.
51. Tikhonravov, “Provozvestnik kosmicheskoi ery.”
52. Tikhonravov suggests December 1 as the date of decay while official RKK Energiia documents suggest December 2 (and 882 orbits) as the date. See Tikhonravov, “Provozvestnik kosmicheskoi ery”; Semenov, *Raketno-Kosmicheskaia Korporatsiia “Energiia”*, 91; “Pervyi iskusstvennyi sputnik zemli.”
53. Memoirs of Kavyzin [Khomiakov] in *Akademik S. P. Korolev*, 451.
54. Memoirs of Kavyzin [Khomyakov] in *Akademik S. P. Korolev*, 451.
55. Golovanov, *Korolev*, 544.

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