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The Almaz Space Station Complex: A History, 1964 - 1992

Part 2: 1976 - 1992*

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During the Cold War, both the United States and the Soviet Union explored the possibility of using humans in space for military purposes. The only such project that was brought to fruition was a Soviet military space station program known as "Almaz." Between 1973 and 1976, the Soviets launched three Almaz stations, which were publicly known as Salyut-2, Salyut-3, and Salyut-5. Several crews visited the stations with varying degrees of success. A major element of the Almaz program was the large Transport-Supply Ship (TKS), a vehicle that was never used with Almaz, but eventually served as the basis for the core of the International Space Station. This article is an attempt to use recently published information from Russia to present a history of the Almaz program.

Keywords: Almaz, Military Space, Soviet Union, TKS, Salyut, Space Stations

(Part 1 ended with Section 11. Plans for the Future. *To aid continuity, Section 11 is taken as the opening section of Part 2.)*

11. Plans for the Future

Although the record with Almaz missions had been mixed, the Soviet military and government apparently had a lot of confidence in the project. On 19 January 1976, the Central Committee and the Council of Ministers issued a major decree (no. 46-13) entitled "On Future Work on the Creation of the 'Almaz' Complex" that stipulated several deadlines for future work in the project. For the next Almaz station, the decree noted:

- in 1977, end the first stage of flight-testing of the third Almaz station, OPS-3, using the Soyuz spaceship to deliver crews.

For the TKS and its Return Apparatus, the document set the following dates:

- in the first quarter of 1976, begin robot flights of the Return Apparatus;
- in 1976, begin two robot space flights of the TKS as a whole; and
- in 1978, begin five piloted flights of the TKS.

The decree also gave formal approval for Chelomey to begin work on a fundamentally modified version of the Almaz station:

- in the second quarter of 1976, end work on the "draft plan" of a modified Almaz space station with two docking ports, OPS-4, a station to be used for continuous piloted operations by using rotating crews; and
- in 1977, move to orbital testing of OPS-4; one of the docking ports would have a Return Apparatus attached to it.

Finally, the decree set a date for operational use of the complete complex:

- in 1980, declare the entire Almaz system (OPS, TKS, and VA) to be completely operational [99].

The decree's stipulations meant that for the first time, Chelomey would be flying both the Almaz OPS and the TKS simultaneously in orbit. As plans went in early 1976, the design bureau would fly Almaz OPS-3 in 1976, fly the advanced OPS-4 in 1977, begin piloted flights of the TKS in 1978, and the declare the whole system operational within two years. It was an ambitious schedule, and its success would depend on a combination of factors, including the success of the next Almaz, the results of testing of the TKS, and finally, but not least, the winds of political change in the upper echelons of the Soviet defense industry.

Cosmonauts continued to prepare for future Almaz missions. The practice was for backup crews from past missions to recycle into prime crew spots for the next flight. The Almaz training group, the Second Department of the First Directorate at the

*Part 1: 1964 - 1976 *appeared in the November/December 2001 issue, JBIS, Vol. 54, pp.389-416, 2001.*

Cosmonaut Training Center was headed by Col. Yevgeniy V. Khrunov from June 1973 (who replaced Shonin, now transferred to the Apollo-Soyuz Test Project). Khrunov himself was replaced by Col.-Engineer Yuriy P. Artyukhin, fresh off his two week mission to Salyut-3, on 11 December 1974. After a major restructuring of the cosmonaut squad, the Almaz group was headed by Col. Viktor V. Gorbatko from 30 March 1976 [100].

12. The Third Almaz Station

12.1 The Launch of OPS-3/Salyut-5

As per the decree in January 1976, the third Almaz station was prepared on time and readied for launch the same year. OPS vehicle no. 0103 was successfully launched into orbit at 2104 hours Moscow Time on 22 June 1976 by a three-stage Proton-K booster. Initial orbital parameters were announced as 219 x 260 kilometers at 51.6° inclination [101]. Officially named Salyut-5, the station performed a series of orbital maneuvers that deposited it in a fairly standard "military" orbit of 260 x 270 kilometers, about 70 kilometers lower than those for the "civilian" DOS articles.

For tracking during the Almaz project, the Soviets used 12 Scientific-Measurement Points (NIP) spread across the Soviet landmass, one of which, NIP-16 at Yevpatoriya, was the site of the main Flight Control Center. During a standard 24 orbit day, the station flew over the Soviet Union for 17 orbits. During the remaining seven orbits, the Soviets used sea-based ships. During the Salyut-3 mission, they used the *Kosmonavt Yuriy Gagarin* and the *Kosmonavt Vladimir Komarov*. The more modern *Gagarin* was stationed in the north Atlantic near Newfoundland, while the *Komarov* remained off the coast of Cuba. For the Salyut-5 mission, the Soviets added the *Akademik Sergey Korolev*, but took off line the *Komarov* [102]. Additionally, the older *Morzhovets* and *Bezhitsa* also supplemented communications.

12.2 The Soyuz-21 Mission

About two weeks following the beginning of the station's mission, the first crew for the station was launched into orbit at 1508 hours 45 seconds Moscow Time on 6 July 1976 in the Soyuz-21 spacecraft. On board were Col. Boris V. Volynov and Lt.-Col.-Engineer Vitaly M. Zholobov, both of whom has served on the backup crew for the previous Almaz mission. Volynov was a member of the famous 1960 group of cosmonauts and had commanded the Soyuz-5 flight in early 1969. It was Zholobov's first flight into space after a wait of over 13 years as a cosmonaut. Initial orbital parameters for the Soyuz vehicle were announced as 193 x 253 kilometers at 51.6°. Originally, mission planners had expected to carry out a three-month mission, but sometime prior to launch, the State Commission decided to limit the flight to a more conservative 60 days [103]. After launch, the Chairman of the State Commission – presumably Strategic Missile Forces officer Col.-Gen. Grigor'yev – announced that the flight program of Soyuz-21 was "to fulfill the targets set for space science by the 25th [Communist Party] Congress...to benefit the national economy" [104]. He made no mention of any military work.

Despite the modifications to the *Igla* system, once they were in orbit, an alarm went off that indicated that one of the antennas of the system had not deployed. The system, however, continued to operate as planned, at least in the initial phases. The crew acquired clear visual contact with the station at a range of 350 meters. As Soyuz-21 closed in on Almaz, at a range of 270 meters, relative velocity between the objects abruptly increased beyond acceptable limits, i.e. more than two meters per second. At that point, the crew asked permission to switch over to manual control. Ground control replied that "The approach process is going normally...wait for switching off of the 'Zone of Braking' indicator light" [105]. The crew replied soon that the light had turned off, meaning that the spaceship was no longer increasing in velocity towards the station. At the same time, it was clear that lines of sight for the two vehicles were slowly diverging beyond acceptable limits. The crew had to take urgent action or else the ships would pass each other by. At a range of 70 meters, Volynov switched over to manual control and skillfully brought the Soyuz to the Almaz for a successful docking at 7 July at 1640 hours Moscow Time. The crew entered the station within five hours of docking.

Within a few days, Volynov and Zholobov settled down to a routine of photo-reconnaissance activities supplemented by some medical, technological, astrophysical, and Earth resources-oriented experiments. The primary goal of the mission was photo-reconnaissance, some of it coordinated with Operation Sever ("North"), a massive Soviet air and sea military exercise east of Siberia. Although the Soviets naturally refrained from making any commentary on any military experiments, Western analysts were quick to point out that the mission was primarily military in nature. By 19 July, the American trade journal *Aviation Week and Space Technology* was reporting that Salyut-5 was definitely a mili-

tary reconnaissance platform and that the experiments conducted on board were little more than "window dressing" to hide the actual experiments program. Later, on 9 August, the same journal reported that voice communications and telemetry monitored during the mission indicated that the Soviets were trying to conceal voice exchanges between the station and the ground. Often, once the complex was over Soviet territory, normal voice communications would cease, and the crew would transmit data via "non-standard" frequencies or transmitters. At several points during the mission, TASS announced that the crew were conducting observations of the Soviet landmass. Presumably, these were of a military nature. For example, on 26 July, the cosmonauts took photos of the southern areas of the country, while five days later, TASS announced that the crew had began studying a vast amount of territory in the south and north of the Soviet Union – although the work was hindered by poor weather [106].

Despite the relative scarcity of information released about the mission, the two cosmonauts on 8 July gave a televised tour of part of the station. On 15 August, the crew held a question and answer session with children on a Young Pioneers tour of the Flight Control Center [107]. Many operations of controlling the station were performed under ground control to relieve the cosmonauts from the routine tasks. Communications with the crew was also kept to a minimum and reportedly only an emergency situation was reason enough to require informing the cosmonauts. Like previous space stations, the crew exercised for about two hours every day to maintain a healthy degree of muscle strength. Most of the exercise equipment was provided by the Air Force's State Scientific-Research Institute of Aviation and Space Medicine (GosNII AiKM). For the first time on a Soviet space mission, the crew also used a "mass meter" to measure their masses in space. In addition to the experiments listed in Table 12, the cosmonauts evidently also tested a mockup of a propellant transfer system, although very little information was released on the details.

Events on board the station were more or less normal through the first month, although both cosmonauts evidently felt an unpleasant odor during their first days on board. The odor was not strong enough to affect their work routine, but the crew worried whether the smell might be from a fuel leak [108]. Their mission took an abrupt turn on their 42nd day in orbit, on 17 August. As the crew were working, the station's alarm suddenly went off; simultaneously, all interior lights turned off and several onboard systems simply died. At the time, the station was passing over the night side of the Earth. In the darkness, with the loud shrill sound of the siren, the crew were totally confused. Within seconds, however, they first turned off the alarm, only to hear dead silence, i.e. it seemed that all of the station's systems had shut down. Volynov immediately transmitted an emergency message to ground control: "There's been an accident on board." Ground control tried to establish what had happened, but just then the station passed out of communications coverage. With no help from the ground, the crew were left on their own. They rejected the possibility that there had been some sort of decompression since there was no audible hiss nor was there any indication that air pressure was dropping. In slowly checking the station's systems, the crew discovered that not only had the station's life-support systems stopped functioning, but that the station had also lost complete attitude control and was drifting. Volynov moved to the station's main control panel while Zholobov moved to the station's periscope, and the two of them, through verbal cues, managed to restore normal attitude. Over a course of two tense hours after the first alarm, the crew managed to restore most of the station's systems back to normal, including the life-support system [109]. If the crew believed that the worst was over, however, they were in for a shock.

After the emergency, Zholobov's health began to deteriorate. He began to suffer from severe headaches, insomnia, nausea, and loss of appetite. Medicine from the first-aid kit was of no help; his condition continued to worsen day by day. At first, the crew decided not to report Zholobov's condition to the ground, hoping that it would improve, but during one routine contact, probably on 20 August, Zholobov himself mentioned his discomfort to ground physicians. Volynov added that his Flight Engineer was looking pale, weak, and "looked as if he was a very sick man" [110]. The following day, the newspaper *Izvestiya* reported that psychologists monitoring the mission had asked for music to be played to the crew to ease the effects of prolonged isolation. The newspaper reported that the cosmonauts had been suffering from "sensory deprivation" [111]. Medication was unable to treat Zholobov's condition, although on 23 August, the crew were said to have carried out observations with the ITS-5 telescope. Journalists who had been stationed at Yevpatoriya were apparently asked to leave by this time. Eventually, with no hope that Zholobov's health would improve, ground control was forced to make an urgent decision. On 23 August, Deputy Chairman of the State Commission,

TABLE 12: *Named Civilian Experiments Conducted on board Salyut-5.*

Name / Instrument	Activity
Amak-3	instrument to analyze blood samples to determine metabolic processes and immune responses and to study concentration of certain chemicals
Aquarium	study of the development of guppy fish and Danio rerio fish
Biokat	study of plant growth in three 'biofixators' with eggs of the danio fish, crepis plant seeds, mushroom spores
Chibis	vacuum suit worn to exert negative pressure on lower body
DRP-90	dynamometer
Fizika/Diffuzia	production of an alloy from 25% toluene and 75% dibenzyl with mixing by thermal convection
Fizika/Potok	study of capillary action of increased surface tension
Fizika/Sfera	study of the melting and hardening of molten metals in weightlessness (mixing of a bismuth-lead alloy with cadmium and tin, which was then cooled down)
Impul's-2	comparison of threshold of sensitivity of the vestibular apparatus to electrical irritants
ITS-5	infrared telescope from the Lebedev Institute of Physics for studying the Sun, the lunar surface, galactic sources, the vertical distribution of water vapor and ozone in the Earth's atmosphere
Kristall	study of the growth of monocrystals over periods lasting 24, 18 and 11 days
Kultivator	use of drosophila to study changes in the chromosome levels
Levkoy-3T	measurement of blood pressure in the brain by rheoencephalography
Pal'ma-3M	measurement of cosmonaut reaction times
Plotnost'	measurement of bone density
Polinom-2M	multi-functional instrument to check blood circulation, breathing patterns, body temperature and heart functions, used for coordination of the overall medical program
Priboy	experiment to test recycling of water
Reaktsiya	soldering (at 1,200°C) of stainless steel with a magnesium-nickel solder
Rezeda-5	study of breathing capacity
Terrarium	study of turtles in weightlessness
Tonus	measurement of muscular tone to identify muscle weakness
Veter	vacuum capacity instrument

Sources: Bert Dubbelaar, *The Salyut Project* (Moscow: Progress Publishers, 1986); I. B. Ushakov et al., eds. *Istoriya otechestvennoy kosmicheskoy meditsiny (po materialam voyenno-meditsinskikh uchrezhdeniy)*, Voronezh: VGU, 2001, pp. 56-57, 108; Christian Lardier, *L'Astronautique Soviétique* (Paris: Armand Colin, 1992)., pp. 205-206; Phillip S. Clark, *The Soviet Manned Space Program: An Illustrated history of the men, the missions, and the spacecraft* (New York: Orion Books, 1988), p. 72; *Soviet Space Programs: 1976-80 (With Supplementary Data Through 1983): Manned Space Programs and Space Life Sciences*, Prepared for the Committee on Commerce, Science, and Transportation, U.S. Senate, 98th Congress, 2nd Sess. (Washington, D.C.: U.S. Government Printing Office, October 1984), pp. 561-562.

former cosmonaut Maj.-Gen. German S. Titov – who at the time was a senior official in the military space forces – spoke personally to Volynov. The Soyuz-21 Commander reported that Zholobov's condition was rapidly worsening, and that he himself was beginning to suffer from headaches. Titov decided to immediately return the crew back home [112]. Volynov took over the responsibility of maintaining the station in a working mode, and transferred documents, exposed film, and the results of experiments to the Soyuz-21 ferry vehicle. In a statement that aroused strong suspicion among Western observers that the mission had been terminated early, the Soviet press announced at 1004 hours GMT on 24 August that the mission would end within 10 hours [113]. The quick notice of the landing seemed to have taken the reporters of Radio Moscow by surprise, making the normally major news story only a one line addition to the news broadcast [114].

The drama in the mission did not end with Zholobov's illness, and the undocking from the Almaz station proved to be one of the most nerve-racking for any Soviet crew. During separation of the Soyuz-21 ferry (at around 1800 hours Moscow Time) on 24 August, the latches on the docking node failed to open up completely and following an automatic firing of the Soyuz thrusters to move away from the station, the latches became jammed, leaving the Soyuz vehicle suspended but connected to the station. Ground controllers quickly relayed a series of emergency commands to the crew but only the first set was apparently received prior to loss of communication as the complex began to move out of range. Volynov attempt once more to detach the spacecraft but only managed to loosen the connection slightly. Volynov later remembered the look of horror on Zholobov's face. For an entire orbit, the two ships remained hanging with each other, unable to separate. It seems that a second series of commands after acquisition of communication allowed the two vehicles to successfully separate [115].

The actual landing was outside a nominal recovery window, around midnight local time. Soyuz-21's Descent Apparatus landed amid very strong gusty winds forcing an asymmetrical firing of the cush-

ioning landing jets on the capsule. The capsule landed with a very strong impact – at 2132 hours 17 seconds Moscow Time – and bounced several times over a distance eight meters before coming to rest [116]. The landing point was about 200 kilometers southwest of Kokchetav in Kazakhstan, in the middle of the Karl Marx Collective Farm. The cosmonauts found themselves hanging in mid-air suspended by their seat straps. Volynov, with great difficulty, managed to open the hatch and leave the capsule. Unable to stand up without any help, he collapsed on the ground where he made a makeshift bed in the warm southern night. Zholobov was unable to follow because his helmet had jammed on to an obstruction within the capsule. Volynov, summoning all his strength, managed to crawl up to the hatch and help Zholobov, taking care not to short-circuit the electrical wiring on the Flight Engineer's suit. Still adjusting to the Earth's gravity, the two men were too weak to move very far from the capsule, and opted not to fire off a flare, fearing that they might set the field ablaze. Within 40 minutes of landing, however, rescuers arrived on the scene to pick up the crew and the capsule [117]. Total flight time for Volynov and Zholobov was 49 days 6 hours 23 minutes and 32 seconds.

In their post-flight reports, the cosmonauts confirmed that there had been a strong odor of nitric acid in the station – perhaps the nitric acid from the engine's propellant tanks [118]. To confirm or refute the crew's contention, and to determine the reasons for the worsening state of the crew, two of the top institutions of space medicine in the country, the GosNII AiKM and the Institute of Biomedical Problems (IMBP) led an investigation commission coordinated with engineers from the TsKBM and the developers of the life-support systems. The commission investigated every possible avenue including the composition of the structural and fitting materials on the station, the nature of the preparatory technology at the launch site, the daily schedule of the cosmonauts, medical indicators, the types of medicine given to the crew, and the nature of the psychological support available to the crew during the flight [119]. Surprisingly, prior to the announcement of the final results of the commission, General Designer Valentin P. Glushko of NPO Energiya had informed top officials in the program that the reason the crew were in such poor shape was because the Almaz station carried toxic materials. Glushko was quoted as saying that "it is impossible to conduct any work on board the station" [120]. Perhaps protective of his own DOS program and fearful of losing control over all Soviet piloted operations, this may have been an attempt by Glushko to reclaim domination in the field. While the crew had indeed "subjectively sensed some strange odors" in the station which were unexplained, the investigative commission failed to find any toxic components in the blood and urine of the crew. A research institute from the Ministry of State Security (KGB), perhaps fearing sabotage, also failed to find any sign of any toxic materials in all the articles returned from Salyut-5. The final report of the commission (headed by Oleg G. Gazenko, the Director of IMBP) stated that the cause of the poor state of the crew was "overload and emotional stress" [121]. According to the report, during the mission, the cosmonauts did not get enough sleep, broke the physical training routine, and received insufficient psychological support from ground control. The commission's recommendations were to be adhered beginning the very next flight. It seems likely that the report did not reveal the whole story; on many other occasions, ground management had not hesitated to blame crews for shortened missions despite the lack of sufficient evidence. As for the near-catastrophic failure of the station in mid-August, no open sources are available to suggest possible causes. The cosmonauts themselves, both were reportedly in worse condition than earlier crews and had lost about 1.5 kilograms each during the flight. They spent the few days following landing completing their flight logs and recovering from their malaise. After about a week Volynov and Zholobov flew back to Zvezdnyy gorodok on 2 September and the next day received the usual awards of Hero of the Soviet Union.

12.3 The Soyuz-23 Mission

Ground controllers implemented at least one major orbital maneuver with Salyut-5 prior to the next launch of a Soyuz crew to the station. One of the primary goals of the mission was to set the record straight on whether the station could be used further for experiments. Indeed, the lingering doubts about the "toxic" atmosphere of the station prompted mission planners to prepare a special "laboratory" for the crew to carry to conduct air tests and trace chemical compounds in the station. They also carried gas masks to wear when entering Salyut-5 [122]. The fact that these precautions were taken indicates that although the official investigative commission had exonerated the air inside the station, there was still some suspicion about the internal atmosphere. One recent Russian source suggests that the atmosphere inside the station may have been automatically replaced – at least partially – after the early return of the Soyuz-21 crew [123]. The prime crew designated for the new flight were

rookie cosmonauts Lt.-Col. Vyecheslav D. Zudov and Lt.-Col.-Engineer. Valeriy I. Rozhdestvenskiy. Both had joined the ranks of the cosmonaut team in 1965 and had spent a significant amount of time mastering all the systems on board the Almaz. Rozhdestvenskiy, a naval officer, had evidently been included on the crew to observe U.S. ships [124].

In early October 1976, the State Commission held an official meeting at the Kosmonavt Hotel at Tyura-Tam and formally approved the choice of Zudov and Rozhdestvenskiy. Chelomey was not present, and his First Deputy at the TsKBM, Gerbert A. Yefremov reported on the state of the station. Glushko approved the Soyuz vehicle ready for flight and Lt.-Gen. Vladimir A. Shatalov, the coordinator of cosmonaut training at the Cosmonaut Training Center delivered a report on the readiness of both the prime and backup crews. The planned duration of the mission has not been revealed, although Soyuz landing windows suggest a relatively short flight of about 17 to 24 days [125]. State Commission Chairman Col.-Gen. Grigor'yev wished the crew success and hoped that they would "breeze freely" [126].

The launch of Soyuz-23 occurred on time at 2038 hours 18 seconds Moscow Time on 14 October 1976. Zudov and Rozhdestvenskiy successfully entered a 194.2 x 249.9 kilometer orbit with an inclination of 51.63° [127]. According to later reports, during the ascent to orbit, the Soyuz launch vehicle deviated from its flight path nearly the full extent possible before a possible launch abort. As a result, the initial orbit for Soyuz-23 was much lower than planned [128]. By its 16th orbit, the ferry had maneuvered close to Salyut-5 and began its final approach regime. At 2158 hours Moscow Time on 15 October, the cosmonauts put Soyuz-23 in its automatic mode for docking when it was approximately seven kilometers from the station. At about 4.5 kilometers from its target, as *Igla* was bringing the Soyuz to Almaz, Rozhdestvenskiy reported to the ground that "There are very strong fluctuations." Zudov added as the vehicle closed into about four kilometers that there were "very strong lateral fluctuations" in the vehicle [129]. By about 1,600 meters range, the spacecraft began to turn as the amplitude of the oscillations increased. Curiously, the indicator lights on board the ship that communicated parameters for lateral drift suggested that the ship shouldn't be turning. By the time, the Soyuz was 500 meters from the station, with the Soyuz now continuing to turn and with approach velocity reducing too fast to carry out a docking, Zudov urgently commanded Rozhdestvenskiy to turn off the approach program, which he did. Transcripts of the communications suggest that the crew was less than pleased with the outcome. They waited for word from the ground while still in sight of the station:

> Zudov: What a pity! Indeed...what a pity! What should be do? [in a despairing voice] The object [i.e. Almaz] is [still] visible. You understand. The object is at the present moving to the left.
>
> Rozhdestvenskiy: You understand. The object is leaving.
>
> Zudov: But who is to blame for this!? All of us! [The station is] moving to the left. The [approach] velocity was not very great [heavy sigh] [130].

At this point, the vehicles were roughly 40 meters from each other. The crew evidently requested permission to try a second attempt at docking, confident that they could still pull it off since the Soyuz ship had slowed down its turning by this time. Ground control replied by asking the crew to shut down the remaining systems on *Igla*, remove their spacesuits, and try and get some rest, adding that there would be no repeat attempt. Given that telemetry showed that the attitude control propellant load was relatively low, they apparently believed that it would be impossible to attempt a second docking attempt. Due to the absence of solar panels on the Soyuz spacecraft, the crew were severely limited in the amount of power reserves available for a second docking attempt. The crew were later told to shut off all non-essential electrical systems including the radio to conserve power and prepare for a return to Earth [131]. Unfortunately for Zudov and Rozhdestvenskiy, their Soyuz craft had already passed the landing opportunity for the day and had to wait an additional day for the next pass over Kazakhstan to land, which was during night time local time. At the time, the Soviet press announced that the docking had been canceled due to a malfunction in the rendezvous and approach electronics system aboard the Soyuz. It was the very first time in the history of the Soviet space program that a failure had been announced while a mission had been in progress.

As the tension increased among ground controllers, many important dignitaries arrived at the Flight Control Center at Yevpatoriya. Among them were General Designers Chelomey and Glushko, top leaders in the Air Force and the Strategic Missile Forces, the head of the Ministry of General Machine Building (MOM) Sergey A. Afanas'yev, and Leonid V. Smirnov, the Chairman of the very powerful Military-Industrial Commission (VPK) [132]. Meanwhile, back at the Cosmonaut Training Center, the crews' families, who had assembled at Zudov's apartment

to welcome the cosmonauts back home, were anxiously awaiting word about their safe return. Retrofire went as planned at 2002 hours Moscow Time on 16 October, and the Soyuz-23 Descent Apparatus entered the atmosphere over North Africa, the normal landing corridor for the Soyuz. Weather in the landing area was, however, not favorable. Shatalov had told the crew to stay in their seats after landing due to squall force winds and blizzard conditions at the targeted location. There was evidently little choice in the selection of a landing site due to the capsule's limited battery power, although rescuers could gain some consolation from the fact that the Descent Apparatus was effectively an all-terrain vehicle.

In the event, the capsule overshot the target landing site by 121 kilometers and drifted down under its parachute into squall force winds and fog, at temperatures of -22° C, and splashed down in sludge ice in Lake Tengiz at 2045 hours 13 seconds Moscow Time (long after dusk local time) [133]. The 32-kilometer wide Lake Tengiz is a salt lake in the middle of the spacecraft recovery zone about 140 kilometers west of Arkalyk in Kazakhstan, and has a surface area of about 1,590 square kilometers. The capsule landed in the partially frozen lake approximately eight kilometers from the northern shore. As the capsule cooled rapidly in the freezing water, the cosmonauts removed their pressure suits and put on their normal flight suits expecting a quick recovery. The cosmonauts were exhausted after removing their pressure suits in the small capsule and decided to eat some of the spacecraft's rations while awaiting recovery. Helicopters began searching for the spacecraft, but the capsule's light beacon was obscured as the helicopters descended in 50-70 meter thick fog. Only fifteen minutes following splashdown, the pyrotechnic cartridges of the reserve parachute hatch suddenly blew, violently moving the capsule into a nearly "upside-down" position. In this position, Zudov, still held by his seat straps, was suspended above Rozhdestvenskiy. The cartridges had evidently fired because the water had short-circuited two contacts. The parachute filled with water and sank to the bottom of the lake. Because the lake was rather shallow, the sunken parachute did not drag the capsule underwater with it. Communications with the crew also ceased at this time, and the bitter cold began to seep into the capsule [134].

Recovery teams tried using rubber rafts to reach the capsule but were obstructed by blocks of ice and icy sludge on the surface of the freezing lake shore, making it impossible for them to reach the spacecraft. In the heavy snow and thick fog, helicopters air-lifted amphibious vehicles to the lake, but they were unable to reach the capsule because of the bogs surrounding the lake. One helicopter, piloted by 34-year old Nikolay Kondrat'yev, flying over the lake in squall winds of up to 20 meters per second, managed to descend to about 4-5 meters above the black "smoking" waters, and with a powerful searchlight, was able to find the floating capsule. Based on received information that water, land, and air routes were effectively blocked, the recovery forces decided to wait until dawn for the helicopters to take in frogmen. Although there was no immediate threat facing the cosmonauts (since the capsule was theoretically sea-worthy), there was a concern over the amount of remaining power aboard the vehicle. Normally the vehicle's batteries were only needed for the short landing sequence of 40 minutes. The emergency situation forced the cosmonauts to shut down everything except a small interior light. Food rations were available for just such an emergency; air to breathe was available through the pressure equalization vent which was above the water line [135]. At some point, it appears that the ventilation holes of the spacecraft may have become immersed underwater, blocking the air route into the cabin. By their fourth hour after landing, the crew were apparently feeling the lack of oxygen and having problems moving at all [136]. Outside meanwhile, the snowstorm continued to prevent an immediate rescue.

Immediately after the landing, officials at the Flight Control Center at Yevpatoriya had received a report from the search and rescue service that the spacecraft had splashed down in Lake Tengiz, and that all-terrain vehicles had departed for the lake and would be arriving within an hour. A second report soon after described the terrible weather and the failure of the helicopters in picking up the capsule from the middle of the lake. A third report received at the control center around one o'clock in the morning Moscow Time indicated that all-terrain vehicles were unable to get through and that all rescue efforts would have to be suspended until dawn [137]. These reports were naturally worrying and the State Commission was seriously fearing that the crew were freezing to death inside the capsule.

Through the night, rescuers on the lake shore prepared for their mission the next day. They prepared two helicopters, one an Mi-8 capable of lifting up to 20 tons, and the second, an Mi-6, which would carry frogmen to the capsule. In preparation for the rescue, the cosmonauts put on their emer-

gency water survival suits in case they had to exit the capsule through the top hatch. The crew also turned on the exterior light beacons again in order for the helicopters to find the spacecraft in the fog and snow. At the break of dawn, with Kondrat'yev at the controls, the Mi-6 took off and found the Soyuz capsule again, this time depositing a team of frogmen next to the capsule. Between squalls of snow, the frogmen attached flotation aids to it, as the Mi-6 returned back to shore. Kondrat'yev switched helicopters, and then took off in the Mi-8 back to the capsule, this time to bring it back to the shore. Once over the capsule, the Mi-8 crew dropped a halyard to the frogmen below, who, in the still turbulent waters, secured it to the spacecraft. Unfortunately, the helicopter was unable to completely lift the capsule out of the water. Instead, Kondrat'yev began dragging the ship through the water. At about five kilometers towards the shore, the capsule nearly sank, but Kondrat'yev kept his cool, and after a 45 minute trip, harrowing for both the helicopter crew and the Soyuz-23 crew, he managed to deposit the capsule on the shore of the lake [138]. Reportedly, the cosmonauts nearly suffocated during the journey to the shore [139]. The recovery was finally over about eleven hours following touchdown. It was around dawn at Yevpatoriya when Smirnov, Afanas'yev, Chelomey, and the others finally left the center. The Soviet press announced the crew's safe recovery at 0700 hours Moscow Time on 17 October 1976. After a series of initial checkups, the crew flew back to Zvezdnyy Gorodok on 26 October and were received with a large welcome ceremony attended by many important officials. Referring to Rozhdestvenskiy, Chelomey emoted, "...fate is fair to people – they found themselves in water, bitter and salty, and one of them is a sailor" [140]. Rozhdestvenskiy had headed a naval diving team during his pre-cosmonaut days, and was one of the few cosmonauts with a non-Air Force background. In addition to praise for the crew, Shatalov also commended the performance of the recovery forces. Helicopter pilot Kondrat'yev received the Order of the Red Star for his efforts.

Yet another commission was formed to investigate the accident, this time under the chair of Vsevolod A. Avduyevskiy, the First Deputy Director of the Central Scientific-Research Institute of Machine Building (TsNIIMash, formerly NII-88). Representatives from NPO Energiya, principally flight director (and former cosmonaut) Aleksey S. Yeliseyev firmly believed that the crew was at fault for discontinuing the docking procedure. He believed that the crew could have attempted a second docking attempt (for which they had trained for) on the 33rd orbit.

The problems had all stemmed from a failure in an antenna of the *Igla* system. Evidently, there were spurious and large "oscillations" in the signals of *Igla* which had led the approach engines of the spaceship to fire in a "self-oscillation" mode. The cumulative effect was a large amplitude in lateral drift [141]. A minute-by-minute reconstruction showed that the crew may have violated prior instructions, although their decisions were not unreasonable. At 2148 hours, Soyuz-23 had acquired "capture" of its target, and all systems were nominal. At 2150, the "lateral extinguishing zone" light had come on, indicating that all lateral movements should have stopped. However, the spacecraft continued to turn since the engines responsible for stopping lateral turns were not turned on. The crew, as they reported, felt the turns, but their information suggested that they should not be turning. Despite another two minutes in the same situation, the crew opted to continue the approach. They evidently realized that discontinuing the current approach would mean abandoning the mission since propellant levels were rather low. The ship had used excessive propellant during the preliminary approach between 7.0 and 5.7 kilometers range. The crew had had the possibility to switch off the approach at four points during the entire time, and in each case had violated prepared instructions, waiting until the last possible moment to do so. However, the mitigating circumstance was that the indicator lights on board the spacecraft suggested that the approach systems were functioning normally [142].

Clearly, the Soyuz's *Igla* system was displaying repeated signs of improper performance, sabotaging entire missions. During a post-mission meeting with Minister of General Machine Building Afanas'yev, the Chief Designer of *Igla*, Armen S. Mnatsakanyan, weakly defended his product but was unable to explain why such large fluctuations (such as seen on Soyuz-23) were not detected on the ground. The Minister wanted a guarantee that *Igla* would be reliable in the future. At the time, Mnatsakanyan's organization, the Scientific-Research Institute of Precision Instruments (the former NII-648) was developing a new approach, rendezvous, and docking system for Soyuz known as *Kurs* ("Course"). In answer to Afanas'yev's demand for reliability, Mnatsakanyan replied that, "Establishing standards for fluctuations on *Igla* would be useless – the future use of *Igla* would end similarly [to Soyuz-23]. We need to quickly introduce *Kurs*" [143]. Neither Afanas'yev nor General Designer Glushko were pleased with Mnatsakanyan's response. During subsequent ground tests, engineers were unable to confirm Mnatsakanyan's hypothesis that the exces-

sive vibrations on *Igla* were due to a badly designed boom on which the *Igla*'s gyro-stabilization antenna was installed. An official Ministry report, dated 2 December 1976, stated that:

> Due to insufficient ground work and low levels of methodical measurements of primary parameters of the apparatus in all stages of its manufacture, testing, and operation which led to the unfulfilled program of the Soyuz-23 flight, a strong reprimand is issued to the Director and Chief Designer of NIITP [comrade] Mnatsakanyan and a warning is given that in case that active measures are not taken to correct the situation, he will be freed from his post [144].

Events behind the scenes were apparently moving too fast for Mnatsakanayan. On 10 December, the Ministry recalled the Chief Designer from Baykonur and ordered him to resign of "his own wishes." Mnatsakanayan refused. Finally, on 6 January 1977, the Ministry issued a formal order firing him from the post of Director and Chief Designer of the institute. Despite his best efforts to protest the decision, Mnatsakanyan never returned to his organization.

12.4 The Soyuz-24 Mission

Through the end of the year, the Salyut-5 station was kept under control for another attempt to board the station. On 22 November, the Soviet media announced that during the automated part of the mission, the station had taken photographs of the Earth, that experiments had been conducted by the ITS-5 infrared spectrometer, and that radiation from the Earth and Moon had been studied. At least three orbital maneuvers were conducted during this period, preparing the way for the third visiting mission, tentatively scheduled for February 1977. Cosmonauts Col. Viktor V. Gorbatko and Lt.-Col.-Engineer Yuriy N. Glazkov were assigned as the prime crew. Gorbatko was another cosmonaut from the original 1960 group and had flown his first space mission, Soyuz-7, in 1969. He had also served as backup on Voskhod-2 and Soyuz-5, both missions involving EVA. Since 1969 he had continuously trained in the Almaz program. His Flight-Engineer Glazkov was a rookie cosmonaut selected in 1965 and had worked on his "Candidate of Technical Sciences" thesis on EVA activities. The fact that both cosmonauts had some background related to EVA spurred speculation in the West that such activities had been planned for the mission, but recent reports suggest that none of the Almaz mission plans included EVAs; spacesuits were, in fact, unavailable on board the station [145]. As Gorbatko later recalled, the main task of the crew was "to determine if the station had been poisoned or not" [146]. The crew carried special gas masks with them which they hid out of sight so as to preclude the press from taking photos of them. In addition to being trained for the mission originally meant for the Soyuz-23 crew, i.e. testing the atmosphere inside the Almaz, the new crew were also trained to perform the *Atmosfera* experiment to completely replace the existing air in the complex. Plans called for using the reserve of compressed air intended for the airlock to renew the atmosphere [147]. Special tools such as wrenches and screwdrivers were manufactured in accordance with specifications submitted by the cosmonauts themselves.

The Soyuz-24 spacecraft was successfully launched at 1910 hours Moscow Time on 7 February 1977 carrying cosmonauts Gorbatko and Glazkov into orbit. Initial parameters were 184.7 x 346.2 kilometers with a 51.65° inclination [148]. The crew conducted orbital maneuvers on the 4th, 5th, and 17th orbits before an automatic approach to about 80 meters of the station. At that point, there was yet another failure in the *Igla* system, prompting Gorbatko to take over manual control to complete the linkup successfully at 2038 hours GMT on 8 February [149]. Entry into the station was delayed for unspecified reasons and the crew had an unusual six hour sleep period prior scheduled at the time [150]. It was another 11 hours before the cosmonauts would make their way into Salyut-5. Ground control was anxious to hear reports from the crew concerning the safety of the station, and prearranged code words had been agreed upon to indicate particular situations. Gorbatko was the first one to enter the station, cautiously testing the air at various points throughout the entire length of the station. Very shortly, he was able to report that "Excellent, it's a big and good home," a coded message meaning that the atmosphere was normal and that there were no odors [151]. The results of the initial tests were then transmitted to Earth and ground control confirmed the initial analysis. The cosmonauts then took their breathing apparatus off and began reactivating the station. Soon after, on 9 February, Chelomey thanked the crew for their work and wished them a successful flight. Within two days, the cosmonauts had completed reactivating the station's basic systems, including replacing components on Salyut-5's computer [152].

Recent reports suggest that the crew had had a very intensive program during their planned 18-day flight, and that the demands made on the cosmonauts were comparable to those for crews who had flown much longer missions lasting as much as two months [153]. Gorbatko himself recalled many years later that:

> The station was built mainly for purposes of reconnaissance...the Almaz that I flew only had reconnaissance equipment on board. This consisted of a very big camera – the *Agat*. Apart from taking photographs with this camera, we also carried out instantaneous development. The highest speed we ever reached was around 30 minutes or even just under. In just under 30 minutes we managed to take the photographs, develop them, and send them back to Earth [154].

While military reconnaissance photography was no doubt a major objective of the mission, the crew also carried out several scientific and technological tasks, some of which were extensions of the activity performed by the earlier Soyuz-21 crew. On 16 February, the Soviet press announced that the crew had reached the halfway point of the mission, a practice similar to Soyuz-15 to preclude speculation on premature termination of the mission.

A major portion of the crew's work was taken up by repair and rehabilitation work on the station. Backup cosmonauts Berezovoy and Lisun worked in a ground-based simulator at TsPK to troubleshoot any problems encountered by the spaceborne cosmonauts [155]. On 21 February, the cosmonauts finally performed the major air-changing *Atmosfera* experiment in the station coordinated with a TV transmission to the Flight Control Center, part of which was later broadcast on Moscow TV. The original rationale for conducting the experiment was as a precautionary measure in case the air inside the station was found to be contaminated. When the cosmonauts verified that the atmosphere was clean, engineers delayed the experiment, but decided to go through with it as a technology demonstration exercise. The air replenishment equipment, developed by the Chelomey design bureau, was described as "a multifunctional combined system" that could supply compressed air to control the station's stabilization system and also account for leaks if necessary. The complete operation was fairly complex and required the use of torqueless nozzles to prevent the station from losing its attitude while the air was being vented into space [156]. During the experiment, air was slowly vented from one end of the station, releasing 100 kilograms of air from tanks in the Soyuz Living Compartment at the other end. Gorbatko manned the main station controls during the exercise, while Glazkov operated the controls for the air replacement exercise. The Soyuz-24 Commander later recalled that when the valves were opened to begin the operation, "there arose a terrible rumble. It gave the impression that the station was going to break open. The sound effect was much like we were inside a rolling metal barrel" [157]. After the exercise, an unidentified Soviet scientist was reported as saying that the air in the station was "quite satisfactory to the crew and the doctors, but all the same it was decided to test the system, which is important for prolonged expeditions" [158].

The rest of the mission was fairly uneventful although there was a minor scare at some point when the crew heard a loud noise, as if the station had been hit by some object. After checking for pressure leaks, the crew concluded that the station had probably been hit by a small particle, perhaps a small meteoroid, a speculation that was communicated to Chelomey on the ground [159]. Due to concern about expiration dates on food stuff on board the station, ground controllers forbid the crew to eat some of the food on the station. The crew's overall impression of the station was, however, positive, and Gorbatko, especially recalled that he was "very pleased" and that the "work was interesting" [160].

The crew conducted two orbital maneuvers on 23 and 24 February, the first one by the Soyuz-24 spacecraft itself. By that time, the cosmonauts had begun to pack the results of their stay in the Soyuz spacecraft and mothballing the station. Prior to disembarking from Salyut-5, Gorbatko and Glazkov packed the small reentry capsule at one end of the station with exposed film from the *Agat-1* camera. The crew finally undocked from the station at 0921 hours Moscow Time on 25 February and landed at 1236 hours the same day 36 kilometers northeast of Arkalyk in strong winds, snow, and temperatures around -17° C. The capsule evidently did not land in the intended recovery zone, and as such, rescue crews were unable to reach the crew immediately. After landing, the crew module tumbled over a couple of times before ending up on its side. The crew received minor injuries in the process and had to wait in a very uncomfortable position for a while, before opting to unstrap themselves and try and leave the capsule. Although they did manage to get out, they decided to crawl back in again due to the bitter cold. Rescue crews took over an hour to reach the crew. As a result of their experience, as well as those of the Soyuz-18-1 and Soyuz-23 crews, NPO Energiya introduced some changes in protective and survival gear for future cosmonauts [161].

Just one day following the crew's return, the small return capsule from Salyut-5 was automatically ejected and landed at 1228 hours Moscow Time on 26 February 1977 [162]. Rescuers safely recovered the capsule and brought it to Moscow, and at

Chelomey's personal request the detachable heatshield from the capsule was also found nearby and brought to the premises of the TsKBM for examination. Engineers were evidently very satisfied with its performance [163].

Gorbatko and Glazkov were formally welcomed back from their mission at Zvezdnyy gorodok on 5 March. Chelomey was one of the speakers and expressed deep gratitude to the crew, noting that the cosmonauts' work was a model for those who would prepare for further flights. Glushko spoke after Chelomey, and perhaps in a moment of reconciliation, enigmatically announced that he "understood and shared Vladimir Nikolayevich's elation – eyes have been opening to mysterious phenomena registered during recent flights." The lead designer of the Almaz station, Vladimir A. Polyachenko later recalled that this gathering was the end of the debate between Glushko and Chelomey over the utility of the Almaz space station [164]. The final speaker was State Commission Chairman Col.-Gen. Grigor'yev who stated that the first stage of the development of Almaz had been completed.

12.5 Soyuz-25 Cancelled

Although the "first stage" was over, there were in fact plans for an additional and final visit to the station in March 1977. Soon after the end of the Soyuz-24 flight, the State Commission asked backup cosmonauts Lt.-Col. Anatoliy N. Berezovoy and Lt.-Col.-Engineer Mikhail I. Lisun to prepare for the Soyuz-25 mission. Their backups were Lt.-Col. Vladimir S. Kozel'skiy and Lt.-Col.-Engineer Vladimir Ye. Preobrazhenskiy. The flight would be a short 15-day jaunt to the station to conduct some additional observational experiments. At a meeting of the State Commission sometime in March, General Designer Glushko told those present (including Berezovoy and Lisun) that he would require two months to build and test the extra 7K-T spaceship for the scheduled Soyuz-25 mission. An *additional* two months would be needed to test the vehicle at Tyura-Tam prior to declaring it safe for launch [165]. The extra four months of automated operation by Salyut-5, however, would require at least 250 kilograms of propellant to maintain proper attitude and orbital parameters [166]. This would leave the station 70 kilograms less propellant than would be required to conduct the 15-day Soyuz-25 mission. Since automatic propellant tankers were not available at the time, the Commission decided to cancel the forthcoming flight and keep the station in automated mode for the remainder of its orbital lifetime [167]. Controllers adjusted Salyut-5's orbit once during this period on 5 March, and once more possibly on 22 March.

On 30 March 1977, the State Commission hosted a final meeting attended by the leadership of the TsKBM, the TsPK, and all the cosmonauts who had trained for the Salyut-3 and Salyut-5 missions [168]. It was a final concluding session to review the results and events in the program, and perhaps to discuss a general course of action for the next Almaz. Salyut-5 meanwhile was said to be continuing "scientific research" in an automated mode, and controllers conducted at least two maneuvers on 14 and 15 April [169]. The station was finally deorbited successfully over the Pacific Ocean on 8 August 1977 after a 412 day mission during which the station had completed 6,630 orbits.

13. Chelomey's Cosmonauts

Through the missions of Salyut-3 and Salyut-5, only military officers had actually crewed the station. But they weren't the only ones to train for long duration missions on the Almaz station. Beginning the late 1960s, it was customary for the Korolev design bureau to train their own engineers for flights on board the Soyuz and Salyut. By the same token, Chelomey also took the initiative to train his own engineers for flights aboard the Almaz station. These civilians would fly as the "third person" on three-person crews, accompanying two military officers into orbit.

The Soviet Central Committee and the Council of Ministers had issued a document (no. 270-105) on 27 March 1967 entitled "On the Preparation of Cosmonaut-testers and Cosmonaut-researchers" which laid the foundation for future training of civilian cosmonauts. A subsequent order by the Ministry of General Machine Building on 22 April 1967 prompted Chelomey to organize a special training squad of engineers from his own design bureau. In late 1967, he sent a small group of engineers for medical screening to the Ministry of Health's Institute of Biomedical Problems (IMBP). Several men passed these tests, and in 1969, the Chelomey design bureau, i.e. the TsKBM, formed a "special contingent group" of trainee cosmonauts. These men were not "official" cosmonauts as they had not been approved by the State Interdepartmental Commission (GMVK) which certified all Soviet cosmonauts. During 1971-72, the special contingent group took part in ground-testing of what would be launched as Salyut-2 and also trained in mockups of the Almaz Return Apparatus. They tested different types of spacesuits, performed ergonomic research, and completed weightlessness flights on board specially equipped Tu-104 aircraft during which they simulated many different possible scenarios for the impending Salyut-2 mission.