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Chapter 15

Korolev's "Circus Act:" Voskhod*

James Harford†

Introduction

In early 1964, with the spectacular flights of Vostok 1 through 6 behind him, Sergei Pavlovich Korolev, the "Chief Designer," was under pressure to continue demonstrating the Soviet Union's world leadership in manned space exploration. He was hard put to do this, however, since the American Gemini program, capable of carrying two astronauts, was well underway while his next generation spacecraft, Soyuz—originally destined to carry multiple cosmonauts to the Moon—was still a long way from development. His clever initiative: strip the Vostok spacecraft, eliminate space suits and launch-escape system, and pack three cosmonauts in. The result was more firsts for the Soviets—first three-man space mission in Voskhod 1, the first extra-vehicular activity from the two-man Voskhod 2.

This paper reviews the political circumstances which led Korolev to pursue the development of Voskhod, which was later described by Vassily Mishin, Korolev's successor, as a "circus act." It also details the design history of the spacecraft and the EVA space suit used by Alexei Leonov, and discusses advanced Voskhod designs not pursued.[1]

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† American Institute of Aeronautics and Astronautics, Princeton, New Jersey, U.S.A.

Sergei Pavlovich Korolev (1906-1966), Soviet rocketry pioneer and spaceship designer. Photo from Novosti Press Agency (Smithsonian Photo No. 76-17276).

Concept

"One person alone, in a single-seated spacecraft, will never undertake interplanetary travel such as flight to the Moon, not to mention Mars. And so the next step (after Vostok) was to design a new spacecraft, the Voskhod, with room for a crew."[2]

Those were the words of four of the Soviet Union's leading spacecraft designers, looking back, in 1967, on ten years of the Space Age. In fact, however, Voskhod (which means "rise," as in "sunrise" which, of course, occurs on the Eastern horizon) was hardly a "new spacecraft." Although it had more capability than Vostok—that is it had a redundant solid propellant braking system and weighed 600 kg more—Voskhod was Vostok, rigged up to be able to sardine three cosmonauts into a spacecraft designed for one. Undertaking the jerry-built project bespeaks of the high-stakes gamble that Korolev was willing to take to outpace the Americans. The Soviets were scrambling. Korolev's bureau had been working hard on the Soyuz manned spacecraft, which would be a truly significant step forward technologically, and which, with some adaptations, would be able to carry cosmonauts to the Moon. Indeed, uprated versions of Soyuz are still carrying cosmonauts into orbit today. But Soyuz was not ready to compete with the two-man American Gemini, whose design had been well known since the end of 1961 from the open U.S. literature.

As he had with Sputnik 2, Nikita Khrushchev again butted into the system. "Khrushchev phoned Korolev and ordered the launch of three cosmonauts right away," recalled Korolev's successor, Vassily Mishin, in a 1990 interview. This would not be easy. Mishin said:

But fitting a crew of three people, and in spacesuits, in the Voskhod was impossible. So—down with the spacesuits! And the cosmonauts went up without them. It was also impossible to make three hatches for ejection. So—down with the ejection devices. Was it risky? Of course, it was. For approximately 20 seconds of flight prior to insertion into orbit, the crew did not have any means of escape in the event of an emergency.[3]

Khrushchev's Intervention

Korolev, responding to Khrushchev, took the risk, but first extracted a tradeoff, according to Gyorgi Vetrov; a Russian space historian. In a personal meeting with his leader in February 1964, says Vetrov, Korolev accepted the Voskhod task, but on the condition that the N-1 program, aimed at a manned lunar landing, would get the backing it had not been getting. Khrushchev agreed to the deal, reports Vetrov, leading to a decree by the Central Committee of the Party on August 3, 1964 authorizing the N-1. "Of course this agreement was never spelled out openly, nor was the staff of OKB-1 ever told that 'Khrushchev personally ordered us to do this or that.' That was not the practice at the time," Vetrov claims.[4] This scenario disagrees, however, with other accounts that have come to light recently. A book published in 1996 commemorating the 50th anniversary of the founding of the Korolev design bureau[5] reports that the Voskhod authorization came from a government decree dated April 13, 1964.

An excellent report summarizing the Voskhod program, by the historian Asif Siddiqi of Carnegie Mellon University, says that the date for the inauguration of what was then called the three-man Vostok program was February, 1964, apparently agreeing with Vetrov. Siddiqi, however, states that the Soviet Air Force had been "studying options on extending the capabilities of the original Vostok vehicle since March, 1963."[6]

First Engineer-Cosmonaut

In any case, Korolev barreled ahead with Voskhod early in 1964. For this project, however, he wanted to include an engineer in the three-man crew. His choice was Konstantin Feoktistov, who was given a major role in the design of the spacecraft. "There were 10 candidates who passed the medical tests," Feoktistov recalled. "The final decision was made by Korolev and he picked me."[7]

One must admire the courage of the young Feoktistov, still in his early thirties. He was being asked not only to fly the hazardous mission himself but to adapt a one-man spacecraft to accommodate three cosmonauts, and do it at minimum increase to the weight of the capsule.

"I began working closely with Korolev himself on the first concept—spherical shape, two compartments, one for the crew and one for the other systems," he told me. "By May we gave Korolev our proposals. He was highly inspired by them and he ordered us to deliver full design reports. We delivered our proposals about two months later, in August, and then we got the green light to go ahead and build the spacecraft. The U.S. was developing Gemini at the time so we knew we were in a space race. There were about 50 design engineers working on the project, and then later a lot of technicians were needed to develop the instruments, the electrical systems, etc., then hundreds of engineers to build the whole system. At the time I had very close connections to Korolev, although they were purely administrative. I would see him every week, sometimes more often."[8]

According to Mishin, it was Feoktistov, himself, who suggested the idea of eliminating the space suits and ejection systems.[9] Without space suits the crew would depend on an absolutely leak-proof capsule to maintain a breathing atmosphere. The life support system provided only a means of changing the composition of the gases—removal of the carbon dioxide breathed by the cosmonauts—but did not allow for replenishment of any lost gases.[10]

How to deal with the absence of a system for ejecting the cosmonauts at landing time? The solution was to work out a soft landing system for the capsule itself. For this Feoktistov got help from Gai Severin, who even today is Russia's leading designer of space suits, EVA maneuvering units and ejection and landing systems.

Soft Landing System

"We worked closely with Feoktistov on the design of Voskhod," said Severin.[11] What he came up with was a second parachute as well as small retro-rockets which would slow the capsule on reentry to one meter per second at touchdown.[12] It was a dicey solution.

"The skeptics," said Severin, "were worried that, since rocket engines are ignited at landing, the parachutes might catch fire. Korolev recognized that there were risks, that there might be failures during the test period, but he was courageous enough to make the decision to go ahead with the tests. We knew that we could show that the danger of fire was small, but that even if there were fire the cabin serves as a heat shield."[13]

The fact is, risky or not, the Russians pulled it off. After one unmanned test flight—Kosmos 47—only six days earlier, Voskhod, on October 12, 1964, launched Feoktistov, Vladimir Komarov and the first doctor to go into space—Boris Yegorov—into a flight of 16 orbits. This was an incredible seven months after the project was OK'd.

"The world applauded again," said Mishin. "It was as if there was, sort of, a three-seater craft and, at the same time, there wasn't. In fact, it was a circus act, for three people couldn't do any useful work in space. They were cramped just sitting! Not to mention that it was dangerous to fly. But, in the West, they drew the conclusion that the Soviet Union possessed a multi-seat craft. It would never have entered anyone's mind there that we would send a crew into orbit without the appropriate means of rescue. It was good that everything turned out all right. But what if it hadn't?"[14]

The Korolev team later rationalized the achievements of the "circus act" flight. "A broad program was carried out," they wrote, "testing the three-man capsule, observing the efficiency and teamwork of the crew, collecting technological and scientific data, and gathering a wide range of biomedical information applicable to long-duration space flight, with the direct participation of the scientist and the doctor. For the first time, investigators observed and worked in space."[15]

It was ironic that Khrushchev, who had ordered the flight, was deposed on October 14, the day after Voskhod returned to Earth.

Leonov EVA in Voskhod 2

There were only two Voskhod flights, but both had spectacular impact. Only five months after Voskhod 1 came another show-stopper, the 17-orbit flight of Alexei Leonov and Pavel Belyaev, on March 18, 1965, in Voskhod 2, in which Leonov performed the world's first walk in space—a 20-minute EVA

(extra vehicular activity). This was just five days before Gus Grissom and John Young became the first U.S. pair to go into orbit, on Gemini 3.[16]

The pace for developing the Voskhod 2 mission was just as frenetic as for Voskhod 1. "Originally," said Vetrov, "no one had planned for Voskhod 2 to be launched so soon. The first plans for EVA were much more cautious and gradual, with dogs leaving the cabin before an actual human. But American plans with EVA's on Gemini forced speedier action."[17] The tension was not lessened by the explosion of a Voskhod 2 unmanned prototype, on February 22, 1965, caused by botched signals from the ground. A worried Major General Nikolai Kamanin, director of cosmonaut training, recorded in his diary that Korolev called him to his sick bed on February 26 (doctors had diagnosed the Chief Designer as having a "focal pulmonary inflammation" causing a temperature of 39°C—102.2°F) to express his anxiety over the upcoming manned flight after the prototype's demise. He was assured that the signal botchup would have been overridden by the cosmonaut. But Korolev was also concerned that the base ring of the airlock, which would be left protruding after the airlock itself was released following Leonov's ingress from space, might cause the spacecraft to spin during reentry. He directed that an unmanned Zenit spacecraft be sent up, carrying the ring, to see how it behaved. A Zenit went up on March 7 and touched down on March 15, the airlock ring causing no excessive spinning.[18]

Airlock Design

The design and construction of the airlock itself was an example of the jerry-built, albeit imaginative, approach which characterized the Voskhod Program. Rather than install an egress hatch which would open, exposing both crew members to space, as was done with Gemini, Korolev had Severin design a simple 1 m cylinder which stove-piped at an angle into Voskhod 2's side. Made of a double thickness of a rubberlike material, covered with protective fabric, it accordioned under the shroud in the space capsule on takeoff. It was equipped with a regulation system for controlling air pressure from normal Earth atmospheric pressure to that of the vacuum of space.[19]

"Gai Ilyich," Korolev directed Severin, "demonstrate to us the durability of your airlock chamber." Severin, "a tall, stately, athletic looking man who was still young, easily jumped up and hung on the end of the cylinder." Mockups of Voskhod 2, with the airlock, stand proudly today in the museums of both the Korolev design bureau and Severin's Zvyezda design bureau.[20]

Also in a place of honor in Severin's museum is the space suit designed for Leonov. He recalled how the suit was developed under great time constraints:

> We had only about nine months, starting in May or June, 1964, to design and make the suit for Leonov's space walk.

We suggested [a suit] based on the old Vostok design. Korolev approved our suggestions. We knew that Ed White was getting ready. Unlike White, who just opened the hatch and looked around, Leonov went through a depressurization system... We had very modest production facilities at Zvyezda, so some of the pieces of equipment were made by Korolev. We had a series of failures. Our plan envisioned a full repetition of the EVA system we had undergone for the unmanned test for the Moon flight. We deployed the space suit in an inflatable chamber, depressurized the chamber, opened the hatch, recorded how the space suit performed, then detached the pressurization chamber and allowed it to burn up because the landing capsule must be spherical on reentry.

We made an additional chamber and space suit and launched it about 1 1/2 months before the Leonov flight. We launched the spacecraft, it entered orbit, the pressurization chamber was deployed, the space suit pressurized, then the communications dead zone started, so we had to wait for the next orbit to see if it was OK. The spacecraft never appeared again. Nobody could understand what happened. It turned out that the spacecraft had been destroyed. The main command signal and the backup signals from the ground stations combined to trigger the self destruct signal which was to be activated in case the spacecraft was headed for a landing in an unfriendly territory. So we still had not tested our space suit. The question in front of Korolev was what to do? There were two alternatives: we could repeat the test program, but that would take 6 months; or we could take all of the responsibility and go ahead with the real experiment. Korolev allowed me to make the decision, and then to defend it before the State Commission. There were two groups organized for analysis. We analyzed the data from the aborted experiment, compared them with the results of our own experiments in the pressurization chamber, and I concluded that there was no reason for delay. The partial data proved that we could proceed.

Late at night I called Korolev at his house in Baikonur, reviewed the results and he agreed with my suggestion to ask the State Commission to allow us to go ahead, but he said the Commission would accept my recommendation only if I could prove convincingly that it would work. Korolev gave me the chance to defend my position. I must emphasize that every Chief Designer must be himself responsible for his projects, so obviously he was placing a great deal of faith in me. The State Commission accepted my recommendation, thank God.[21]

The crew for Voskhod 2—Belyaev as crew commander and Leonov the pilot cosmonaut for the EVA—was not finally confirmed until three days before the flight itself. There had been some apprehension about Belyaev's fitness for the mission when he did poorly on altitude chamber tests two months earlier.

As Kamanin explains, however, "Leonov told me what had happened. During the training session, Belyaev began to gasp for breath because oxygen was not coming into the altitude chamber. But he displayed admirable composure, found the problem, and corrected it. Those responsible for the malfunction

were the factory specialists supporting the equipment, but Belyaev did not want to 'tell' on them and took all the responsibility for what had happened."[22]

An exultant Kamanin records in his March 18 diary that, "Today has been a hectic, unforgettable day. For the first time in history, a man walked in outer space..." Leonov entered space, after donning a suit and prebreathing oxygen to purge his lungs of nitrogen, through the cylindrical airlock. TV pictures of the walk were widely broadcast. What was not revealed until years later, and was not included in Kamanin's diary, was that Leonov almost could not reenter the airlock. His space suit had expanded and it took him twelve minutes of struggle before he could depressurize the suit and squeeze himself back through the opening.

Reentry System Failure

A second anomaly on that flight occurred when the automatic reentry system failed. Alexei Yeliseyev, one of the engineer-cosmonauts, was in the control center at the time. "No one understood what the problem was," he remembered:

> There were many guesses, frantic proposals—everyone had clearly begun to get nervous... And here Korolev took the supervision into his own hands. He established quiet and asked everyone to sit down. Then he calmly listened to the work supervisor in charge of the control system. He asked...about the possible causes and...a suggestion for further action.[23]

Korolev's decision was to perform a manual descent. He told the crew of the decision himself, said Yeliseyev, "in such a calm and assured tone that on board the craft and on Earth a normal businesslike atmosphere was again restored." The spacecraft flew an extra—17th—orbit, to give Belyaev time to prepare for manual retrorocket firing. He asked Leonov to check the spacecraft's attitude, and the extra time needed for the check caused the spacecraft to overshoot by about 2000 km its intended landing area. Voskhod 2 set down in deep snow near Perm, wedged between two large fir trees about three or four meters above the snow. The cosmonauts opened the hatch but stayed inside. A recovery helicopter reached them after 2 1/2 hours but could not land safely in the deep snow and thick growth of trees. They spent the night in the capsule in bitter cold, while wolves howled around them. In the morning they got out of the capsule somehow and a helicopter flew over them and reported seeing them chopping wood for a campfire. Korolev sent his own team of rescuers who helicoptered to the site, went down a rope ladder and skied about 200 m to the capsule. The rescuers and the cosmonauts then skied to the helicopter where they had to spend a second night in the taiga, although this time with food, tents and warm clothes.[24] "Sergei Pavlovich was constantly in communication with the head of the search service...," recalled Yeliseyev, and when the rescue was

complete, had enough of a sense of humor to say, "And now bring a half a kilo of Validol for the State Commission."[25]

In an interview in 1991, a 57-year old Leonov—affable and communicative, and probably 40 pounds heavier than he was as a cosmonaut—recalled his famous flight, and remembered also a 1962 meeting with Korolev when he was first shown the Voskhod that he would fly:

"Korolev told us," he said, "that 'Any seaman on a ship has to know how to swim and so each cosmonaut has to know how to swim and do construction work outside of his vehicle.' He looked at me and said, 'Now orlyonok [eaglet], put on a space suit, and go through all the procedures for the engineers.'

I went through the procedures and then Korolev left. Gagarin said, 'Congratulations, now your selection has been made.'

But actually Korolev had chosen me in advance just as he had Gagarin."[26]

It was not until Gemini 4, on June 3, that an American astronaut, Ed White, flying with Jim McDivitt, would top Leonov's feat with a twenty-one minute EVA. White maneuvered himself with a hand-held nitrogen-powered thruster. The Americans, too, had trouble with automation. As a result of a computer failure, McDivitt, making a manual reentry after four days in orbit, was one second late in activating the retrorockets. The spacecraft, after sixty-six orbits over a ninety-nine hour period, landed in the ocean about 64 km off course.

Gemini: A Big Leap

Unlike the built-on-the-cheap Voskhod, however, Gemini was a major step ahead in spacecraft technology. Bell-shaped like Mercury, it was almost three times as heavy at nearly 4 metric tons. It was, however, more than a ton lighter than Voskhod. The space for the two astronauts was comparable to that in "the front seat of a small sports car." It could maneuver with its own onboard propulsion, and had a guidance and navigation system and a rendezvous radar.[27]

Gemini, therefore, became the vehicle for enabling the American astronauts to learn how to achieve rendezvous. This was not easy. McDivitt and White, in Gemini 4, had trouble with a practice rendezvous because, according to Andre Meyer Jr., of the Gemini project office, they didn't understand the orbital mechanics.

"Adding speed also raises altitude, moving the spacecraft into a higher orbit than its target..." wrote Meyer. "As the Gemini 4 crew observed, the target seemed to gradually pull in front of and away from the spacecraft. The proper technique is for the spacecraft to reduce its speed, dropping to a lower and thus shorter orbit, which will allow it to gain on the target. At the correct moment, a burst of speed lifts the spacecraft to the target's orbit close enough to the target

to eliminate virtually all relative motion between them. Now on station, the paradoxical effects vanish, and the spacecraft can approach the target directly."[28]

There were, all told, 10 two-man Gemini flights over a period of 20 months, from March 1965, to November 1966, and they were crucial to the eventual Apollo program.

Gordon Cooper and Pete Conrad, in Gemini 5, had no ill effects from 8 days of weightlessness, the time required for going to the Moon and back.

Rendezvous of Gemini 6 And 7

Gemini 7, with Frank Borman and Jim Lovell as the crew, set a trip longevity record which would stand for five years—14 days in orbit—and actually flew before Gemini 6. The latter's flight was delayed when an Agena vehicle, which was supposed to serve as a rendezvous target, exploded 6 minutes after launch. Instead, Gemini 6, with Wally Schirra and Tom Stafford, went up on Gemini 7's 11th day in orbit. Schirra performed the first real rendezvous when he brought his ship, with no less than 35,000 thruster firings, to within 2 m of the Borman-Lovell craft.

Pavel Popovich tried to one up Schirra in an interview with an *Izvestia* reporter on December 21, 1965, a few days after the Gemini 6-7 rendezvous. Speaking of the Vostok 3 and 4 flights three years earlier he said, "...our ships came to within 5 kilometers distance in space. Thus, in principle, the American experiment of an orbit rendezvous repeats in some degree what we did." He then conceded that "techniques had advanced a great deal" and graciously complimented Schirra for his skill.[29]

Schirra, though, at a press conference a few days later, denigrated the comparison. "If anybody thinks they've pulled off a rendezvous at three miles (5 km), have fun! This is when we started doing our work. I don't think a rendezvous is over until you are stopped—completely stopped—with no relative motion between the two vehicles, at a range of approximately 120 ft (37 m). That's rendezvous! "[30]

The Unrealized Voskhods: 3 to 7

Intensive work, under great pressure from Korolev, was done in 1964-65 on an ambitious Voskhod mission which never materialized. It would have involved a test of an artificial gravity system consisting of rotating "orbital blocks" tethered by flexible cable. One of the engineers involved in the project, which was directed by Pavel Tsybin, was L. B. Vilnitskii. "Our section," he wrote, "had to develop complex and large mechanisms: winches, drums with an entire kilometer of cable, fittings, drives, etc., All this had to be done in 2-3

months instead of the 1 to 1 ½ years it should have taken in normal operations...Sergei Pavlovich...began to literally beg and plead for us to maximally accelerate our development."

But the development of the system presented problems that proved insurmountable. This is not surprising since artificial gravity systems have still not been developed in either the U.S. or Russia.[31]

Siddiqi's summary of the unrealized Voskhod designs[32] indicates that the artificial gravity mission was the final one proposed, and was designated Voskhod 7. But each of the earlier missions would have made substantial impact on the world scene as well. Voskhod 3, for example, would have been a mission of perhaps two weeks in duration. It would have carried its crew to a record, highly elliptical orbit and would have been preceded by an unmanned flight designed to test an automated life support system. The life support systems on Voskhods 1 and 2 had experienced some malfunctions. Voskhod 4 would have carried the first all-female crew into orbit. Korolev, not totally satisfied with the performance of Valentina Tereshkova on Vostok 6, had to be persuaded to support this mission by General Kamanin.

A group of cosmonauts were picked by the Soviet Air Force during this period to perform military Voskhod missions that were never carried out.

In early 1965, according to Siddiqi's research, four doctors from the Institute of Medical and Biological Problems began training for a five-day space biology flight, which would have been Voskhod 5. One of the experiments would have been to perform surgery on a rabbit in orbit.

Voskhod 6 would have tested an autonomous manned extra-vehicular maneuvering unit, designed by Severin. Neville Kidger reports that the Voskhod 6 EVA unit would have weighed 90 kg, been equipped with solid rockets for forward and reverse thrust and with 14 air thrusters for rotation in six degrees of freedom, and operated for four hours.[33]

Korolev Dies and So Does Voskhod

On January 14, 1966, Sergei Pavlovich Korolev died unexpectedly after what was to have been a routine operation for removal of rectal polyps. A large cancerous tumor had been discovered and Korolev's heart gave out in the recovery room after the operation to remove the tumor had been completed. He had been on the operating table for eight hours.

Preparations for Voskhod 3 continued, however, and on February 22, 1966, a 3KV, Voskhod-type, vehicle carried two dogs into a highly elliptical orbit on the Kosmos 110 mission, presumably to evaluate the effect on animals of the Van Allen radiation belts prior to launching cosmonauts.

For some weeks afterwards announcements seemed to indicate that Voskhod 3 would soon be launched. But Mishin, appointed officially to succeed

Korolev on May 11, 1966, apparently felt that continuing the program would only delay the Soyuz and lunar landing efforts, although it was the higherups who finally cancelled it.

Thus, Voskhod became history.

Reference Notes

[1]This paper is an adaptation, and update, of Chapter 10 of *KOROLEV How One Man Masterminded the Soviet Drive to Beat America to the Moon*, John Wiley & Sons, New York, 1997.

[2]Tikhnoravov, M. K., Rauschenbakh, B. V., Skuridin, G. A., and Vaisberg, O. L., "Ten Years of Soviet Space Research," *Kosmicheskiye Issledovaniya* 67, Vol. 5, No. 5, p. 572.

[3]Mishin interview with G. Salakhutdinov in *Ogonyok*, No. 34, Aug. 18-25, 1990, pp. 4-5. English translation in JPRS-USP-91-002, Apr. 16, 1991, p. 68. It is relevant to note that the U.S. space shuttle has no escape system, nor can the solid boosters be discarded or their engines cut off for the full two minute duration of their firing.

[4]Vetrov communication with author, Sept. 4, 1995.

[5]Rocket-Space Corporation Energia named for S. P. Korolev, Kaliningrad, 1996, p. 116.

[6]Siddiqi, Asif, "Cancelled Missions in the Voskhod Program," *Journal of the British Interplanetary Society*, Jan. 1997, p. 26.

[7]Feoktistov interview with the author, Moscow, Dec. 15, 1991.

[8]ibid.

[9]Mishin interview with Salakhutdinov.

[10]Ezell, Edward C., and Ezell, Linda N., *The Partnership*, NASA History series, p. 80.

[11]Severin interview with author, Kaliningrad, Sept. 16, 1993.

[12]Ezell and Ezell, *The Partnership*.

[13]Severin interview.

[14]Mishin interview with Salakhutdinov.

[15]Tikhonravov, Rauschenbakh et al., *Ten Years of Soviet Research*.

[16]The first two Geminis were unmanned tests.

[17]Vetrov communication with the author.

[18]Kamanin, Nikolai, "Pages From a Diary," *Sovetskaya Rossiya*, Mar. 19, 1990, p. 6.

[19]Ishlinsky, *Academician S. P. Korolev*, p. 421, and Haeseler, Dietrich, "Leonov's Way to Space," *Spaceflight*, Aug. 1994, pp. 280-81. Haeseler reports that one of the airlocks was sold at auction at Sotheby's, New York, for $80,000 in 1993.

[20]Ishlinsky, *Academician*, p. 421.

[21]Severin interview.

[22]Kamanin, Pages from a Diary.

[23]Ishlinsky, *Academician*, pp. 486-87.

[24]Leonov interview with the author, Moscow, Dec. 11, 1991. Also, Kamanin diary. Also, Ishlinsky, pp. 254-55.

[25]Ishlinsky, *Academician*, pp. 254-55.

[26]Leonov interview.

[27]Ibid, p. 177.

[28]Hacker, Barton C., and Grimwood, James M, *On the Shoulders of Titans: A History of Project Gemini*, NASA SP-403, Washington, 1977, p. 483.

[29]Popovich interview in *Izvestia*, Dec. 29, 1965.

[30]Schirra statement at Dec. 30, 1965, NASA press conference.

[31]Ishlinsky, *Academician*, p. 336, and private communication from Maxim Tarasenko, Sept. 1, 1995.

[32]Ibid, Siddiqi, p. 27.

[33]Kidger, Neville, "The Soviet 'Back-Pack'," *Spaceflight*, Vol. 34, March, 1992, p. 82.