

Feature Articles:

- 5** **Soyuz-1 Revisited: From Myth to Reality**
By Asif A. Siddiqi
- 17** **'Not Too Wild a Dream':
NASA and the Quest for Life in the Solar System**
By Roger D. Launius (Chat with the Author)

International:

- 28** **The Early Years of the Molniya Program**
By Bart Hendrickx

Military:

- 37** **The Icarus Paradox:
Air Force Doctrine and Space Technology**
By Michael Terry

Technology:

- 44** **U.S. Spacecraft Nuclear Power Systems:
Past, Present and Future**
By Louis Varricchio

Oral History Interview:

- 52** **Richard Nygren**
By Rebecca Wright and Carol Butler

Program Profile:

- 66** **European Space Agency Archives**
By Gherardo Bonini

Reviews:

- 67** **Beyond Horizons:
A Half Century of Air Force Space Leadership**
Book by David Spires, Review by Stephen B. Johnson
- 68** **Russians in Space, A Compact Disc**
CD by Yaroslav Galovanov, Review by John Graham

Letters:

- 69** **Letters to the Editor**



Yuri Gidzenko (front), Thomas Reiter and Sergei Avdeyev at the base of their Soyuz launcher, September 3, 1995. ESA astronaut Reiter spent 177 days aboard Russia's Mir Space Station during September 1995-February 1996.

Photo courtesy of ESA



Soyuz-1 Revisited: From Myth To Reality

by Asif A. Siddiqi

In the pantheon of Soviet space historiography, the mission of *Soyuz-1* has been unlike any other event. The death of cosmonaut Vladimir Mikhaylovich Komarov after a one-day mission in April, 1967 was perhaps the biggest blow to the fortunes of the Soviet piloted space effort in the 1960s. At the time, little information was

forthcoming from official Soviet sources. Thus emerged the growth of an unprecedented cottage industry of rumors and half-myths that have persisted through succeeding generations and have become more and more outlandish. So many different variations of his death have become ingrained in the collective history of the Soviet space program that one would not be surprised to hear that Komarov was abducted by aliens during his mission. It was only in the late 1980s that Soviet journalists were allowed to dispel some of the half-truths about the flight. In June, 1989 the Soviet newspaper *Poisk* published extracts from the diary of Col.-Gen. Nikolay P. Kamanin, the aide to the Soviet Air Force Commander-in-Chief for Space, describing in detail the actual train of events both on the ground and in space. These were augmented by subsequent revelations through the years. This current work is an early attempt to circumvent the rumor mill and to address the mission using the new documentary evidence and to answer the question: What really happened on *Soyuz-1*?

a single Soviet piloted space flight in more than two years. In the same period, NASA had performed ten spectacular

Gemini missions in Earth orbit, punctuated by several rendezvous and dockings and spacewalks, all indications of a remarkable level of maturity in Earth orbital operations. For two years now, the TsKBEM had been preparing for its own coup, a complex flight involving two *Soyuz* spacecraft that would dock in orbit, followed by a transfer of two crew members from one *Soyuz* to another by a spacewalk.

From an outsider's perspective, the natural course of action for the TsKBEM would have been to add another precursor *Soyuz* mission into the schedule. The



Dmitriy Ustinov, the Secretary of the Communist Party's Central Committee responsible for space and defense industrial affairs. He was the de facto head of the Soviet space program between 1965-1976.

Photo © Asif A. Siddiqi

THE BACKDROP TO THE MISSION

Precursor automated flights in the *Soyuz* program began in late 1966 but their performance left much to be desired. In three attempts to launch the *7K-OK Soyuz* ship into orbit, one had failed to orient properly during reentry, one had been destroyed during launch, and the third had been recovered from the bottom of a lake with a hole in its heat shield. The Central Design Bureau of Experimental Machine Building (known in its Russian abbreviation as the 'TsKBEM'), responsible for designing and building the *Soyuz*, was seemingly caught in a bind. There had not been

two spacecraft that actually reached orbit had had significant problems, primarily in their reentry phase, and certainly there would have been the need to verify the operation of all the components of reentry such as the heat shield, parachute system, orientation systems, etc. Despite the three attempts to launch the *Soyuz*, TsKBEM Chief Designer Vasiliy P. Mishin and his engineers had recovered only a single *Soyuz* Descent Apparatus (called the 'Reentry Module' in the West) after a space mission, one whose thermal protection system had had a catastrophic failure. This is not to say that Mishin did not undertake a thorough analysis of the situation. The results of the three *Soyuz* attempts were the subject of in-

tense discussion; the main decision for the engineers was whether to carry out another automated mission or whether to go directly to a piloted flight. Deputy Chief Designers Konstantin D. Bushuyev and Yakov I. Tregub of the TsKBEM led this analysis in February and March of 1967. Mishin invited a host of representatives from all organizations involved in the *Soyuz* to hear from each their assessment of the status of their particular system and its potential readiness for a piloted flight. Remarkably, most of the other designers and engineers recommended crewed operations. Among the dissenters was TsKBEM Department Chief Ivan S. Prudnikov who based his objections on the insufficient testing of the new improved heat shield. The majority of engineers, however, expressed confidence in the work of the heat shield.¹

On March 25, 1967, the Military-Industrial Commission (VPK), the management authority over the Soviet defense industry, met to discuss the preparations for the impending mission. Representing the operations team was the State Commission, a separate *ad hoc* body that would oversee the actual flight. Five men, including State Commission Chairman Maj.-Gen. Kerim A. Kerimov, Mishin, and Kamanin, reported to the VPK Chairman Leonid V. Smirnov on the status of preparations for the mission.² Smirnov asked several questions including "Do you think the equipment will work smoothly?" Kamanin replied that:

Three launches of *Soyuz* spaceships and the completion of all ground tests have made us confident that the flight will be successful, although at one point some of the cosmonauts had certain doubts about the ship's bottom. We know that following the burn-out of the bottom of ship *No. 3*, the Central Design Bureau of Experimental Machine Building has worked hard to reinforce it. Chief Designer Mishin has said on more than one occasion that now there should be no doubts about the bottom. We believe Mishin.³

Kamanin introduced all the cosmonauts preparing for the flight, the eight prime and backup crew members, Bykovskiy, Gagarin, Gorbatko, Khrunov, Komarov, Kubasov, Nikolayev, and Yeliseyev as well as four additional understudies who were expected to fly a subsequent *Soyuz* mission after finishing their training on June 1.⁴ Although there was no formal decision on the prime crew, Komarov (for *Soyuz-1*) and Bykovskiy, Yeliseyev, and Khrunov (for *Soyuz-2*) were the leading candidates. Mishin personally met with Communist Party Central Committee Secretary Dmitriy F. Ustinov two days later to discuss the flight, setting in motion a series of events that would cripple the Soviet space program.⁵

The decision to move ahead with the docking mission has been obfuscated and mired in controversy and speculation for 30 years. One TsKBEM engineer, who later emigrated to the United States in the 1970s, added to the rumor mill by recalling that:

The management of the Design Bureau knew that the vehicle had not been completely debugged; more time was needed to make it operational. But the Communist Party ordered the launch despite the fact that four preliminary launches had revealed faults in coordination, thermal control, and parachute systems. It was rumored that Vasily Mishin, the deputy chief designer who headed the enterprise after Korolev's death in 1966, had objected to the launch.⁶

There was clearly a great deal of political pressure from General Secretary Leonid I. Brezhnev and Ustinov to get the flight off the ground. Apart from the successes of *Gemini*, there were other compelling reasons; May Day, one of the most important holidays in Soviet culture, was imminent, and there is reason to believe that the *Soyuz* flight was timed to roughly coincide with the anniversary. A simple automated flight of the vehicle would have hardly amounted to much for such an auspicious occasion. When asked in an interview in 1990 whether the *Soyuz* flight was beset by political pressure, Mishin replied:

Truly, there never was a time when we worked in peace, without being hurried or pressured from above. The unskilled, totally bewildered, high-ranking bureaucrats believe that they are fulfilling their duties if they are shouting "Let's go, let's go!" at people who don't even have time to wipe the sweat off their brows.⁷

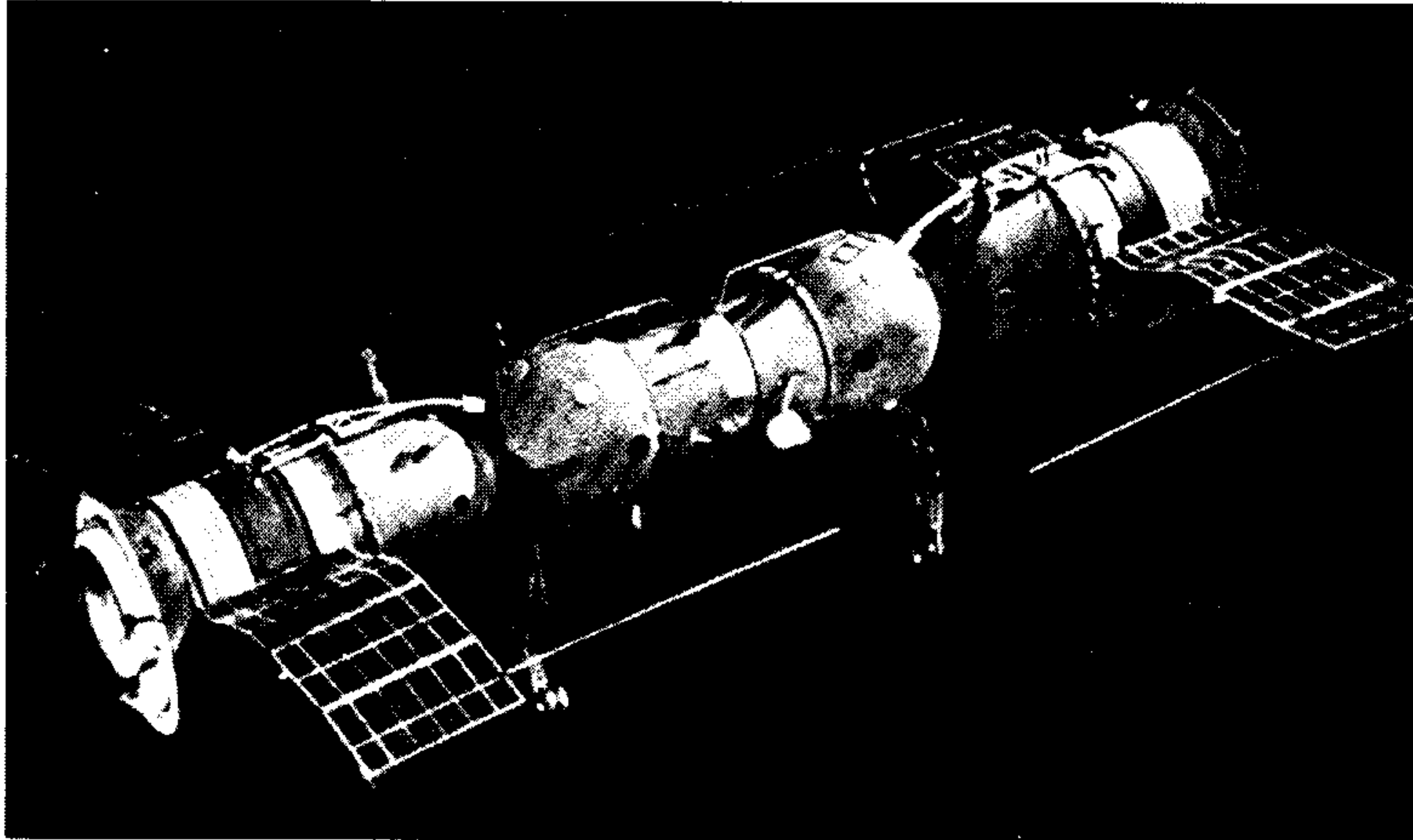
Asked about the possibility that his deputies may have committed errors during the preparations, Mishin emphasized that:

No, the deadlines and the pressure from above have nothing to do with that. Not a single supervisor for any of the *Soyuz* systems would have given the 'go-ahead' to the flight if he were not certain of that system's satisfactory operation.⁸

Ultimately it was a decision motivated by the apparently huge lead in piloted space exploration accrued through 1965 and 1966 by the United States. Throughout 1966, both the political and technical managers of the Soviet space program banked on the inauguration of the *Soyuz* program to take some steam out of the U.S. space program that finally seemed to have gained its wings after years of humiliation. When Mishin, Bushuyev, Tregub, and others recommended a go-ahead with the flight, they clearly did not have full confidence in their ship. Korolev, of course, had also taken his own chances, particularly with the two *Voskhod* missions which were highly risky endeavors. The EVA mission of *Voskhod-2*, for example, was not preceded by a successful test mission. But *Soyuz* was a far more complex spacecraft that was a completely untested quantity in terms of crewed operations. Thus, the *Soyuz* mission was a gamble of ex-

traordinary levels, a risk that was mitigated only partially by the technical problems that engineers believed they had overcome despite three failed precursor missions.

The intensive discussions on *Soyuz* in February and



Two *Soyuz* spacecraft shown docked together nose to nose. This would have been the configuration of the *Soyuz-1/2* spacecraft had Komarov's flight not run into trouble after launch. The Soviets performed an exact repeat of the mission in January 1969 with *Soyuz-3/4*. Photo © Asif A. Siddiqi

March 1967 were mirrored by the slowly increasing number of rumors emanating from 'unofficial' sources from the Eastern bloc that a Soviet space spectacular was imminent. On March 7 a commentator on Prague Radio reported that "much more complicated manned operations in Earth orbit are about to begin which have taken over two years to prepare."⁹ Just two days later, Lt.-Gen. Kamanin, in a long interview with Warsaw Radio, said that piloted flights would begin again that spring. He added that the Soviets were not locked onto any particular date and that the flight would come only when they were assured of success. The recent deaths of the American astronauts on *Apollo 1* had been the result of unnecessary haste in the U.S. space program; the Soviets, he claimed, were not in such a hurry.¹⁰

INTO ORBIT

After an unusually grueling training program involving countless hours in simulators on the ground, the eight primary and backup cosmonauts for the mission took their final exams for the flight on March 30, and all passed with excellent marks. On April 6, the men visited the depths of the Kremlin to meet with high Central Committee officials and receive wishes of good luck. The same day, Kamanin, accompanied by veteran and rookie cosmonauts, flew into Tyura-Tam. Komarov followed on April 8 and Gagarin on April 14.¹¹ For many it was the first time that they had spent the celebrated 'Cosmonautics Day,' the anniversary of Gagarin's pioneering flight, at the Baykonur Cosmodrome.

There was a meeting of the State Commission on April 14 when the members decided to begin fueling the two launch

vehicles and spacecraft. Assuming an eight day period for complete preparation, the first launch was tentatively set for April 24-25. Mishin telephoned both Ustinov and Brezhnev later the same day; Ustinov evidently expressed some anxiety over the impending flight.

The mission would be inaugurated by the launch of the active *7K-OK(A) Soyuz-1* on the first day with Komarov. The following day as the ship was flying over Tyura-Tam, the passive *7K-OK(P) Soyuz-2* would be launched with Bykovskiy, Yeliseyev, and Khrunov. The two spacecraft would dock on the very first orbit of *Soyuz-2*. After docking, Yeliseyev and Khrunov would exit from their depressurized Living Compartment (or the 'Orbital Module' in Western vernacular) and crawl over to the depressurized Living Compartment of *Soyuz-1*. Following the transfer, *Soyuz-1*, now with a crew of three, would return the following day. *Soyuz-2*, with a crew of one, would also return that same day. Apart from the dramatic nature of the flight, the mission had

significant value for future operations in the *NI-L3* piloted lunar landing project as well as possible Earth orbit rendezvous profiles for the circumlunar *LI* program. There still appeared to be misgivings about the flight. Kamanin wrote in his journal on April 15:

I am personally not fully confident that the whole program of flight will be completed successfully, although there are no sufficiently weighty grounds to object to the launch. In all the previous flights we believed in success. Today there is not such confidence in victory. The cosmonauts are prepared well, and the ships and the instruments have gone through hundreds of tests and verifications, and all seems to have been done for successful flights, but (still) there is no confidence. This can perhaps be explained by the fact that we are flying without Korolev's strength and assurances; we were spoilt by Korolev's optimism.¹²

Fueling of the *Soyuz-1* launch stack began at 2300 hours Moscow Time on April 15. The entire morning of April 17, the cosmonauts attended a final five hour class under TsKBEM Department Chief Boris V. Raushenbakh's supervision to study once again the modes of docking, orientation, etc. In the afternoon, Mishin arrived to talk personally with the crews about various portions of the mission. Even at this late point, there appears to have some disagreement over which mode of operation to use for the crucial docking maneuver. Mishin favored a completely automatic docking believing in the infallibility of the ship but was opposed by Kamanin and some of the cosmonauts including Komarov and Gagarin. For more than two years Bykovskiy, Gagarin, Komarov, and Nikolayev, the four Commanders, had been training for an automatic approach followed by a manual docking and were reluctant to let automation do the whole

thing. At the meeting, Komarov argued that the *Igla* rendezvous radar system could automatically bring the active vehicle within 300-200 meters of the passive vehicle, following which he could manually dock the two spacecraft. Mishin listened to their arguments and delayed a final decision on the matter until the following day. By the end of the day, fueling of the *Soyuz-1* launcher had concluded while fueling of the *Soyuz-2* booster had begun. Thus with both launchers either fueled or in the process, the launching was informally set for April 24-26.¹³

The Council of Chief Designers met on the morning of April 18 to discuss the docking issue. State Commission Chairman Kerimov supported an automatic approach via the *Igla* to 50-70 meters followed by manual docking, although many engineers still defended the fully automatic variant. TsKBEM Department Deputy Chief and cosmonaut Konstantin P. Feoktistov mediated the issue and argued in favor of the semi-automatic profile, and the Council accepted his recommendations. Later in the day, Feoktistov discussed various contingency measures for emergency situations with the cosmonauts. The final State Commission meeting prior to launch took place on April 20 at site 2 at the firing range. The launch of *Soyuz-1* was set for 0335 hours Moscow Time on April 23, while the launch of *Soyuz-2* was set for 0310 hours Moscow Time the following day. All the Chief and Deputy Chief Designers confirmed that the launch vehicles, space ships, and support services would be completely ready to accomplish the launch on time. Kamanin proposed Komarov as the sole crew member for *Soyuz-1*, and Bykovskiy (Commander), Yeliseyev (Flight-Engineer), and Khrunov (Research Cosmonaut) as the crew members for *Soyuz-2*. The Commission approved the crews, and gave the formal go-ahead for the flight.¹⁴

On April 22, the *IJA511 Soyuz* launcher was already at the launch pad at site 1. In the late morning, the prime and backup crews had their customary meeting with the launch command and industrial representatives. A number of Chief Designers met with the crews and informed them that after the *Soyuz-1* launch there would only be two reasons for a postponement or cancellation of the *Soyuz-2* launch:

- if there was a failure in the *Igla* rendezvous system; or
- if there was a low charge in the solar batteries on *Soyuz-1*.

Kamanin counseled Komarov that the most important factor on the mission would be safety, and that in the case of

any malfunctions, there would be no need to proceed with the complicated docking procedure. Later in the day Komarov attended a press conference for journalists with special access. He dedicated his flight to the 50th anniversary of the Bolshevik Revolution.¹⁵

A final meeting of the State Commission lasting 45 minutes began half-an-hour before midnight recommending a full go-ahead for the flight. Komarov woke up about two hours after midnight while doctors attached sets of medical sensors to his body. He was dressed in a plain light woolen gray suit and a blue jacket. At 0300 hours he arrived at the pad to give a short speech addressed to State Commission Chairman Kerimov before bidding farewell. Mishin, Kamanin, and Gagarin accompanied him to the rocket; the latter went up with him all the way to the top of the



Training for *Soyuz-1/Soyuz-2* mission in 1967. From the left are *Soyuz-1* pilot Vladimir Komarov, *Soyuz-2* engineers Yevgeniy Khrunov and Aleksey Yeliseyev, and *Soyuz-1* backup pilot Yuriy Gagarin.

Photo from the files of Peter Gorin

rocket and remained there until hatch close.

There were no anomalies prior to launch. The spacecraft, *7K-OK(A) No. 4*, lifted off exactly on time at 0335 hours Moscow Time on April 23, 1967 with its sole passenger, 40-year old Col.-Eng. Vladimir M. Komarov. He was the first Soviet cosmonaut to make a second spaceflight. It took 540 seconds for the ship to successfully enter orbit. The official Soviet news agency TASS released a brief statement calling the flight '*Soyuz-1*,' and announced orbital parameters and some vague objectives of the program. Characteristically there was no mention of the impending *Soyuz-2* mission. Rumors in the West had, however, reached crescendo proportions, some clearly indicating that a docking with a second ship was planned.¹⁶ Cosmonaut Popovich informed Komarov's wife, Valya, that her husband was in orbit about 25 minutes after launch. She told reporters that "my husband never tells me when he goes on a business trip."¹⁷

For the first time on a Soviet piloted mission, the Chief Operations and Control Group (GOGU), i.e. the flight control team, was located at the Scientific Measurement Point No. 16 at Yevpatoriya in Crimea. GOGU Chief Col. Pavel A. Agadzhanov, the 'flight director,' was assisted by a team of 20 controllers including TsKBEM Deputy Chief Designers Boris Y. Chertok and Yakov I. Tregub and Department Chief Raushenbakh. The flight control team would actively communicate with the spacecraft in orbit, while maintaining continuous contact with the State Commission, all of whose members remained behind at site 2 at Tyura-Tam. Additional ballistics support was provided by the NII-4's military Coordination-Computation Center in Moscow.

PROBLEMS

The initial incoming report from telemetry streams from two ground stations indicated that the *Soyuz* spacecraft's left solar panel had not opened upon entering orbit. As Agadzhanov's team examined the data, they found other anomalies. A backup antenna in the telemetry system was inoperable and the 45K solar-stellar attitude control sensor's optical surface had probably been contaminated by engine exhaust. While the antenna was a minor annoyance, the sensor malfunction was serious since without it, *Soyuz-1* would be unable to orient the ship properly to change orbital parameters in preparation for the rendezvous and docking. Telemetry indicated at the time that current orbital parameters were 196.2 x 225 kilometers at 51° 43' inclination. It was on the second orbit that controllers first established stable communications with Komarov on ultra-short wave frequencies; for reasons unknown, the short-wave system was inoperable. Komarov calmly reported:

I feel well. The parameters of the cabin are normal. The left solar battery has not opened. There's been no spin towards the Sun. The "solar current" is 14 amperes. Short-wave communications are not working. I attempted to manually perform spinning. Spinning did not occur, but pressure in the (orientation engines) dropped to 180.¹⁸

Unconfirmed reports suggest that Komarov even tried to knock the side of the ship to jar open the recalcitrant panel.

Already the situation had deteriorated dramatically. Since one solar panel was not operative, and the ship had failed to automatically orient the other towards the Sun, power on board the ship was far below normal. Power experts at Yevpatoriya had calculated that the buffer batteries could operate with the current levels of power up to the 17th orbit after which Komarov could use reserve batteries for up to two more orbits, i.e. *Soyuz-1* could safely operate for about a day, significantly less than the three days needed for a docking mission. In the meantime, Agadzhanov told Komarov to shut down non-essential systems and try at all costs to orient the right panel towards the Sun. On the third orbit, Komarov told ground control that the left panel was still folded against the ship, and that the vehicle had not oriented towards the Sun. Current had stabilized at a low 14 amperes, far below that required for a nominal flight. The 45K attitude control sensor was still inoperative. Despite the troubles, the State Commission believed that the orientation problem would be solved, and recommended that preparations for the launch of *Soyuz-2* be continued. Kamanin meanwhile sent Gagarin directly to Yevpatoriya to assist the GOGU in its operations.¹⁹

On the fifth orbit, Komarov attempted to manually ori-

ent the ship by using the Earth's horizon to position the vehicle at correct attitude, but he found it difficult to do so partly because it was difficult to keep a target hold on the moving Earth. Additionally, his attempt appears to have been overruled by the onboard control system. Apart from the astro-orientation system that used the 45K solar-stellar sensor and the manual orientation system, the vehicle was also equipped with ionic sensors but use of these also met with little success on the fifth orbit. From the seventh to the thirteenth orbits, Komarov was outside radio visibility via ultra-short wave communications since the spacecraft would pass over the Atlantic and the American continent. The cosmonaut was ordered to sleep during this period while consultations between Moscow, Tyura-Tam, and Yevpatoriya continued through the day at a feverish pitch.

Most of the senior members of the State Commission, including Chairman Kerimov, Kamanin, and Academy of Science President Mstislav V. Keldysh recommended immediate postponement of the *Soyuz-2* launch hoping to return Komarov on the earliest possible opportunity, i.e. the 17th orbit. Incredibly, Mishin still had hope, and believed that the Commission should make a final decision on the 13th orbit once Yevpatoriya reestablished contact with Komarov. There was even a momentary plan to have the two EVA cosmonauts, Yeliseyev and Khrunov, manually unfurl the jammed solar panel during their spacewalk from one ship to the other. But on the 13th orbit, Komarov reported that his second attempt to use the ionic orientation system had failed.²⁰ He added that the left solar panel was still jammed; current on the ship had remained static at 12-14 amperes. Mishin later recalled that "because of the emergency, the shortage of power on board caused a chain of problems (including) a change in the temperature conditions."²¹ Immediately, the State Commission unanimously canceled the *Soyuz-2* launch. Evidently the *Soyuz-2* cosmonauts were bitterly disappointed blaming the Commission for "excessive caution and indecisiveness."²²

THE REENTRY

The problem now was how to return the spacecraft from orbit, nominally on the 17th orbit, but with the 18th and 19th orbits as reserve. Agadzhanov's team at Yevpatoriya considered the matter carefully. There were three main failures on board *Soyuz-1*, the unopening of the left solar panel, the failure of the ionic orientation system, and the malfunction of the 45K solar-stellar attitude control sensor. The recalcitrant solar panel not only deprived the spacecraft of much needed power, but also caused an asymmetry in the ship that prevented the open solar panel from facing the Sun. Due to this mechanical imbalance, engineers

strongly believed that all of Komarov's efforts to spin the ship in the direction of the Sun would fail, and in fact, would simply waste the precious propellant in the orientation engine system. If there was too little fuel in that system, then during retro-fire, Komarov might not be able to compensate for moments arising from the mass displacement due to the single opened panel.

The *Soyuz* had three orientation systems. If all three orientation systems were inoperative, it would be practically impossible for Komarov to return his ship. With an incorrect attitude *Soyuz-1* would either burn up in the atmosphere or fly into a higher orbit. The ionic orientation system had already failed to perform twice. Engineers also believed that the system would be unreliable during the morning hours when the return was planned due to ion pockets that could disrupt the work of the sensors. As for the 45K solar-stellar sensor, it was not functioning at all. This left manual orientation, which was working, but as Komarov reported, it was extremely difficult to manipulate in the Earth's shadow since it would be difficult to locate the Earth's horizon. Normally, using manual orientation, the cosmonaut would cross the Earth's terminator into lighted areas. In Komarov's case, with a reentry at the earliest opportunity, he would still be in the dark.²³

Time was already running short for Komarov. If he was to perform a successful reentry on the 17th orbit, then Agadzhanov's team needed to transmit a precise set of commands to Komarov on the 16th orbit. It was already the 15th orbit and officials at both Yevpatoriya and Tyura-Tam were still arguing over a proper choice of orientation for reentry. It had been almost 24 hours since the launch, and not one member of either the State Commission, nor the Chief Operations and Control Group had slept. In their state of alarm, members continuously violated established rules to communicate only via secret channels between the two centers. On the 15th orbit, Komarov reported that he believed that the ionic system and its associated attitude control engines were in working order. Based on his recommendations and assessment from data on the ground, the State Commission recommended that the ship be landed on the 17th orbit using the automatic ionic orientation with the backup set of orientation engines. Agadzhanov, Raushenbakh, and Chertok carefully checked over the set of instructions that Gagarin personally transmitted to Komarov. In the final seconds before loss of contact, Mishin and Kamanin both wished Komarov good luck.²⁴

At the appointed time, *Soyuz-1* initiated the reentry sequence. The main engine was supposed to fire for deorbit at 0256 hours 12 seconds Moscow Time on April 24 but nothing happened. Ballistics reports pouring into Yevpatoriya indicated that *Soyuz-1*'s orbital parameters had remained the same. Once communication with Komarov was reestablished, the cosmonaut reported that the ion system appeared to have worked fine, but evidently, as the ship had crossed the equator, it had flown into an 'ion pocket' in the Earth's shadow

where the concentration of the ions was less than what the sensors could detect. The ship's control system correctly issued a command to prohibit the firing of the retro-engine.²⁵ State Commission members decided to immediately begin preparations for another landing attempt on the 18th orbit but the flight control team felt that there was not simply enough time to prepare for landing; as the 17th orbit was ending, they did not have any new instructions ready to transmit to Komarov. With time running out, the State Commission decided to land Komarov on the 19th orbit.

With use of both the ionic and solar-stellar orientation systems out of question, the only remaining option was for Komarov to manually orient the ship prior to retrofire, but using a very complex series of operations in orbit. Komarov would have to orient the ship manually to the Earth's horizon in the light portion of the orbit. Just before entering the Earth's shadow, he would transfer attitude control to the spaceship's *KI-38* gyroscope system. Once he was out of the shadow, he would check if *Soyuz-1* was still correctly oriented for retrofire. If not, he would once again take over manual control and issue all the commands to complete the retrofire sequence for a landing on the 19th orbit. It was an incredibly difficult task, one which none of the cosmonauts had ever trained for on the ground. At the same time, one of the power specialists warned that Komarov had one to two orbits at the most, i.e. he might not have very many more chances to attempt reentry. Gagarin once again transmitted the new set of instructions to the *Soyuz-1* cosmonaut. Komarov seemed calm and agreed to carry out all the operations on time. The initiation of the 150 second retro-burn was set for 0557 hours 15 seconds on April 24.

Komarov performed brilliantly and carried out his assigned program almost to the letter, and replied through the increasing static that:

The engine worked for 146 seconds. Switch-off occurred at 0559 hours 38.5 seconds. At 0614 hours 9 seconds, there was the command 'Accident-2.'²⁶

Naturally, controllers were alarmed by the 'Accident-2' message, but Raushenbakh gathered his resolve and explained to the team not to worry. The attitude control system had evidently been unable to handle the strong movements due to the asymmetry of the vehicle, and the gyroscopes had issued the 'Accident-2' command after the spacecraft deviated from its set angle by eight degrees. That only meant that instead of a guided reentry, Komarov would perform a direct ballistic return. All other parameters, such as the length of the burn, were well within range for a successful reentry.

At Tyura-Tam, the State Commission were huddled together on the second floor of the administrative portion of the huge Assembly-Testing Building at site 2. Journalists at the launch site were excluded from the meeting, but were able to overhear voices. Cosmonaut Leonov served as an

intermediary to brief reporters on the ongoing situation. Mishin, Kerimov, Keldysh, Minister of General Machine Building Sergey A. Afanasyev, and Air Force First Deputy Commander-in-Chief Marshall Sergey I. Rudenko all exchanged brief comments as they heard Komarov's report. About 15 minutes after retrofire, there was the expected break in communications as Komarov's capsule entered an ionization layer. A few minutes later, Komarov's voice cut through the radio silence; he evidently sounded "calm, unhurried, without any nervousness."²⁷ By this time, Kamanin and a group of Air Force officers had already taken off from Tyura-Tam in an *Il-18* aircraft to head for the projected landing range. The latter was at the reserve landing area for the mission, about 65 kilometers east of Orsk, far west of the planned site for a guided reentry. According to ballistics data, *Soyuz-1* had landed at 0624 hours Moscow Time.

THE LANDING

Once ground control determined the landing site, the reserve search and rescue service at the town of Orenburg was called into operation to locate the Descent Apparatus. It was a beautiful and sunny morning at the landing site, and visibility was evidently very good. Members of the rescue service recalled that:

The commander of one of the *An-12* search aircraft reported to the helicopter commander that he could see *Soyuz-1* in the air. All the group members were immediately at the windows. But we couldn't see the reentry vehicle descending in the air. The helicopter commander began a rapid descent. Then the helicopter turned sharply to the right, and many of the group members saw the reentry vehicle down in a green field. It was lying on its side, and the parachute could be seen right next to it. And then the soft-landing engines kicked in. That alarmed the specialists on the helicopter, because the engines were supposed to switch on just *before* the landing of the reentry vehicle, right above the ground.²⁸

The first helicopter landed 70-100 meters from the capsule, which was surrounded by a cloud of black smoke. The fire inside the vehicle was still very intense; the bottom of the ship with its soft-landing engines had, in fact, completely burned through. Witnesses claimed that streams of molten metal were falling on the ground. Along with foam fire extinguishers, they used earth around the ship to temper the fire: "The vehicle was completely destroyed while the fire was being extinguished, and the spot looked like a small earthen mound, beneath the peak of which was the cover for the hatch-crawlway."²⁹

The rescue service originally communicated on an open

channel with ground controllers at Moscow, Tyura-Tam, and Yevpatoriya, although they spoke in code. Once the rescuers had seen the ship on the ground and on fire, one of the pilots had cryptically reported "I see the object, the cosmonaut needs urgent medical attention out in the field."³⁰ At that point, perhaps to preclude rumors, the search service terminated all communications with the three control centers. For the next few hours, there was no news from the site as Mishin, Kerimov, and others anxiously waited for any scrap of news.

Kamanin, meanwhile, landed at Orsk airport about two hours after the *Soyuz-1* impact, fully expecting to meet Komarov there. Once out of his plane, he was told that the ship had landed 65 kilometers away, that it was burning, and that the cosmonaut had not been found. Another unconfirmed report came in that Komarov was wounded but alive in a hospital in a town three kilometers from the landing site. The Air Force General decided to go directly to the landing site first, although he had been explicitly ordered to wait for a call from Moscow to report on Komarov's status. Back at the control centers, there was complete confusion. Ustinov in Moscow was frantic for information. He began calling up Party Secretaries in Orenburg and Orsk on special lines, but could not reach anyone. Although the vehicle had landed at 0624 hours, Ustinov received no information on the state of the cosmonaut for the next three-and-a-half hours.

When Kamanin arrived at the landing site, the *Soyuz-1* Descent Apparatus was still on fire. He was not the first high space official on the scene. Academician Georgiy I. Petrov, the Director of the Academy of Sciences' Space Research Institute, had arrived there first and was directing efforts to assess the situation. There was still no sign of the cosmonaut. Local residents reported that the ship had fallen towards the Earth at a great speed, and that the parachute was turning and not filled up with air. They confirmed the observations of the search and rescue service that at the moment of landing, there were some explosions followed by the fire. Kamanin recalls:

A cursory examination of the ship convinced me that Komarov was dead and was still in the remains of what used to be his ship. I ordered to clear out the debris on the ground and search for Komarov's body. Simultaneously I sent one of the workers by helicopter, and others by automobile to the local hospital in order to verify the story of the injured cosmonaut. After an hour of excavations (i.e. at around 0930 hours) we discovered the body of cosmonaut Komarov among the remains of the ship...³¹

Finding the body had been a difficult job. One of the rescuers recalled that:

The group's physicians set to work—they shoveled away the top layer of dirt from the top of the mound from the

hatch cover. After the dirt and certain parts of instruments and equipment were removed, the cosmonaut's body was found lying in the center chair. The physicians cleaned the dirt and the remnants of the burned helmet phone from the head. They pronounced the death to be from multiple injuries to the cranium, spinal cord, and bones.³²

Kamanin meanwhile flew back to Orsk and personally telephoned Central Committee Secretary Ustinov with the following short message:

I was at the location, cosmonaut Komarov has died, the ship burnt up. The primary parachute of the ship did not open, and the reserve parachute did not fill with air. The ship hit the ground at a speed of 35-40 meters per second; after impact there was an explosion of the braking engines and a fire started. I was not able to report on the fate of the cosmonaut earlier since nobody could see anything, and during that time we extinguished the fire in the ship by covering it with dirt. Only after carrying out excavations were we able to find Komarov's body.³³



Chief Designer Vasily Mishin in a photo dating from the 1960's. He served as head of the TsKBEM between 1966-1974.
Photo from the files of Peter Gorin

At noon on April 24, Ustinov called Soviet General Secretary Brezhnev, who was at an international conference of communist parties in Czechoslovakia, with information on the accident. Ustinov also edited a TASS report that was issued after a full 12 hours of silence from the Soviet press. The official line was that although the flight

had been eventless until reentry, "when the main parachute was deployed at a height of seven kilometers, the spaceship, according to preliminary reports, crashed at great speed as a result of the parachute cords getting entangled, killing Komarov."³⁴

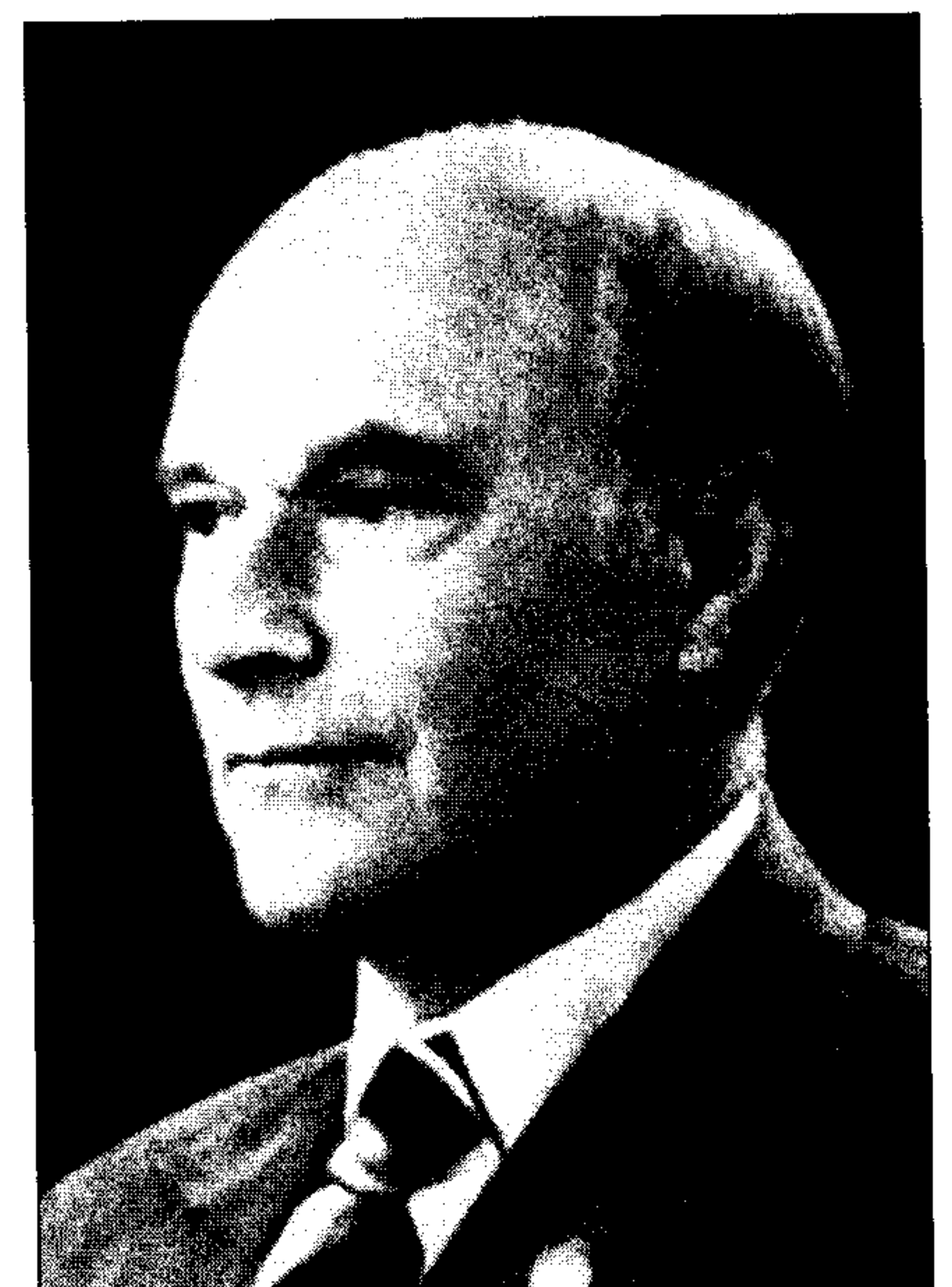
In the early afternoon, State Commission members Kerimov, Keldysh, as well as Chief Designers Mishin, Fedor D. Tkachev and Gay I. Severin arrived at the impact point, escorted by KGB agents. Soon, senior engineers from the TsKBEM including Deputy Chief Designer Pavel V. Tsybin and specialists involved in *Soyuz* development arrived to

catalog and inspect the entire landing area. Komarov's remains were taken in a coffin back to Moscow arriving an hour after midnight on April 25. On board the aircraft were Keldysh, Kamanin, and the other cosmonauts who had trained for the mission, Bykovskiy, Gagarin, Gorbatko, Khrunov, Kubasov, Nikolayev, and Yeliseyev. They were met in Moscow at the airport by Komarov's widow, Valentina Yakovlevna Komarova. His remains were then cremated and the urn placed in the Red Banner Hall of the Central House of the Soviet Army for mourners to pay homage. The next day, the Soviet Party and government gave him a state funeral with full honors and his ashes, like Korolev's, were interned in the Kremlin Wall. In a grisly aside to his death, not all of Komarov's remains were found during the initial search, and a group of Young Pioneers, the equivalent of Boy Scouts in the USSR, discovered additional remains that were later buried at the crash site itself. Reportedly, Party officials took great pains to hide this fact from the general public.³⁵

THE INVESTIGATION

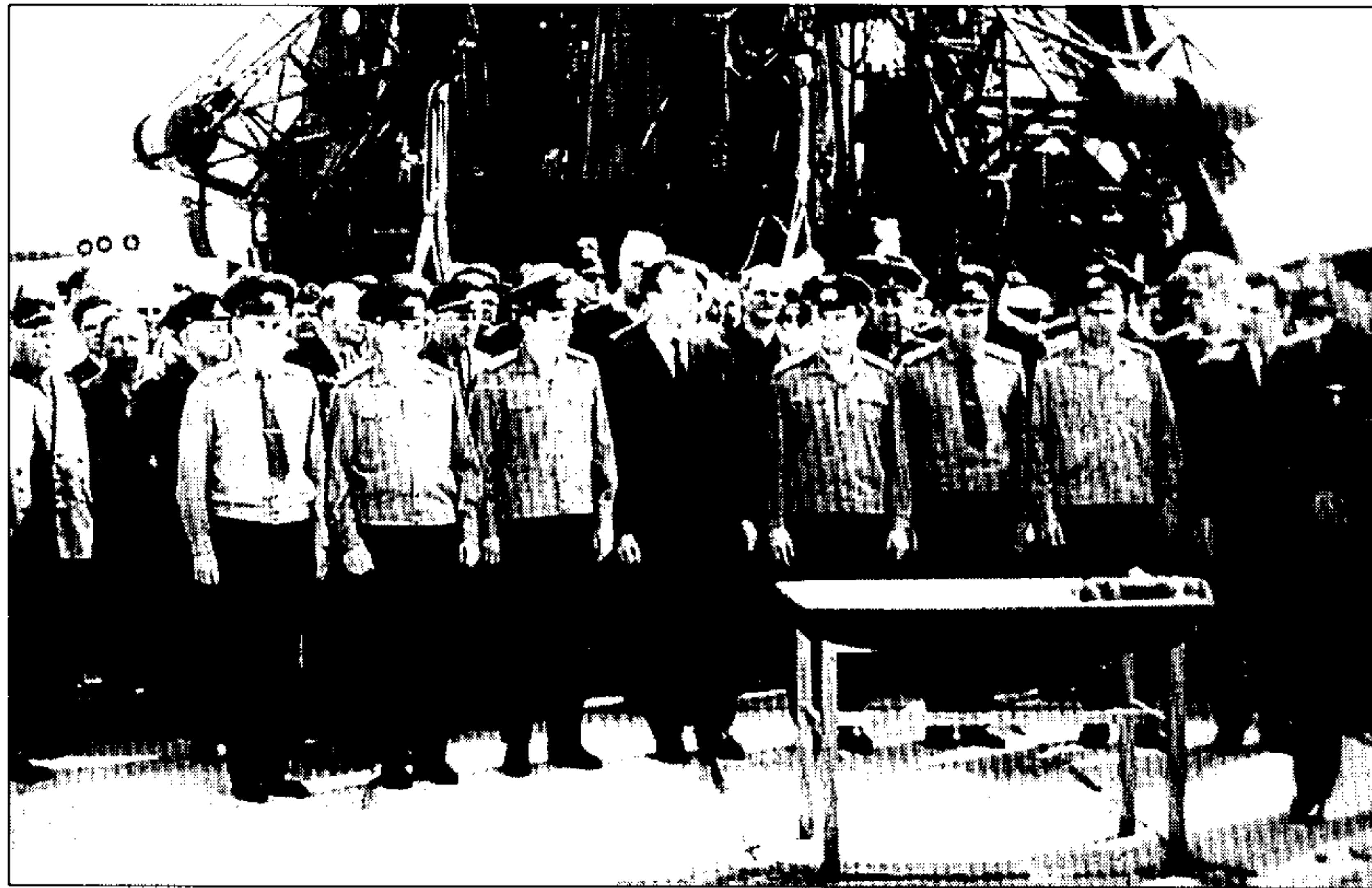
All further piloted flights were indefinitely canceled at the time. On April 27, Ustinov met with the leading space industry representatives and established a special governmental commission headed by himself to determine the causes of the accident. The Commission included seven subcommissions. One of them, to investigate the landing itself, was headed by the recently appointed Director of the M. M. Gromov Flight-Research Institute (LII) Viktor V. Utkin, a respected aeronautical engineer. The Commission included two representatives from the TsKBEM, Chief Designer Mishin and Deputy Chief Designer Bushuyev. *Soyuz-1/2* backup cosmonauts Gagarin and Bykovskiy also served as members.³⁶

The Utkin Subcommission finished its work, which included some experimental analyses, by June 20, and emerged with the cause of



Deputy Chief Designer Konstantin Bushuyev of the TsKBEM in the early 1960's.
Photo from the files of Peter Gorin

the accident: a release failure in the container block of the primary parachute. The parachute was packed in a container whose hatch was jettisoned, releasing a 'braking' or drag parachute, slowing down the vehicle to a manageable 40 meters/second, sufficiently slow to allow the primary parachute to fill up with air instead of shredding. The drag parachute itself was supposed to pull out the main parachute, but it did not do so because the latter had gotten jammed in the container. Under nominal circum-



Soyuz-1/2 cosmonauts arriving at the Baykonur Cosmodrome in April 1967 for launch. Front row from the left are: Vladimir Komarov (*Soyuz-1*), Valery Bykovskiy (*Soyuz-2*), Yevgeniy Khrunov (*Soyuz-2*), Yuriy Gagarin (*Soyuz-1* backup), Andrian Nikolayev (*Soyuz-2* backup), Viktor Gorbalko (*Soyuz-2* backup), and Valeriy Kubasov (*Soyuz-2* backup). Photo © Christian Lardier

stances, automated instruments on board the capsule would have detected an increase in velocity, discarded the primary drag and main parachutes, and activated the backup system. On *Soyuz-1*, once instruments detected the velocity increase, the capsule was unable to discard the primary chute since it was still stuck in the container. This meant that the primary drag chute was still deployed above the spacecraft. Once the single backup parachute was released it was to have come out in the shape of a long thin cylinder and then unfurl to its dome shape. In Komarov's case, the backup chute began to extend under the still attached drag parachute from the primary system. Hindered by the flailing drag chute, the backup parachute never filled with air. Without any means of braking, the ship plummeted and hit the ground at a velocity of 144 kilometers/hour (40 meters/second). An autopsy of Komarov confirmed that he died on impact with the ground and that the effects of the fire were secondary. Despite rumors to the contrary, Komarov did not cry or scream before the impact, although during the last seconds he was surely aware that he had little chance to live.³⁷ Due to the rapid velocity of descent, the frontal heatshield was never discarded at an altitude of three kilometers, and the soft-landing engines never fired prior to touchdown. The latter, in fact, detonated *after* landing, burning with the 30 kilograms of concentrated hydrogen peroxide from the capsule's attitude control engines. From launch to impact, Komarov's ill-fated flight had lasted 1 day 2 hours 47 minutes and 52 seconds.

The commission discovered that the reason that the primary parachute never issued was due to friction *within* the container, between the parachute and the inside walls of the container. The increased pressure within the parachute container relative to the low pressure outside the vehicle caused the parachute to simply block up against the insides of the container. This effect was never detected on four drop tests

of the parachute system prior to the flight. As late as 1990 Chief Designer Mishin continued to believe that the parachute had been in-

correctly packed during preparations. The solar panel failure was later traced to the panel getting snagged on the external vacuum-shield cover of the spacecraft. The 45K attitude control sensor had failed due to a "steam-up" of its optical surface. The Commission recommended redesigning the parachute container by making it conical instead of cy-

lindrical, increasing its internal volume, and polishing the inside walls. Additional measures would include installing an autonomous node for separating the primary drag chute, and photographing the assembly of the parachute packages.³⁸

There was also an unofficial and more likely version of the cause of the accident, one that attributed the accident to gross negligence on the part of technicians at the TsKBEM's manufacturing plant. During pre-flight preparations, the two *Soyuz* ships had been coated with thermal protection materials and then delivered into a high-temperature test chamber to polymerize the synthetic resin. In the case of the two *Soyuz* ships for the April 1967 mission, technicians baked the vehicles in the chamber with their parachute containers, but apparently *without* the covers for the containers. In Deputy Chief Designer Chertok's investigation of the matter in the early 1990s, he could not find anyone still alive who could remember why the covers had been left off. Due to the omission of the covers, the interiors of the parachute containers were coated with the polymerized resin that formed a very rough surface, thus eventually preventing the parachute from deploying on *Soyuz-1*.³⁹ Clearly the most chilling implication of this manufacturing oversight was that both *Soyuz* spacecraft were doomed to failure, i.e. if Komarov had not faced any troubles in orbit and the *Soyuz-2* launch had gone on as scheduled, all four cosmonauts would have certainly died on return.

The unofficial cause of the accident was never included in the official report on *Soyuz-1*, partly because those at the manufacturing plant who knew of the violation of testing procedure chose to remain silent on the issue so as not to incriminate themselves. This, of course, still doesn't explain why technicians never noticed the rough surfaces during the packing of the parachutes. Perhaps Mishin's assertion that



Soyuz-2 EVA cosmonaut Aleksey Yeliseyev in front of his EVA suit and backpack.

Photo © Asif A. Siddiqi

the parachutes were packed incorrectly was also true? The existence of concurrent official and unofficial versions raises at least a question of how the Soviets managed crisis resolution in their space program in the 1960s. Clearly, job security for some was a big factor in squelching the unofficial version of the events. But how did a post-accident testing program incorporate

procedures that accounted for the unofficial version without explicitly acknowledging it? Was the unofficial account common knowledge among technicians and engineers? These questions still remain unanswered despite the fact that the massive official history of Mishin's organization, published in 1996, finally included both the official and unofficial causes of the *Soyuz-1* accident.⁴⁰

The one major casualty of the post-*Soyuz-1* investigation was Chief Designer Tkachev of the Scientific-Research and Experimental Institute of the Parachute-Landing Service (NIEI PDS) who had designed the *Soyuz* parachute system. Although the unofficial version clearly exonerated his organization of any blame, Tkachev was fired from his job in 1968 ending his role in designing the parachute systems for *Vostok*, *Voskhod*, *Zenit*, *Soyuz*, and many other Soviet spacecraft of the era. Two parachute failures during tests following *Soyuz-1* apparently sealed his fate.⁴¹ He was replaced by Chief Designer Nikolay A. Lobanov.

Through the years, there have been sporadic but unconfirmed reports of Komarov bidding his farewells in orbit, Komarov screaming to his death, and even Komarov attempting to repair his ship in space by climbing into inaccessible areas of his ship.⁴² All of these can be rejected as untruths or exaggerations. With regard to foreign monitoring of his mission, there was one postscript to the mission that emerged thirty years after *Soyuz-1*. Boris A. Pokrovskiy, a high-ranking official in the Command-Measurement Complex, the Soviet space tracking service, wrote in his memoirs in 1996 that:

I remember that several days after Komarov's death I was summoned by General A. G. Karas (the then-head of the 'military space forces') who told me on the telephone to bring a tape-recorder to his office. It turned out that the USSR Ministry of Foreign Affairs had forwarded a tape received via "diplomatic channels" from the FRG (West Germany). Remembering that I knew a little German, Andrey Grigoryevich invited me to listen to the tape that German specialists had recorded by ra-

dio containing several minutes of information from on board '*Soyuz-1*.' The specialists' commentary on the tape was naturally in German. From Komarov's brief phrases it was possible to conclude that he was somehow distraught, and later through the radio noise it was possible to hear the word "killed." But no words were spoken on the parachute system. There were words on the rise of temperature inside the ship. The recording was made, apparently, on one of the last orbits, if not the final one. The German commentary was not especially interesting...⁴³

CONCLUSION

In retrospect, the *Soyuz-1* flight should not have been carried out when it was. The spacecraft was insufficiently tested in space conditions, and was certainly not ready for the ambitious first mission it was scheduled to accomplish. Although participants continue to deny that there was explicit pressure from Brezhnev, Ustinov, and Serbin to accomplish the flight as soon as possible, the *implicit* pressure had a much more imposing effect. It was not just a matter of Soviet prestige in space exploration, it was also the fact that perhaps many of the leading designers' jobs were on the line. When Brezhnev or Ustinov complained about the lack of Soviet successes in space, it translated into political pressure on Mishin, Kerimov, Keldysh, and others. Thus, both sides made decisions that were counterproductive and eventually had fatal consequences to the Soviet space program. All told, the responsibility and guilt for the accident lay not on the conscience of any one man, but on a technological culture that considered high risks acceptable in the face of incessant political pressure from above.

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NOTES

¹ Yu. P. Semenov, ed., *Raketno-Kosmicheskaya Korporatsiya "Energiya" imeni S. P. Koroleva* (Korolev: RKK Energiya named after S. P. Korolev, 1996), pp. 180-181.

² N. Kamanin, "For Him, Living Meant Flying" (in Russian), *Vozdushniy transport* 9 (1994): 9. The other two speak-

ers were Maj.-Gen. A. G. Karas (Commander of the Central Directorate of Space Assets) and Maj.-Gen. A. I. Kutasin (the Air Force head for rescue and recovery operations).

³ Ibid.

⁴ The four understudies were Beregovoy, Kolodin, Shatalov, and Volynov. Most notably, first cosmonaut Yuriy A. Gagarin was included as a key member of the training group despite widespread concern among the upper echelons of the Soviet space program that he was too "valuable" to lose on a mission. On December 21, 1963, Gagarin was officially moved to a desk job as a Deputy Director of the Air Force's Cosmonaut Training Center (TsPK) at Zelenyy near Moscow. Lt.-Gen. Kamanin, in April 1963, wrote in his journal that "Gagarin hopes that someday he will fly new space missions. It is unlikely, however, that this will happen. Gagarin is too dear to mankind to risk his life for the sake of an ordinary spaceflight." See Kamanin, "For Him, Living Meant Flying." Gagarin, unwilling to accept a desk job, vigorously pursued his case and was allowed into the *Soyuz* training group in September 1965.

⁵ Ustinov's official title was Secretary of the Central Committee for Defense Industries and Space. There was apparently also a State Commission meeting the same day. See Viktor Mitroshenkov, *Zemlya pod nebom* (Moscow: Sovetskaya rossiya, 1987) p. 404.

⁶ Victor Yevsikov, *Re-Entry Technology and the Soviet Space Program (Some Personal Observations)* (Falls Church, VA: Delphic Associates, 1982), p. 4. See also Dmitriy Payson, "Eternal 'Soyuz'—Today Marks the 25th Anniversary of the First Docking in Orbit" (in Russian), *Nezavisimaya gazeta*, January 15, 1994, p. 6 where the author states that "The *Soyuz* was hastily prepared for launching and it was launched (an unprecedented act!) despite the categorical refusal of Vasiliy Mishin..."

⁷ G. Salakhutdinov, "Once More About Space" (in Russian), *Ogonek* 34 (August 18-25, 1990): 4-5.

⁸ Ibid.

⁹ *Soviet Space Programs, 1966-70: Goals and Purposes, Organization, Resources, Facilities and Hardware, Manned and Unmanned Flight Programs, Bioastronautics, Civil and Military Applications, Projections of Future Plans, Attitudes Toward International Cooperation and Space Law*, Prepared for the Committee on Aeronautical and Space Sciences, U.S. Senate, 92nd Cong., 1st Sess., U.S. Government Printing Office, Washington, D.C., December 1971, p. 364.

¹⁰ Ibid., p. 364; Peter Smolders, *Soviets in Space* (New York: Taplinger Publishing Co., Inc., 1973), p. 150.

¹¹ Mitroshenkov, *Zemlya pod nebom*, pp. 405-406. Among the cosmonauts accompanying Kamanin were rookie G. T. Beregovoy, and veterans A. A. Leonov and P. R. Popovich. Note that another source says that the prime and backup crews arrived at the launch site on April 10, 1967. See Grigoriy Reznichenko, *Kosmonavt-5* (Moscow: Politicheskoy literatury, 1989), p. 97.



Soyuz-2 cosmonauts Aleksey Yeliseyev and Yevgeniy Khrunov rehearsing their EVA transfer in and airborne laboratory during a parabolic drop. Photo © Asif A. Siddiqi

¹² Lev Kamanin and Aleksandr Nemov, "Komarov's Star: The Tragic Details of the Testing of the 'Soyuz-1' Space Ship" (in Russian), *Poisk* 5 (June 1989): 4-5.

¹³ Ibid. There was a minor delay on April 18 when a valve on one of the systems for loading nitric acid into the spacecraft failed. The problem was fixed without much delay.

¹⁴ Ibid.

¹⁵ *Soviet Space Programs, 1966-70*, p. 18; Mitroshenkov, *Zemlya pod nebom*, p. 407; Kamanin and Nemov, "Komarov's Star."

¹⁶ For a summary of these rumours, see James Oberg, "Soyuz-1 Ten Years After: New Conclusions," *Spaceflight* 19 (1977): 183-189.

¹⁷ Smolders, *Soviets in Space*, p. 156.

¹⁸ Kamanin and Nemov, "Komarov's Star"; B. Y. Chertok, *Rakety i lyudi: goryachiye dni kholodnoy voyny* (Moscow: Mashinostroyeniye, 1997), pp. 444-445.

¹⁹ Kamanin and Nemov, "Komarov's Star"; M. F. Rebrov, *Kosmicheskiye katastrofy* (Moscow: IzdAT, 1993), p. 27; Chertok, *Rakety i lyudi*, pp. 445-446.

²⁰ Kamanin and Nemov, "Komarov's Star"; *Russian Space History, Sale 6516* (New York: Sotheby's, 1993), description for lot 46; Reznichenko, *Kosmonavt-5*, p. 97. One unconfirmed source suggests that Komarov may have actually

tried to fire his main engine to change his orbit. According to Leonard Nikishin, "Soviet Space Disaster on the Revolution's Anniversary: How and Why Soviet Cosmonaut Komarov Died," *Moscow News* 9 (March 1-8, 1992): 16, "The first orbital correction was widely off mark because the maneuver thrusters' exhaust affected the operation of the attitude control system's ion sensors."

²¹ Salakhutdinov, "Once More About Space."

²² Rebrov, *Kosmicheskiye katastrofy*, pp. 27-28.

²³ Chertok, *Rakety i lyudi*, pp. 446-447; Kamanin and Nemov, "Komarov's Star."

²⁴ Chertok, *Rakety i lyudi*, 447.

²⁵ Nikishin, "Soviet Space Disaster on the Revolution's Anniversary"; Kamanin and Nemov, "Komarov's Star"; Chertok, *Rakety i lyudi*, p. 447.

²⁶ Chertok, *Rakety i lyudi*, p. 448.

²⁷ Rebrov, *Kosmicheskiye katastrofy*, p. 28.

²⁸ Iosif Davydov, "How Could That Have Been?: Slandered Space" (in Russian), *Rossiyskaya gazeta*, June 11, 1992, p. 5. Author's emphasis.

²⁹ Ibid.

³⁰ Nikishin, "Soviet Space Disaster on the Revolution's Anniversary." Note that in Semenov, *Raketno-Kosmicheskaya Korporatsiya...*, p. 181, the first detection is said to have been from an *Il-14* aircraft while in Nikishin, "Soviet Space Disaster on the Revolution's Anniversary," the author suggests that it was from a helicopter.

³¹ Kamanin and Nemov, "Komarov's Star."

³² Davydov, "How Could That Have Been?."

³³ Kamanin and Nemov, "Komarov's Star."

³⁴ Smolders, *Soviets in Space*, p. 159.

³⁵ Semenov, *Raketno-Kosmicheskaya Korporatsiya...*, p. 181; Kamanin and Nemov, "Komarov's Star"; Nikishin, "Soviet Space Disaster on the Revolution's Anniversary."

³⁶ Semenov, *Raketno-Kosmicheskaya Korporatsiya...*, p. 182; Chertok, *Rakety i lyudi*, p. 453. For Gagarin, see Mitroshenkov, *Zemlya pod nebom*, p. 411. For Bykovskiy, see Reznichenko, *Kosmonavt-5*, p. 97.

³⁷ Rebrov, *Kosmicheskiye katastrofy*, p. 29; Semenov, *Raketno-Kosmicheskaya Korporatsiya...*, p. 182; Nikishin, "Soviet Space Disaster on the Revolution's Anniversary." Note that in Davydov, "How Could That Have Been?," the author gives the impact velocity as 26-30 meters/second (or 94-108 kilometers/hour). Most Western sources quote the incorrect 450 kilometers/hour.

³⁸ Semenov, *Raketno-Kosmicheskaya Korporatsiya...*, 182; Chertok, *Rakety i lyudi*, p. 457; Salakhutdinov, "Once More About Space."

³⁹ Chertok, *Rakety i lyudi*, p. 457; Semenov, *Raketno-Kosmicheskaya Korporatsiya...*, p. 182.

⁴⁰ See Semenov, *Raketno-Kosmicheskaya Korporatsiya...*, p. 182.

⁴¹ Chertok, *Rakety i lyudi*, p. 458.

⁴² For one of the more outlandish examples of a recent "tabloid" account of Komarov's death in the Russian press, see Yana Yurova and Yuriy Ryazhskiy, "Cosmonauts Interviewed on Past, Future of Space Program" (in Russian), *Moskovskiy komsomolets*, October 19, 1994, p. 8. The authors of the article claim that Komarov somehow climbed into the "pressurized service bay" of the ship, presumably by somehow puncturing through the heat shield. In the service bay now, Komarov then discovered that the main crew module he had just vacated had depressurized. Trapped in the cramped bay, but somehow possessing of a radio transmitter, Komarov evidently then found the time to swear at all the managers of the space program including Soviet leader Brezhnev. He apparently died, so the story goes, when oxygen expired from the service bay.

⁴³ B. A. Pokrovskiy, *Kosmos nachinayetsya na zemlye* (Moscow: Patriot, 1996), p. 403.