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The Magazine of Spaceflight

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Front Cover: After spending 180 days aboard Russia's Mir space station, Shannon Lucid greets the astronaut who replaced her as cosmonaut researcher during her first reunion with astronaut John Blaha near the docking tunnel that connected Mir to Atlantis on Flight Day 4, September 19, 1996 during STS-79. This historic meeting marked the first astronaut change-over of crewmembers on Mir. NASA Photo S79E-5095. **Back Cover:** When the Space Shuttle Advanced Solid Rocket Motor (ASRM) Program was alive and well, NASA needed a new type of vehicle to move the larger diameter case segments at the ASRM manufacturing site in Yellow Creek, Mississippi. Shown here is one of two Kneel-Down Transporters built for this purpose which had arrived by barge On December 7, 1992 at NASA's Kennedy Space Center from KAMAG Transportation Company in Germany. After the ASRM cancellation, the fate of these two vehicles is not known. NASA Photo KSC-92PC-2508.

The Triumph and Tragedy of Salyut I

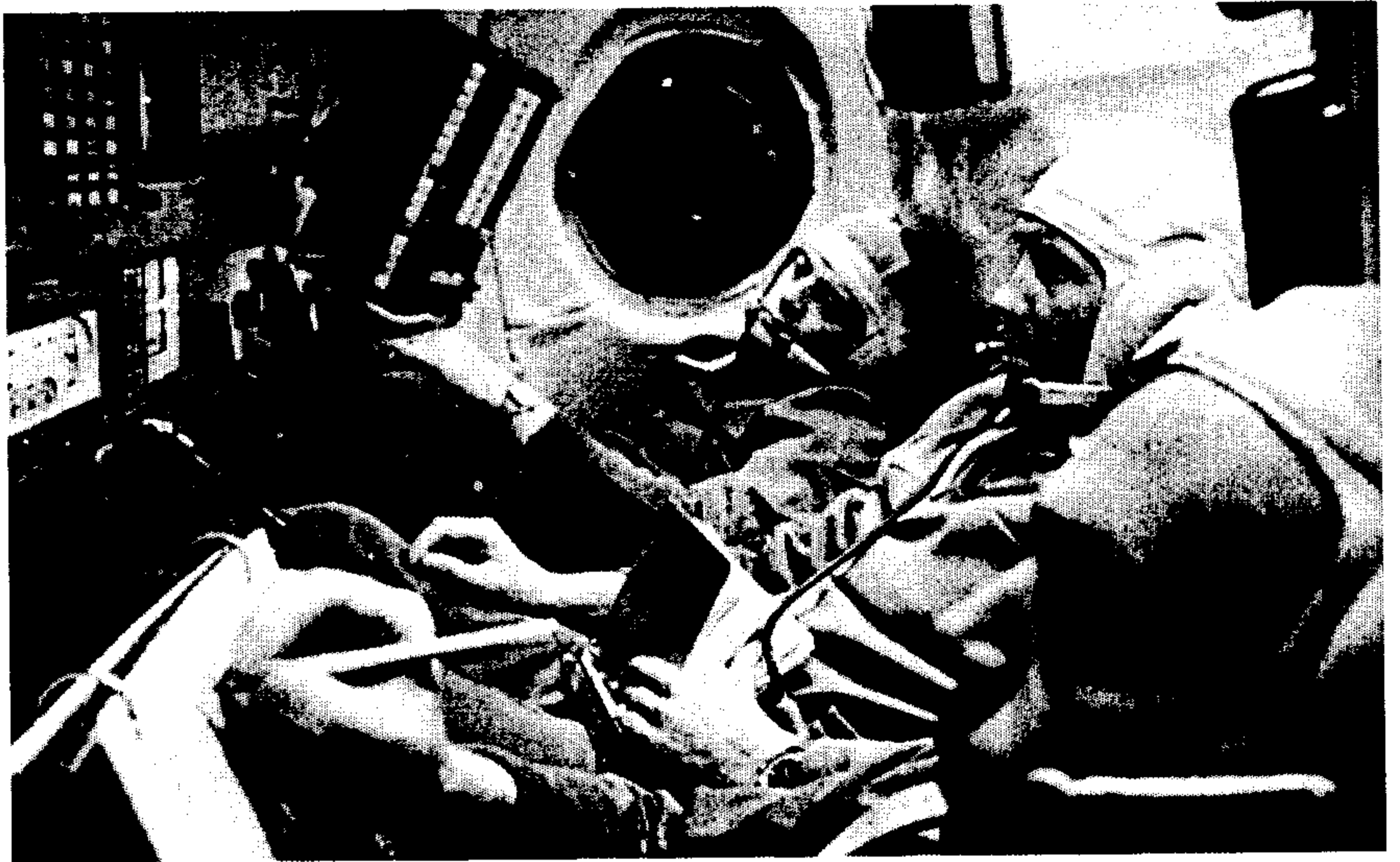
by Asif Siddiqi

Twenty-five years ago this year the Soviet Union carried out the first space mission to the Salyut space station in Earth orbit. At the conclusion of that flight the three-member Soyuz-11 crew tragically perished during a depressurization accident which stopped the Soviet human space program in its tracks. It was a devastating blow to the space effort, resulting in a radical redesign of the Soyuz spacecraft itself and a delay of about two years before piloted flights resumed. At the time of the accident, Soviet authorities revealed few details of the Salyut mission, and it was only during preparations for the Apollo-Soyuz Test Project (ASTP) that the specifics of the hardware failures were revealed. More details finally began to emerge in 1993 with the publication of the diaries of Col.-Gen. Nikolay P. Kamanin, the Deputy Commander-in-Chief of the Soviet Air Force in charge of space affairs, who was not only responsible for crew selection, but also oversaw the activities at the Yu. A. Gagarin Cosmonaut Training Center near Moscow [1]. The most comprehensive account of the deaths of the Soyuz-11 cosmonauts came earlier this year in a remarkable three-part series of articles in the Russian journal *Novosti Kosmonavtiki* authored by Igor Marinin. Unless otherwise stated, the following account is based on Marinin's articles (see references). The full story, definitely worthy of a movie, is without doubt one of the most spectacular and heart-wrenching episodes in the history of the Soviet space program.

Zarya and Soyuz

The Soviet Union had had numerous projects to build orbiting space stations in the 1960s. None of these came to fruition until the loss of the 'Race to the Moon' in 1969. By the end of that year, the primary focus of Soviet human space programs became space stations. In the search for a quick solution to the creation of such a station, the Soviet leadership opted to use already designed hardware.

The official decision to build the Long-Duration Station (abbreviated as DOS in Russian) was adopted by the Central Committee of the Communist Party and the USSR Council of Ministers on 9 February 1970 in resolution no. 105-51 [2]. This was after a long battle that pitted the two most



The ill-fated crew of Soyuz 11 during training. Left to right: Vladislav N. Volkov, flight engineer; Georgy T. Dobrovolsky, commander and Viktor I. Patsayev, test engineer. Photo source Novosti Press Agency Publishing House, Moscow.

important space organizations in the Soviet Union against each other. The final decision ordered the transfer of several nearly complete frames of the military Almaz Orbital Piloted Station (OPS) from the Design Bureau headed by Vladimir N. Chelomey to the organization led by Vasiliy P. Mishin [3]. The latter was to cooperate with one of the branches of Chelomey's organization to modify the OPS into a flyable article and deliver it for launch within one year. (Note: This branch was the TsKBM Branch, also known as Branch No. 1).

Over the course of the following fourteen months, the engineers at Mishin's Central Design Bureau of Experimental Machine Building (TsKBEM, formerly the OKB-1) carried out some intensive work which involved the transfer of a number of key systems from the basic 7K-OK Soyuz spacecraft to the space station frames. The result was the "new" article 17K, originally named Zarya, which has been described extensively in many Western sources [4]. During this period, the original 7K-OK Soyuz spacecraft was also modified into a dedicated ferry spacecraft, to be used for transporting crews and supplies back-and-forth to the station. The new variant, designated 7K-T, incorporated the first Soviet docking system designed to enable crews to travel internally without extra-vehicular activity (EVA).

Crew Preparations

The first crews for the Zarya space station were proposed by Chief Designer Mishin on 23 April 1970. At the time, he envisioned two missions to the station, the first lasting 30 days and the second lasting 45 days. Four crews were suggested, with the ultimate hope that the first two would actually fly into space. They were (in order of Commander, Flight-Engineer, Test-Engineer): *Crew 1*: V.A. Shatalov/A. S. Yeliseyev/N.N. Rukavishnikov; *Crew 2*: G.S. Shonin/V.N. Kubasov/P.I. Kolodin; *Crew 3*: B. V. Volynov/K. P. Feoktistov/V.I. Patsayev; *Crew 4*: Ye.V. Khrunov/V.N. Volkov/V.I. Sevastyanov.

Upon receipt of Mishin's proposals, Col.-Gen. Kamanin categorically refused three of the four crews due to a number of unrelated reasons. Firstly, he believed that it would be a complete waste to have two experienced cosmonauts (Shatalov and Yeliseyev) on a single crew. Secondly, he was against the inclusion of Volynov as Commander of the third crew because he was Jewish. Although Kamanin personally had no quarrel with Volynov, the cosmonaut training chief had been ordered from apparatchiks in the Central Committee not to allow Volynov to train for further spaceflights or travel abroad due to his family heritage [5]. Kamanin had, in fact, appointed Volynov to the relatively innocuous position as Commander of the Student-Cosmonaut Detachment to divert him from public view. Thirdly, Feoktistov's position on the third crew was challenged by Kama-

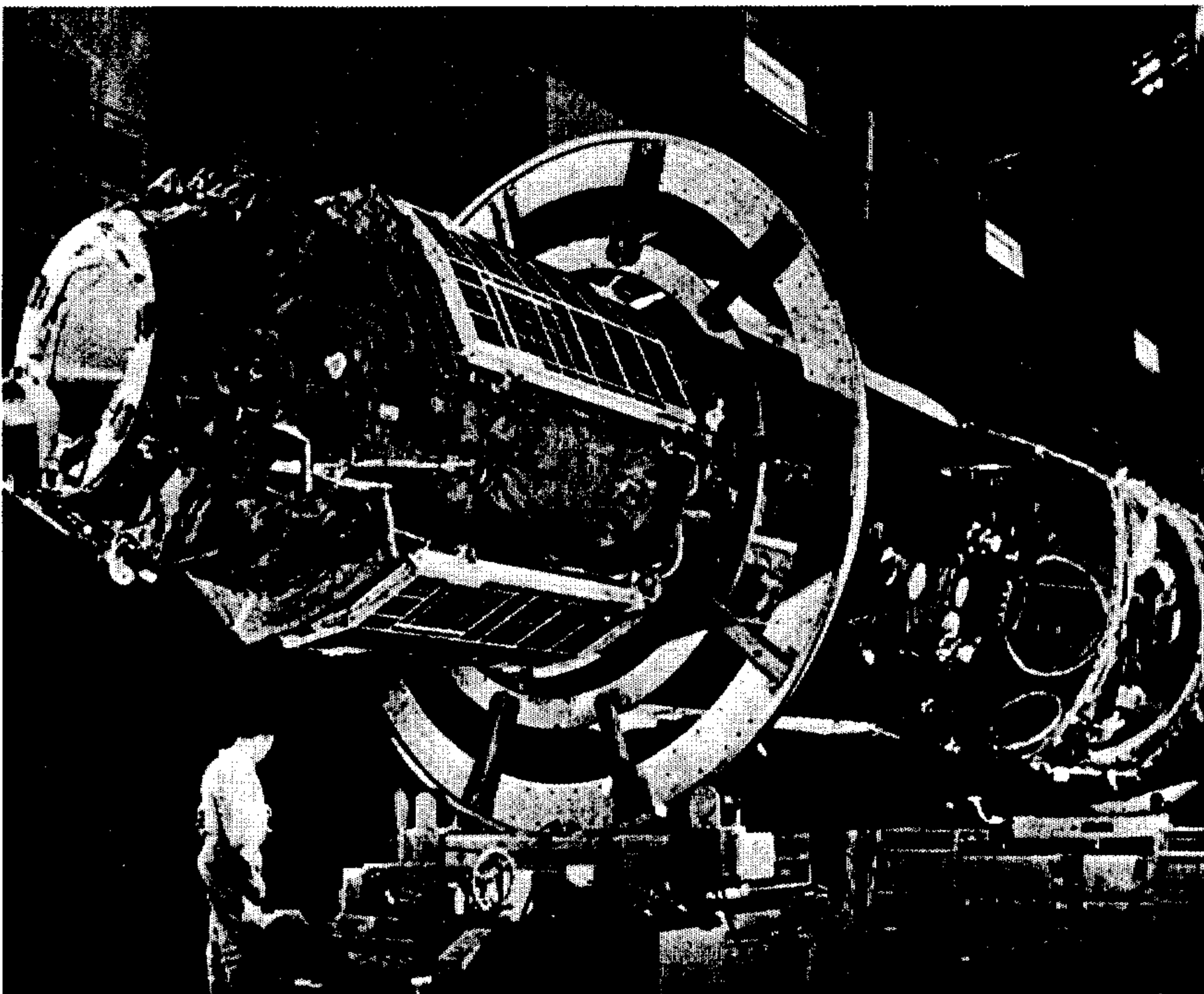
nin since he had been recently been divorced and this might not be a perfect example of a Soviet cosmonaut. Finally, Kamanin opposed the inclusion of Khrunov on the fourth crew. Despite an admirable performance on his Soyuz-4/5 EVA mission, Khrunov had apparently been involved in a hit-and-run accident in 1969 during which he had failed to come to the assistance of the victim. Kamanin believed that his punishment was still not over.

Over the following days, Mishin's deputies hammered out a compromise variant for the first four crews, bringing in Col. Aleksey A. Leonov, who had hitherto been training for the L-1 and L-3 lunar programs, and two other cosmonauts Sevastyanov and Dobrovolskiy. Thus by 13 May 1970 the new crews for the first DOS (or DOS-1) became: *Crew 1*: G.S. Shonin/A.S. Yeliseyev/N.N. Rukavishnikov; *Crew 2*: A.A. Leonov/V.N. Kubasov/P.I. Kolodin; *Crew 3*: V.A. Shatalov/V.N. Volkov/V.I. Patsayev; *Crew 4*: G.T. Dobrovolskiy/V.I. Sevastyanov/A.F. Voronov.

The first two crews were earmarked as the initial expeditions to the DOS-1 station. Both crew commanders (Shonin and Leonov) were considered two of the best candidates for rendezvous and docking maneuvers and both were veterans of previous space missions. Shonin, as Commander of the first crew to the station was also named Commander of the space station group at the Cosmonaut Training Center [7]. The first three crews began dedicated training for the station flight by mid-September, although the fourth crew did not in fact come together and begin training until January 1971, just two months before the planned launch of the space station. Despite commencement of training, Sevastyanov was said to be away from training for long periods due to commitments to public events after his record-breaking flight on Soyuz-9 in June 1970.

Mission Planning

Dmitriy F. Ustinov, the Secretary of the Central Committee in charge of space and defense issues and the *de facto* policy chief of the Soviet space program, presented Mishin with a rough timetable for the space station missions at a meeting on 23 September 1970. The launch of the DOS-1 Zarya station was to be set for 5 February 1971. Shonin's crew were to be launched into orbit just 10 days later to begin the first occupation of a space station in history. By November, however, it had become clear that this timetable was too ambitious. There were a number of major delays in the delivery of instruments as well as failures in ground



Salyut 1 assembly. Photo source Novosti Press Agency Publishing House, Moscow.

testing which necessitated a thorough review of the manifest. Finally, at a meeting on 21 December, the State Commission for Zarya headed by Chairman Lt.-Gen. Kerim A. Kerimov officially moved the launch back by a month to mid-March 1971 [7]. At the same time, there were serious discussions on the length of the two planned visiting missions. Mishin continued to maintain that the first flight should be at least 30 days in duration, while Kamanin argued for a more conservative 22-24 days. The conflict remained unresolved, both persons refusing to yield, and a final decision was left until further ground testing was finished.

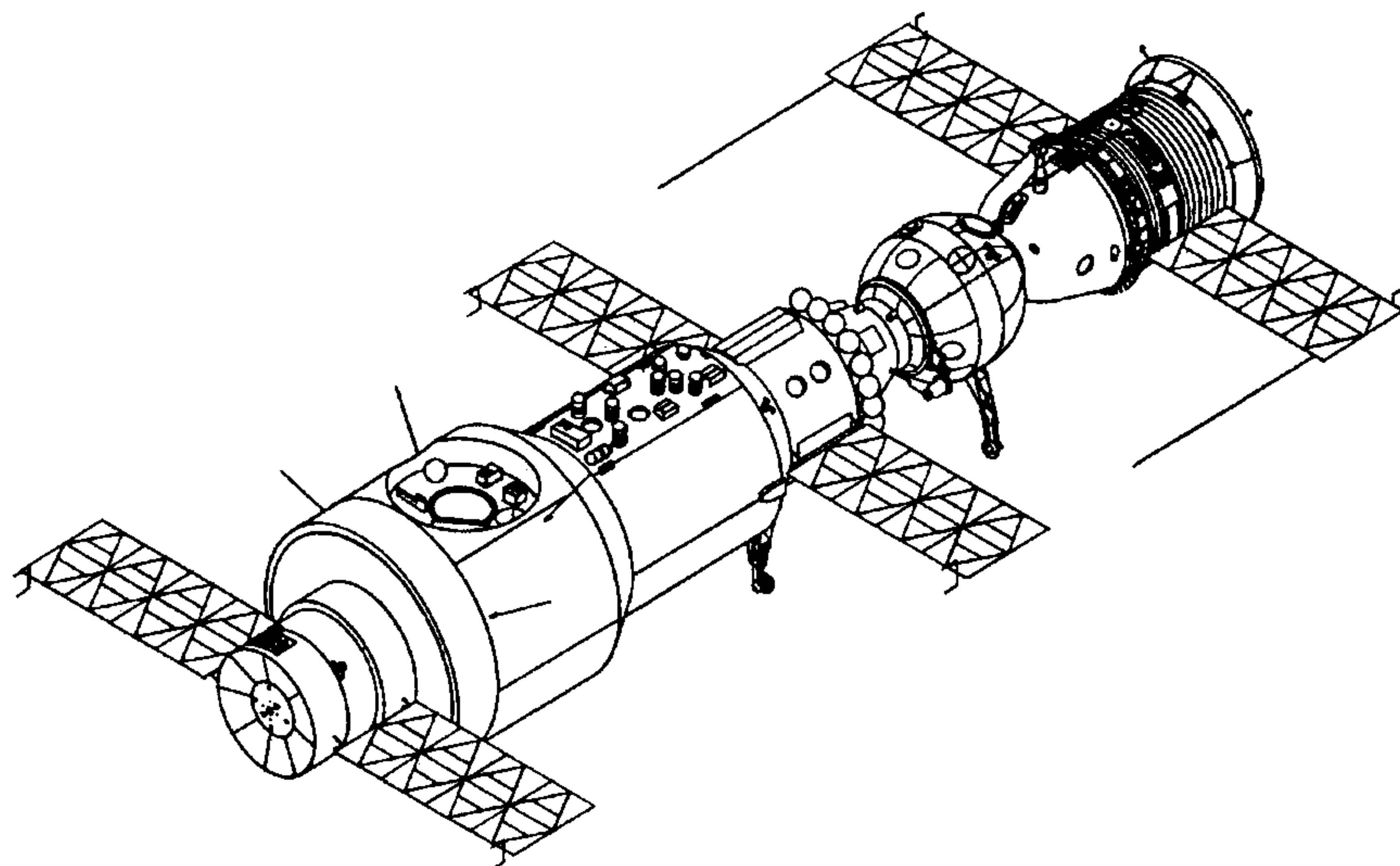
The Shonin Incident

On 5 February 1971, just over a month prior to the scheduled launch of the space station, Col. Georgiy S. Shonin, the Commander of the first outbound crew did not report to training at the Cosmonaut Training Center (TsPK). Kamanin personally took over the investigation and found to his surprise that this was not the first time that there had been such an absence. After further investigations, it was ascertained that Shonin had, without authorization, checked into a hospital for an unspecified "illness" which had come to light after a recent trip to the Tyura-Tam launch site. Leonov, the Commander of the second crew made a vain attempt to defend Shonin's actions, but it was too late. When Mishin discovered this lapse in training, he immediately asked

Kamanin to dismiss Shonin from the mission and in "a fit of temper" proposed an all-civilian crew of Yeliseyev, Kubasov, and Rukavishnikov to fly the first mission. It was yet another example of an on-going feud between Mishin and Kamanin over the naming of civilian engineers to Soyuz crews. In the end, Mishin backed down on his all-civilian proposal and Kamanin removed Shonin from the prime crew. The "ill" cosmonaut was sent off to Burdenko Hospital and found to have an unstated "reactive condition" as well as "psychological faults." Curiously Shonin never flew another space mission, although he appears to have recovered from this censure and trained again for space missions in the late 1970s [8].

On 12 February, Kamanin named revised crews for the first missions, having Shatalov replace the missing Shonin on the first crew, since the former was the only Soviet cosmonaut at the time who had experience in docking two spacecraft. Thus, the new crews were: *Crew 1*: V.A. Shatalov/A.S. Yeliseyev/N.N. Rukavishnikov; *Crew 2*: A. A. Leonov/V.N. Kubasov/P.I. Kolodin; *Crew 3*: G.T. Dobrovolskiy/V.N. Volkov/V.I. Patsayev; *Crew 4*: A. A. Gubarev/V.I. Sevastyanov/A.F. Voronov [9].

On 2 March 1971 a readiness review meeting of the Council of Chief Designers took place during which delays were once again acknowledged. There had been continual postponements in vibration testing of the station flight article, while serious malfunctions had cropped up in the ground test-



Salyut 1 and Soyuz 11 in docked configuration. Drawing courtesy Daniel James Gauthier.

ing of the *Igla* docking system to be used on the transport Soyuz spacecraft. Of four *Igla* systems built by the NII Tochnykh priborov (Precision Instruments Scientific Research Institute), three had failed testing; the fourth was working only marginally. Furthermore, there were also delays in the packing of the parachutes in the Soyuz capsule and the testing of the station's life-support system. Given these malfunctions and delays, it could be speculated that the station was launched in great haste and without adequate testing. The launch of Zarya was now set for 15 April at the earliest, while the Shatalov crew would be launched on 18-20 April. A decision on the duration of the two visiting flights was once again postponed.

Salyut Launched

The three crews arrived at Tyura-Tam for a preliminary visit on 20 March 1971 at which time there was another *Igla* failure during training. They returned to the launch site on 6 April to view the launch of the space station. At some point immediately preceding the launch of the Zarya, the name of the station was changed from Zarya to Salyut, possibly as a salute to the flight of first cosmonaut Yuriy A. Gagarin whose tenth anniversary was being celebrated the same month. This decision was based upon the perception that cosmonauts on board the station might be confused by the Zarya designation, since the ground segment of the tracking network (called the Command-Measurement Complex) used by the crews was also named Zarya [10]. The name change was made so late that the Zarya designation was still inscribed on both the sta-

tion and the launch vehicle fairing on the pad.

DOS-1 (17K 11F715 serial number 121) was launched successfully at 0439 hours Moscow Time on 19 April 1971 from site 81 at Tyura-Tam on top of a three-stage Proton-K booster (8K82K serial number 254-01) into an initial orbit which was announced as 222 X 200 kilometers at 51.6 degrees inclination [11]. The mass of the station was about 18,900 kilograms. The Soviet press referred to the station as simply 'Salyut' and no mention was made of any impending visiting flights. By the end of the first orbit, it was discovered that a large cover on the exterior protecting the scientific experiments package had not been jettisoned, thus possibly jeopardizing the scientific value of any visiting expedition. During the second day of flight, there were also failures of two ventilation units used for the life-support system, although this appears not to have caused any major concern on the ground.

The Soyuz-10 Mission

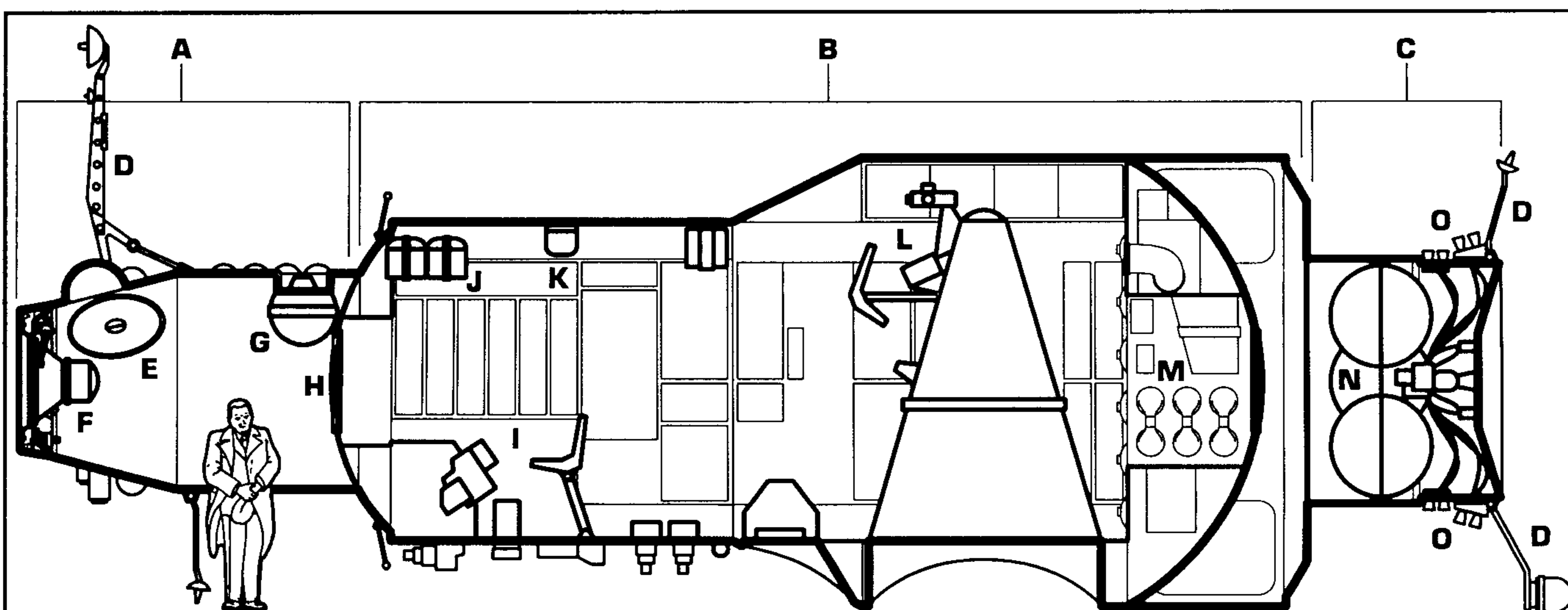
The day after the Salyut launch, the prime crew for the first mission was presented to the Soviet press. It was announced that their launch would take place on 22 April at 0320 hours Moscow Time, a night launch. Shatalov, Yeliseyev, and Rukavishnikov took their places in their Soyuz spacecraft despite some concern due to heavy showers during the night; the State Commission, however, agreed to proceed with the launch. The Soyuz launch vehicle was filled with propellant and all pre-launch procedures appeared to be going according to schedule until T-1 minute. At that point, one

of the masts on the launch system did not retract as planned. Abruptly there was a great fear that if there was a launch, the launch escape system would be spuriously activated and cause an explosion as had occurred during a Soyuz launch in December 1966 [12]. Mishin and Petrushev opted to reluctantly postpone the launch. A quick decision was taken to keep the booster on the pad fully fueled and try again the following day.

During the second launch attempt, the exact same thing occurred again and a mast from the launch structure refused to retract. Mishin was apparently aware of the reasons for this deviation from normal procedures, and took control of the situation. Taking complete responsibility for any negative consequences, he called out for the launch to proceed. In the event, there was no problem and the Soyuz-10 spacecraft (7K-T serial number 31) lifted off successfully at 0254 hours Moscow Time on 23 April 1971 on top of a Soyuz booster (11A511 serial number 25). Commander Col. Vladimir A. Shatalov, 43, Flight-Engineer Aleksey S. Yeliseyev, 36 and Test-Engineer Nikolay N. Rukavishnikov, 38 entered their planned orbit soon after. The vehicle was named Soyuz-10 upon orbital insertion. Shatalov and Yeliseyev were the first Soviet cosmonauts to make a third spaceflight, having flown their first mission just two years before. Rukavishnikov, the only rookie on board had extensively trained for the L-1 lunar program in the late 1960s. The backup crew were cosmonauts Leonov, Kubasov, and Kolodin. Initial orbital parameters (as announced) were 209.6 x 248.4 kilometers orbit with a 51.6 degree inclination.

Despite a successful launch, the prognosis for the mission was dim. The lid on the scientific compartment was still lodged in its place and threatened to sabotage at least 90% of the scientific experiments program. Furthermore, of the eight ventilation units in the life-support system, six (!) had failed promising an internal atmosphere full of carbon dioxide and "other harmful materials." During Soyuz-10's fourth orbit when an attempt was made to modify the spacecraft's orbit to insert it on a similar orbit to the Salyut station, it was discovered that there were malfunctions in the integrators and gyroscopes of the ferry vehicle. Shatalov took control of the situation and asked for permission to manually change the orbit, which he did without any problems.

The following morning at 16 kilometers distance from the station, Shatalov switched on the *Igla* system which successfully brought the Soyuz to within 180-200 meters of Salyut. At that point, he took over manual control successfully linking up at 0447



Salyut 1 Cutaway Diagram

- | | |
|---|--|
| <p>A. Transfer Section
 B. Work Section
 C. Instrument Section
 D. Rendezvous/Docking Antennas
 E. EVA Hatch
 F. Docking Drogue</p> | <p>G. Orion Telescope
 H. Hatch Between Transfer & Work Sections
 I. Main Control Station
 J. Air Regenerating System
 K. Movie Camera Mounted In Porthole
 L. Control Station For Large Camera System
 M. Hygiene Area
 N. Main Propulsion System
 O. Attitude Control System</p> |
|---|--|

Drawing by Daniel James Gauthier

hours Moscow Time on 24 April. About 10-15 minutes following soft-docking Shatalov radioed to the ground that the docking indicator light had not lit in the Soyuz, suggesting that hard docking had not taken place. Ground telemetry confirmed that full docking had not occurred, and that there was still a 9 centimeter gap between the two vehicles. Shatalov attempted to tighten the two ships by firing the Soyuz engines, but this did not prove to be successful. On their fourth orbit together, orders were received from the ground to try and undock the Soyuz-10 spacecraft and attempt a redocking. That there had been "incredible difficulty" in undocking was first revealed in an article in the Soviet media in 1990, a fact that was hid for close to twenty years [13]. On the fourth orbit of combined flight Shatalov evidently attempted to unlatch the Soyuz-10 ship from the Salyut station, but the spacecraft refused to dislodge themselves. There was serious cause for concern at this point, since there was the possibility of losing the station, and perhaps the crew as well. Being unable to undock by normal means, there were two options: dismantling the docking apparatus, detaching it from the Soyuz and moving away from the station; or detaching the spherical Living Section (called the Orbital Module in the West) from the Soyuz spacecraft and separate, thus leaving the Living Section docked to Salyut. In both cases, the station would be unusable in the future since the single docking node would be occupied. The situation was compounded by the fact that there was only a limited amount of oxy-

gen left in the Soyuz spaceship (about 40 hours) within which time all of this would have to be done. Luckily for everyone, on the fifth orbit of combined flight at 1017 hours on 24 April, Shatalov once again tried to undock and was successful. The two spacecraft had been docked for 5 hours 30 minutes.

Shatalov maintained station-keeping distance from Salyut as ground control debated whether to attempt a second docking with the station. After assessing the state of on board gyroscopes, propellant levels, and internal air, it was decided to abandon the mission and prepare for an emergency return to Earth. The crew successfully landed without incident at 0240 hours on 25 April 120 kilometers north-west of Karaganda, during the first ever night landing in the Soviet human space program. The mission had lasted only 1 day 23 hours 46 minutes 54 seconds. The Soviet media at the time characteristically claimed that entry into the station was not even on the agenda for the mission and all the objectives of the flight had been successfully achieved.

Crews Switched for Soyuz-11

The investigation into the Soyuz-10 failure was completed by 10 May, when it was ascertained that the Soyuz docking apparatus had been damaged during the docking maneuver [14]. There had been a breakdown in the coupling shock absorbing claws in the active part of the docking node when the two ships had attempted hard dock. The sys-

tem had been subjected to 160-200 kilograms of force during the maneuver, when the force at docking was projected to be 80 kilograms. The coupler could only withstand up to 130 kilograms. A decision was taken to reinforce the docking system two-fold while introducing the capability of the crew to manually advance the pins of the docking system. In the meantime Mishin proposed that despite the failure of Soyuz-10, that plans should now include two further missions to the Salyut station to complete the original objectives of the program. The first was to begin on 4 June and the second on 18 July 1971. Mishin also proposed to have the following crew be reduced to two cosmonauts in order to carry bulky spacesuits which would allow an EVA by one cosmonaut to visually inspect the docking node on the station, as well as for removing the cover for the scientific experiments package. Kamanin categorically refused this idea arguing that the cosmonauts had not been trained for EVA, adding that the KB Zvezda which produced the spacesuits would not be able to certify flight-ready suits by the launch date. In the end the matter was dropped, an irony considering the later course of events.

At a meeting of the major leaders of the program on 11 May 1971 in Moscow, there was further disagreement between Mishin and Kerimov on one side and Kamanin on the other. The former proposed two missions lasting 30 days each. Kamanin opposed this idea based on his belief that on board supplies on Salyut might be all used up before

the end of the second expedition, thus creating a dangerous situation for any crew. In the end, a final decision was taken: the goal of each mission would be to dock with the station and "revive" its systems; any decision on duration would be made during a particular flight. Based on information from ballistics computations, Mishin tentatively planned for a 25 day flight beginning on 6 June 1971.

There were a number of failures once again in the *Igla* system during preparations for the next mission, but the State Commission under Kerimov assessed the anomalies and on 24 May certified the Soyuz vehicle (with modifications to the docking system and improved autonomous capabilities) as fully flight-ready. Leonov, Kubasov, and Kolodin were formally named the prime crew while Dobrovolskiy, Volkov, and Patsayev were designated their backups. The two crews arrived at Tyura-Tam on 28 May in preparation for the launch.

All plans for mission were thrown into complete uncertainty when on 3 June, the flight doctors from the Institute of Medico-Biological Problems detected a swelling in the right lung of primary crew Flight-Engineer Kubasov [15]. Suspecting that this was the beginning of tuberculosis, they unanimously called for his removal from the crew. According to the rules in place by the Ministry of General Machine Building and the Ministry of Health, "...if one of the members of the crew is taken ill prior to departure to the cosmodrome, he should be replaced by the corresponding member of the other crew. Carrying out the replacement of the individual at the cosmodrome is not possible. In case of such a necessity, it is only possible to carry out the replacement of the [entire] crew." The verdict was simple but painful. The Leonov, Kubasov, Kolodin crew would have to be replaced by the Dobrovolskiy, Volkov, Patsayev crew.

Yaroslav Golovanov, then a correspondent for *Komsomolskaya pravda* who was at Tyura-Tam at the time recalled later that "what happened at the Kosmonavt [Hotel, where the crews were staying] is hard to describe." Leonov broke down and was apparently throwing things around. Kubasov who was the center of the controversy was simply stunned. That night Petr I. Kolodin, the prime Test-Engineer arrived at the Hotel completely inebriated on vodka bemoaning the fact that he may never go to space. Leonov later took the matter directly to his superiors and pleaded that they only replace the indisposed Kubasov with his backup Volkov, thus making the new crew Leonov, Volkov, and Kolodin. It appears that the State Commission was in fact leaning towards this solution despite the Ministry

edict. All the cosmonauts, physicians, TsPK chiefs, and Kamanin himself decided to call for only Kubasov's replacement. Mishin and Kerimov tentatively agreed with this recommendation until Mishin had further discussions with participants in Moscow, when he changed his mind and insisted on replacing the entire prime crew. The next day, 4 June, two days before the launch, after the Soyuz booster had been transported to the launch pad, a final session of the core members of the State Commission was held. Again Kamanin recommended replacing only Volkov. This time Mishin had the support of most of the other attendees including Maj.-Gen. Nikolay F. Kuznetsov, the Director of the TsPK. The decision was taken to replace the entire Leonov crew and launch the Dobrovolskiy crew. Later that evening, during a visit by Mishin to the cosmonauts, Kolodin in a moment of outrage "lectured [Mishin] with a lot of extraneous items, which he later much regretted." [16] According to one report, Kolodin told Mishin that "history would never forgive him" for his decision to send the backup crew [17].

The Soyuz-11 Mission

The original backup crew of Commander Lt.-Col. Georgiy T. Dobrovolskiy, 43, Flight-Engineer Vladislav N. Volkov, 35 and Test-Engineer Viktor I. Patsayev, 37 were successfully launched into orbit at 0755 hours on 6 June 1971 in their Soyuz (7K-T serial number 32) spacecraft. The Soviets announced the mission as Soyuz-11. Both Dobrovolskiy and Patsayev were making their first flights, while Volkov was making his second. The crew had been formed less than four months before. The new backup crew were Leonov and Kolodin (There was no backup Flight-Engineer). The Soyuz-11 spaceship entered an initial orbit of 191.5 X 220.5 kilometers at 51.64 degrees inclination (as announced). After two orbital changes the spacecraft was within 7 kilometers of the Salyut station at which point, the *Igla* system was switched on; successful docking was accomplished at 1045 hours. Ground control at Yevpatoriya in Crimea had to wait a tense half-hour before Dobrovolskiy announced that the docking had successfully taken place. During the fourth orbit of joint operations pressurization checks were proved to be acceptable and the crew opened the hatch to the station. Patsayev was the first one in the station; the crew immediately turned on the air regeneration system and replaced two of the six faulty ventilation units of the life-support system. Unfortunately, the crew sensed a strong odor of burning in the air

which forced them to spend a tense night in their ferry craft. The next day, they returned to the station to discover the odor gone and immediately set about on activating instruments on the station in support of their experiments program. By 9 June medical and biological experiments had begun, while experiments in other areas were started on 11 June, comprising spectroscopic measurements of natural formations and water surfaces in the USSR. The science experiments program has been described in detail elsewhere and is not included here for brevity [18].

Throughout the mission, there were televised reports from the cosmonauts in Salyut which were shown on Soviet television. The three men became household names and in many ways assumed the role of folk heroes to Soviet citizens. It was as if there was a feeling of vindication following their country's loss in the race to Moon. For the first time in many years, the Soviet human space program could claim a genuine advance and victory over the United States. It would not be an overstatement to claim that much of the general population anticipated the return of the three cosmonauts in a unified way that had not been witnessed for many years.

Although there were TV reports from Salyut, the complete story behind the habitation was characteristically hidden from the public. During the first two weeks of the mission, there were a number of unspecific personality clashes between members of the crew which were mediated by cosmonauts on the ground at Yevpatoriya who served as 'capcoms.' [19] Although these difficulties were resolved, a more serious emergency occurred on 16 June when cosmonaut Volkov suddenly radioed to the capcom Shatalov that he sensed a strong odor of smoke. Assuming the worst case scenario of a fire in the station, cosmonauts Nikolayev and Yeliseyev on the ground ordered the crew to immediately evacuate to their Soyuz ferry craft and begin preparations for undocking. Having quickly moved into the Soyuz, the crew first began attempts to establish the cause of the emergency, by switching on the backup electrical supply system on Salyut and turning on filters to purify the atmosphere. Following a tense period, during which tests showed the atmosphere in the station was safe, the cosmonauts entered the Salyut station once again. According to cosmonaut Bykovskiy at ground control, during the emergency, Volkov had become extremely nervous and had tried to resolve the situation by himself ignoring the assistance of his crew mates Dobrovolskiy and Patsayev. In an unusual move, Chief Designer Mishin communicated personally with Volkov informing him



The above two photos show medical workers frantically trying to revive the Soyuz 11 crew members. The above two images are of cosmonaut Georgiy Dobrovolskiy, the commander of the Soyuz 11 mission minutes after death. The beard was from the approximately 24 days spent onboard the Salyut 1 Space Station in June of 1971. At the time, this had been the longest piloted space mission in history. These still images were taken from the video "Soviet Space: The Secret Designer" and used by permission of Rudy, Inc.

that all operational decisions should be taken by the Commander (Dobrovolskiy) and tasks carried out only at his disposal. Volkov irritatedly shot back that the entire crew were aggravated and that all decisions should be made collectively. In an amplification of the event, Mishin in an interview in 1989 recalled that a personality clash had developed between Dobrovolskiy and Volkov during which Volkov, the only space flight veteran on board declared himself the Commander of the mission usurping Dobrovolskiy's role. There were apparently several "complicated conversations" between Mishin and Volkov after the incident [20]. In Kamanin's opinion, Volkov had acted hastily and had had a disdainful attitude toward those at ground control. Mishin also added that there may have indeed been a fire on the station originating from a power cable and the crew apparently asked for permission to return to Earth immediately but were dissuaded by ground control [21]. Western analysts monitoring transmissions from Salyut noted that the Soyuz-11 spacecraft had been powered up on 17 June indicating that the crew had actually prepared for an emergency return on that day. The Soviets merely announced later that "minor correction work" had been undertaken on 17 June [22]. The entire situation was apparently diffused following extensive consultations with cosmonauts on the ground who were able to bring the crew back to their experiment program.

The Soyuz-11 crew were scheduled (20 June) to observe the third N-1 lunar rocket launch attempt from Tyura-Tam using a special instrument known as *Svinets* provided for military operations. The launch was,

however, moved to 22 June and eventually to 27 June and the crew's ground track was not over the launch site at the time of the N-1 launch. The *Svinets* apparatus was, however, used skillfully by Commander Dobrovolskiy on 24 and 25 June to observe the launch of solid-propellant intercontinental ballistic missiles from Tyura-Tam.

Unknown to the general public, the cosmonauts' medical program was not completely successful. The cosmonauts were apparently reluctant to exercise and the problem was compounded by several failures on the station. Kamanin wrote in his diary on 23 June that:

...the readaptation will be particularly difficult for Volkov: during the flight he has been more reluctant to do physical exercises than the other crew members, he has totally rejected meat food, he has often been irritated and has already been making a lot of mistakes [23].

The running track was rarely used due to unexpected vibrations when exercising which shook the solar panels and communications antennae. The *Chibis* vacuum facility to be used for shifting blood to the upper regions was the source of many problems and was rarely used. The load-bearing *Pingvin* ("Penguin") space suits also tore at various places during exercises, neutralizing their impact. (The cosmonauts also wore a suit called *Atlet* meaning "athlete" during sessions on the treadmill). Naturally, the lack of calisthenics was a great concern to doctors on the ground who believed that the crew would be in extremely poor shape after

a full 25 day mission

The Return

The three cosmonauts began preparations to return to Earth on 26 June and began packing for their return to Earth. They had exceeded the world record endurance for a single piloted space flight two days earlier on their 18th day in space. Their return was anticipated in the Soviet public as no other space mission in history.

Despite increasing numbers of mistakes on the part of the crew which was attributed to fatigue, the crew completed all their return procedures on time and on the evening of 29 June transferred to the Soyuz-11 spaceship and closed the hatch between the two spacecraft. The crew moved into the Descent Apparatus (called the Re-Entry Module in the West) and shut the hatch to the spherical Living Section. A major crisis occurred at this point, when the "Hatch Open" indicator light between the Soyuz Living Section and the Descent Apparatus failed to turn off. Fatigued and anxious, Volkov excitedly called out to ground control: "The hatch is not pressurized, what should we do, what should we do?!!" Cosmonaut Yeliseyev who was the capcom at the time, calmed Volkov down and gave the crew detailed instructions to go through the entire hatch closing procedure once more. Dobrovolskiy and Patsayev expertly followed the instructions, but the indicator light remained turned on. All members of the crew became increasingly nervous since in a few minutes that hatch would be the last barrier between the crew and open space.

After intensive discussions on the

ground, it was decided to place a piece of paper over the sensor which detected hatch close, presumably in the belief that it was a sensor error. Dobrovolskiy found a piece of plaster which he placed over the sensor and shut the hatch once more. This time the indicator turned off, and all subsequent pressurization checks proved satisfactory. The 20 minute crisis with the hatch had strained the nerves of the crew, but following the tests, the cosmonauts apparently calmed down and proceeded with preparations to undock from the station. At 2125 hours 15 seconds, the Soyuz-11 spaceship undocked from Salyut and flew around the station and Patsayev took a number of photographs (which have never been published). The retro-fire engines were to be switched on 0135 hours 24 seconds on 30 June, but "communications with the crew was interrupted." [24] The separation of the three Soyuz modules was to take place at 0147 hours 28 seconds, but ground control was unsure if this had indeed taken place due to the loss of communications. Search procedures proceeded on the assumption that all was going according to plan on the Soyuz-11 ship, and the teams from the USSR Air Defense Forces detected the Return Apparatus of the spacecraft on time in the assigned location. The capsule landed at 0218 hours 202 kilometers east of Dzhezkazgan in Kazakhstan. The mission had lasted 23 days 18 hours 21 Minutes 43 seconds. As soon as the vehicle hatch was opened, the rescue teams found the crew lifeless in their seats.

The recovery teams attempted to revive the cosmonauts after bringing them out of the capsule, but it was in vain. An on-the-spot investigation indicated that there was blood in their lungs, nitrogen in their blood, and hemorrhages in their brains, which were all obvious indicators of death by depressurization. An inspection of the ship's interior showed that all the radio-transmitters had been turned off, the shoulder straps of all the cosmonauts were unfastened, and Dobrovolskiy himself had been tangled in his straps. One of two valves in the capsule was open showing a pressure of 10 millimeters. There were no other anomalies detected in the cabin.

A commission was established on 3 July under USSR Academy of Sciences President Mstislav V. Keldysh which produced a detailed report soon after. Kamanin himself has also included in his personal diaries, a reconstruction of the tragic events based on telemetry and on board voice tapes. It appears that the re-entry burn was on time and completely successful. The last communication from the crew was reportedly from Dobrovolskiy who said, "So long. I am starting the landing procedure." [25] At the

very moment that the Soyuz spacecraft separated into its three component modules (exactly on time), 12 explosive bolts used for separation produced an overload displacing a ball joint from its seating [26]. This accidentally jerked open a ventilation valve which was to be opened only *after* landing; suddenly there was a direct passage from the crew compartment to the vacuum outside. The crew immediately noticed the drop in pressure inside the capsule; Dobrovolskiy quickly unfastened his seat belts and rushed to the frontal hatch thinking that the problem was the faulty hatch seal from the undocking incident. The hatch was completely secure, yet the pressure continued to drop in a whistle that continued to get louder. In fact, the sound of the air whistling out of the spacecraft was coming not only from the suspect valve, but also from on board radio transmitters and receivers, making it difficult to isolate the true source. At this point Volkov and Patsayev unfastened their belts and switched off all communications systems to find the source of the whistling; the sound was apparently coming from a point under Dobrovolskiy's seat---a ventilation valve. Dobrovolskiy and Patsayev attempted to manually close the valve, but the time was just too short [27]. Both fell back in their seats, Dobrovolskiy having time to refasten his belts in a hurried move, which left them tangled.

The speed of the pressure loss in the capsule was incredibly swift. Just four seconds after the ventilation valve failure, Dobrovolskiy's breath rate shot up from 16 (normal) to 48 per minute. After the beginning of pressure loss, the cosmonauts lost the capacity to work at 10-15 seconds and were dead by 48-49 seconds. They were apparently "in agony" 3-5 seconds after separation until about 20-30 seconds before death. All the pressure in the capsule dropped from a normal level of 920 millimeters to zero in a matter of 112 seconds.

On 12 July 1971, the official governmental commission to investigate the disaster issued a preliminary report that included the following:

During the descent of the spaceship, 30 minutes before landing, pressure in the return capsule dropped rapidly, which led to the unexpected death of the cosmonauts. This has been confirmed by medical and pathological-anatomical examinations. The drop in the pressure was the result of failure of the hermetic sealing of the spaceship...Technical analysis indicates that there are several possible explanations of the de-sealing.

Investigation into the exact cause continues [28].

A more detailed explanation of the deaths was given to NASA officials during preparations for ASTP in October 1973:

The fatal cabin depressurization occurred when a "breathing ventilation valve" located in the interface ring between the orbital module and the descent module opened inadvertently during the downward path of the descent vehicle...At approximately 723 seconds after retrofire, the 12 Soyuz pyro-cartridges fired simultaneously instead of sequentially to separate the two modules. The force of the discharge caused the internal mechanism of the pressure equalization valve to release a seal that was usually discarded pyrotechnically much later to adjust the cabin pressure automatically. When the valve opened at a height of 168 kilometers, the gradual but steady loss of pressure was fatal to the crew within about 20 seconds [sic] [29].

Both Kamanin and Mishin appeared to believe that the crew could have prevented their deaths by putting a finger in the suspect 'hole' in their spacecraft. In an interview in 1990, Mishin added that "They could hear the hiss of escaping air. They could have put a finger over the hole and that would have done it." [30]. There was even some question that the crew had not been properly trained in the operation of the valve which was apparently to be operated only after landing of the Soyuz. The technical documentation on the valve included the following: "If in case of a water landing, the hatch does not open due to rough seas, or rescue teams are late in coming for over an hour, the cosmonauts may open the valve." [31]

The exact reason why the seal failed is still unknown, although an article in *The Washington Post* in 1973 by Thomas O'Toole has provided some interesting clues. O'Toole's description, based on a "classified report" was the first and only Western report to accurately describe in great detail the hatch closing emergency prior to re-entry. The author adds that: [When], the exhausted cosmonauts were fighting the warning light on the hatch they apparently failed to notice that the cabin pressure had crept up to almost 20 pounds per square inch. What this did was to exaggerate any weakness in the hatch seal."

Whether this indeed actually occurred is not known. [32]

Despite the tragic outcome of the mission, there was brief consideration given to mounting a second mission to the Salyut station. Two crews had already begun dedicated training for this flight during the Soyuz-11 mission on 16 June. They were: *Crew 1*: A.A. Leonov/N.N. Rukavishnikov/P.I. Kolodin; *Crew 2*: A.A. Gubarev/V.I. Sevastyanov/A.F. Voronov.

In addition three more crews had been tentatively formed to serve as understudies in preparation for the next Salyut mission. Training for all the crews was terminated on 9 July 1971, nine days after the Soyuz-11 tragedy. The immediate goal was to make changes to the Soyuz spacecraft and introduce mandatory spacesuits for all the crew members. Since the introduction of spacesuits would take additional volume and mass, it was decided to truncate further crew members from three to two. Thus cosmonaut Kolodin lost his chance to fly in space. Among the many stranger-than-fiction ironies of this first space station project, clearly one of the most chilling was the last minute replacement of the Soyuz-11 prime crew. In an interview in June 1988, Kolodin confided that the deaths of Dobrovolskiy, Volkov, and Patsayev still played on his conscience, adding, "I was to fly, and Dobrovolski and his colleagues were to have remained on Earth. They were killed and I'm alive." [33] Although he was scheduled to fly a Soyuz mission in 1978, Kolodin did not, in fact, ever join the ranks of 'true' cosmonauts. Leonov and Kubasov, the two remaining members of the crew trained for further space station missions which were canceled due to failures and were eventually transferred to train for ASTP in June 1973. Both flew the mission two years later as Soyuz-19 in July 1975. Kubasov's lung problem later turned out to be only an allergic reaction. [34]

Conclusion

The shock to the Soviet space program was immeasurable. The Soyuz-11 accident was clearly the most devastating loss ever in the Soviet piloted space program. The loss of three of the country's best cosmonauts in a seemingly unexplainable accident squelched any thought of celebration at completion of a 'new step' in the exploration of space. Apart from the obvious human cost, the political costs were also severe. After years of carrying out a confusing series of minor space missions that ranked poorly in comparison to the Apollo Moon landings, the Soviet space program had been snatched of its first true victory in many years at the very last moment. It was a cruel reminder that the unending setbacks of the

past four years were not over.

The Salyut space station flew autonomously for several months during which five orbital maneuvers were conducted. The sixth engine firing on 10 October 1971 brought the vehicle, the world's first true space station, on a re-entry trajectory over the Pacific Ocean the following day. It had been in orbit for 175 days. Thus ended one of the most dramatic, eventful, and ultimately tragic episodes in the history of the Soviet space program. ●

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Footnotes

- 1.) These were published in the Russian newspaper *Vozdushniy transport*.
- 2.) V.M. Petrakov, "Soviet Orbital Stations," *Journal of the British Interplanetary Society* (September 1994), 363-371.
- 3.) Chelomey's organization was known as the Central Design Bureau of Maching Building (TsKBM) while Mishin's organization was known as the Central Design Bureau of Experimental Maching Building (TsKBEM).
- 4.) See for example Christian Lardier, *L'Astronautique Sovietique* (Paris: Armand Colin, 1992), 200-202; Phillip Clark, *The Soviet Manned Space Program: An Illustrated History of the Men, the Missions, and the Spacecraft* (New York: Orion Books, 1988), 56-60.
- 5.) The officials responsible for this order were Ivan D. Serbin, the Head of the Defense Industries Department of the Central Committee of the Communist Party and Tsarev of the Military-Industrial Commission.
- 6.) Sergey Voevodin, "Commander of the Soviet Cosmonaut Detachment," VSA039, March 27, 1993.

- 7.) Kerimov's official post was as Head of a Chief Directorate in the Ministry of General Machine Building (MOM).
- 8.) He trained for a military Transport-Supply Ship (TKS) mission in 1977-79 before resigning from the cosmonaut team on 28 April 1979.
- 9.) S. Shamsutdinov and I. Marinin, "Flights Which Never Happened: Part 3" (in Russian), *Aviatsiya i kosmonavtika* (March 1993), no. 3: 43-44.
- 10.) Dmitriy Payson, "Without the 'Secret' Stamp: 'Salyut' and Star Wars" (in Russian), *Rossiyskiye vesti* (November 21, 1992), 4.
- 11.) Spacecraft information from Vladimir Agapov and Vadim Molchanov.
- 12.) There was a launch failure on 14 December 1966 when a Soyuz (or 11A511) booster exploded at site 31 at Tyura-Tam killing one person and injuring many. The payload was an automated Soyuz (or 7K-OKP no. 1 spacecraft).
- 13.) German Nazarov, "You Cannot Paper Space With Rubles: How To Save Billions" (in Russian), *Molodaya gvardiya* (April 1990), no. 4: 192-207.
- 14.) K. Lantratov, "20 Years From the Flight of 'Soyuz-12'" (in Russian), *Novosti kosmonavtiki* (September 25-October 8, 1993), no. 20: 39-40.
- 15.) Another report suggests that the doctors found "a dark spot on the lungs." See Iosif Davydov, "How Could That Have Been?: Slandered Space" (in Russian), *Rossiyskaya gazeta* (June 11, 1992), 5.
- 16.) Gordon R. Hooper, *The Soviet Cosmonaut Team: Volume 2: Cosmonaut Biographies* (Lowestoft, UK: GRH Publication, 1990), 131.
- 17.) Lardier, 1992, 190.
- 18.) See for example Lardier, 1992.
- 19.) The cosmonauts involved in ground control were V.F. Bykovskiy, V.V. Gorbato, A.G. Nikolayev, V.A. Shatalov, and A.S. Yeliseyev.
- 20.) A. Tarasov, "Missions in Dreams and Reality" (in Russian), *Pravda* (October 20, 1989), 4.
- 21.) Tarasov, 1989.
- 22.) Clark, 1988, 64.
- 23.) Nikolay Kamanin, "This Should Never Happen Again!" (in Russian), *Vozdushniy transport* (1993), no. 24: 12.
- 24.) Evgeny Riabchikov, *Russians in Space* (New York: Doubleday & Company, Inc., 1971), 295.
- 25.) Peter Smolders, *Soviets in Space* (New York: Taplinger Publishing Co., Inc., 1973), 246.
- 26.) Tarasov, 1989.
- 27.) Mishin says that it was only Patsayev who attempted to close the valve. See G. Salakhutdinov, "Once More About Space" (in Russian), *Ogonek* (August 18-25, 1990), no. 34: 4-5.
- 28.) Smolders, 1973, 248.
- 29.) Edward Clinton Ezell and Linda Neuman Ezell, *The Partnership: A History of the Apollo-Soyuz Test Project* (Washington, D.C.: NASA SP-4209, 1978), 230. It apparently took 48-49 seconds for the crew to die, not 20 seconds as reported by the Soviets in 1973.
- 30.) NOVA: "The Russian Right Stuff: The Dark Side of the Moon," broadcast on 27 February 1991, WGBH-TV, Boston, MA; Tarasov, 1989. The valve was apparently a millimeter across. See Payson, 1992.
- 31.) Kamanin, 1993.
- 32.) Thomas O'Toole, "Soviet Union Still Trails U.S. In Space," *The Washington Post*, (June 17, 1973), A1, A8.
- 33.) Hooper, 1990, 132.
- 34.) Davydov, 1992.