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Soviet Salyut-6 Scientific Space Station: The First Manned Phase— September 1977 – March 1978 [redacted]

An Intelligence Assessment

Information as of 1 June 1979 has been used in preparing this report.

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Soviet Salyut-6
Scientific Space Station:
The First Manned Phase—
September 1977 – March 1978 [redacted]

Overview

The currently active Soviet Salyut-6 space station was launched on 29 September 1977 and was placed into the standard 52-degree earth orbit associated with the Soviet manned space program. It is the third successful "scientific" Salyut orbited by the Soviets, and represents their most ambitious manned space endeavor to date. It further demonstrates the Soviet commitment to men in space. The experience gained during the Salyut-6 mission probably will lead to continuous manning of space stations by cosmonauts. [redacted]

Thus far, the Salyut-6 mission can be broken down into three active phases. The first is defined arbitrarily as the period from launch in September 1977 through 16 March 1978, when the first manned phase (comprising Soyuz-25, Soyuz-26, Soyuz-27, Progress-1, and Soyuz-28) ended. This phase was followed by an unmanned, inactive period of 91 days. The second active phase of the mission began on 16 June with the docking of Soyuz-29, and ended with the undocking and subsequent recovery of the Soyuz-29 crew on 2 November 1978. This phase involved three manned Soyuz vehicles and three unmanned Progress automatic resupply vehicles. The third (and current) active phase began on 26 February 1979 when Soyuz-32 cosmonauts Lieutenant Colonel Vladimir Lyakhov and Valeriy V. Ryumin boarded Salyut-6. [redacted]

The first phase of the Soviet Salyut-6 mission involved four Soyuz spacecraft manned by a total of eight cosmonauts, and one unmanned Progress automatic resupply spacecraft. It set several significant historical precedents:

- It was the first time two vehicles were docked with a Salyut space station to form a three-vehicle complex.
- It was the first time two crews manned a Salyut simultaneously.
- It was the first use of an unmanned resupply vehicle (the Progress-1 delivered propellants, life support equipment, and supplies).
- It was the first time Soviet cosmonauts performed extravehicular activity (EVA) to accomplish useful tasks.

Table

Significant Events in First Manned Phase of Salyut-6 Mission

1977	
29 September	Salyut-6 inserted into orbit.
9 October	Soyuz-25, manned by Vladimir Vasilevich Kovalenok and Valeriy V. Ryumin, inserted into orbit. It failed to dock with Salyut-6 on 10 October, and was deorbited on 11 October.
10 December	Soyuz-26, manned by Yuriy Viktorovich Romanenko and Georgiy Mikhaylovich Grechko, inserted into orbit. It docked with Salyut-6 on 11 December.
19 December	Soyuz-26 cosmonauts conducted EVA to inspect the Salyut-6 station and its primary docking port.
1978	
10 January	Soyuz-27, manned by Vladimir Aleksandrovich Dzhanibekov and Oleg Gregoryevich Makarov, inserted into orbit. It docked with the Salyut-6/Soyuz-26 complex on 11 January.
16 January	Dzhanibekov and Makarov returned to Earth on Soyuz-26.
20 January	Progress-1 unmanned cargo resupply vehicle inserted into orbit. It docked with the Salyut-6/Soyuz-27 complex on 22 January.
6 February	Progress-1 undocked after completion of the transfer of fuel, cargo, and scientific equipment.
8 February	Progress-1 intentionally deboosted over Pacific Ocean.
2 March	Soyuz-28, manned by Aleksey Aleksandrovich Gubarev (USSR) and Vladimir Remek (Czechoslovakia), the first international crew, inserted into orbit. It docked with the Salyut-6/Soyuz-27 complex on 3 March.
10 March	Gubarev and Remek returned to Earth on Soyuz-28.
16 March	Romanenko and Grechko returned to Earth on Soyuz-27 after setting new man-in-space record of 96 days, 10 hours.

[redacted]

- It included the first refueling operation in space (the cosmonauts transferred propellants from Progress-1).
- It was the first time a space crew included a citizen of a country other than the United States or the USSR.
- It set a new man-in-space record of 96 days 10 hours.[1] [redacted]

Analysis confirms that Salyut-6 is a scientific space station, as the Soviets stated. One of the major functions performed by the crews on Salyut-6 was Earth resources photography using the MKF-6M (Mnogospektral'nyy Kosmicheskiy Fotoapparat) multispectral space camera. With this camera, the Salyut-6 cosmonauts photographed extensive regions including wide areas of the USSR and the German Democratic Republic (GDR). In addition to Earth observations and photography, the Salyut-6 cosmonauts conducted tests to determine the structural integrity of the space complex consisting of Salyut-6 and two ferry vehicles. [redacted]

The first non-Soviet cosmonaut in space from a country belonging to the Council for Economic Mutual Assistance (CEMA) was Vladimir Remek from Czechoslovakia. A cosmonaut researcher, he was launched to Salyut-6 aboard Soyuz-28 in March 1978. He began his training at the Zvezdnoy Gorodok (Star City) cosmonaut training center near Moscow on 6 December 1976 with the first group of CEMA cosmonauts made up of candidates from Czechoslovakia, Poland, and the GDR. The Soviets expect to gain international prestige and greater cooperation from member countries through the CEMA program. Consequently, we expect that representatives from each of the CEMA countries will visit Salyut-6 during its lifetime. [redacted]

The Soviets' use of EVA and of new space suits demonstrates their ability to acquire the necessary knowledge and experience to construct and maintain large structures in space, should they decide to do so. Furthermore, as the result of major Soviet technological advances in joint mobility and thermal control, the new space suits greatly increase their EVA capability. [redacted]

Significant medical and biological studies were conducted on board Salyut-6, as were extensive experiments to determine the feasibility of producing unique materials in a gravity-free environment. The experiments involved the formation of alloys and the growth of semiconductor crystals. They were conducted using a multichamber electrofurnace delivered by the unmanned Progress-1 cargo vehicle. [redacted]

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[1] During the second phase of this mission, the Soviets exceeded their own record, setting a new man-in-space record of 140 days (on 2 November 1978, by Cosmonauts Vladimir Vasilevich Kovalenok and Aleksandr Sergeyevich Ivanchenkov). [redacted]

The semiconductor crystals grown included bismuth antimonide, lead telluride, and a combination of mercury, cadmium, and tellurium. The mercury/cadmium/tellurium crystals formed the first three-component alloy ever produced in space. These crystals, along with bismuth antimonide and lead telluride, are the best known infrared detectors. The military applications of such infrared detectors range from thermal imaging devices to sensors on early-warning satellites. However, the scope of the semiconductor crystal experiments was such that it suggested research, rather than the production of crystals for direct military applications. [redacted]

In addition, with Salyut-6, the Soviets are continuously accumulating valuable long-term man-in-space experience. By contrast, the United States has not had a man in space since the termination of the Apollo-Soyuz Test Project in 1975, and the first US space shuttle mission—which will have a duration of no more than seven days—probably will not go into orbit before early 1980. [redacted]

The table lists the significant events in the first manned phase of Salyut-6, and the appendix presents brief biographic profiles of the cosmonauts. [redacted]

Table

Figures

[redacted]

Contents

[redacted]

Soviet Salyut-6
Scientific Space Station:
The First Manned Phase—
September 1977 – March 1978[redacted]

Background

On 19 April 1971, the USSR launched its first large space station, Salyut-1. During the six-month active lifetime of the station, the Soviets made two attempts to man it. The first—Soyuz-10, with a crew of three—failed because the two vehicles could not achieve a hard dock. The second attempt—Soyuz-11, with a crew of three—succeeded in docking with Salyut-1 in June 1971. After almost 24 days in orbit, the crew left Salyut-1, but died during reentry. Salyut-1 was intentionally deboosted and destroyed during reentry on 11 October 1971.[redacted]

Salyut-4, the second successful scientific space station, was launched on 26 December 1974.[2] During its 26-month lifetime, it was visited by two two-man crews. The crew of Soyuz-17, launched in January 1975, visited the station for 29 days. The crew of Soyuz-18, launched in May 1975, remained on Salyut-4 for 63 days. The space station then remained in orbit for more than a year while the Soviets monitored the onboard systems. Salyut-4 was intentionally deboosted and destroyed during atmospheric reentry on 2 February 1977.[redacted]

Salyut-6 (see figure 1), the Soviets' most ambitious manned space endeavor to date, was launched on 29 September 1977 from the Tyuratam Missile Test Center (TTMTC). The station has two docking ports. One of the designers of Salyut-6—Professor K. P. Feoktistov, a former cosmonaut—stated that there are several advantages in having two docking ports. If one port is not functional, the second could be used to dock a vehicle, and the crew could attempt to repair the faulty port assembly. Furthermore, should an emergency situation arise when a Soyuz vehicle is docked to the Salyut station, a second ferry vehicle could be sent up to rescue the cosmonauts. With two docking ports, a second ferry vehicle could also be sent to the orbiting station to replenish supplies and/or relieve the crew on board, so Salyut-6 has the capability to be permanently manned.[redacted]

[redacted]

Command and Control and Mission Support

Command and control of the Salyut-6 mission is directed by the flight control center in Moscow. This center is supported by space tracking stations in the Soviet Union and by ships located outside the territorial waters of the USSR (see figure 2). The ground sites of the Soviet space tracking network have access to Salyut-6 daily. The ships, associated with the Academy of Sciences of the USSR (the Kosmonavt Yuriy Gagarin and the new Kosmonavt Vladislav Volkov in the Atlantic Ocean, and the Kosmonavt Vladimir Komarov in the Mediterranean Sea), are used to communicate with Salyut-6 outside the radio horizon of the USSR.[redacted]

The ground stations can relay information to Moscow using either land communications or the orbiting Molniya communications satellites. The ships, on the other hand, relay information only via the satellites. All of the ground stations and some of the ships are equipped with radars and computers enabling them to determine the trajectory of Salyut-6. This information is then transmitted to the flight control center, where it is combined to provide accurate orbital data. These data are needed both to support the space station and to control its docking with another spacecraft.[redacted]

The flight control center can command Salyut-6 in real time, or can transmit programed commands that will control it on some future orbit. The center can adjust the orbit of the space station, control its attitude and life support systems, and operate the various onboard scientific sensors. The ability to do this at the flight control center relieves the cosmonauts of work that can be accomplished automatically, thereby allowing them to perform other tasks that cannot be automated.[redacted]

Mission Chronology

The Salyut-6 mission began with the launch of the space station on 29 September 1977. On 9 October 1977, Soyuz-25 was launched from the TTMTC, and the first attempt to man Salyut-6 occurred on 10 October 1977. The vehicle was to dock with the primary docking assembly, and the mission appeared to proceed normally until rendezvous and docking procedures were being performed. The cosmonauts, Lieutenant Colonel Vladimir Vasilevich Kovalenok (flight commander) and Valeriy V. Ryumin (flight engineer), apparently experienced problems with the automatic rendezvous system. They did not achieve a hard dock, and the mission was aborted. The Soyuz-25 crew returned safely to Earth on 11 October, but the docking failure set back the first phase of the Salyut-6 mission at least two months. [redacted]

Soyuz-26, manne cosmonauts Yuriy Viktorovich Romanenko (flight commander) and Georgiy Mikhaylovich Grechko (flight engineer), was launched from the TTMTC on 10 December 1977. Simulations in preparation for this flight probably took place at the cosmonaut training center at Star City, which contained a complete underwater mockup of the Salyut-Soyuz complex to simulate weightless conditions. In an article in *Aviatsiya i Kosmonavtika (Aviation and Cosmonautics)*, Colonel A. Khorobrykh reported that Romanenko and Grechko trained there prior to their flight. The training included developing an exit procedure for Grechko to examine the docking unit and transfer space tools, and a complete rehearsal of the inspection. [redacted]

Soyuz-26 successfully docked with the secondary docking assembly of Salyut-6 on 11 December. After entering the station, the cosmonauts activated the onboard systems and began preparations to inspect the primary docking assembly. On 19 December, after depressurizing the transfer compartment, Grechko left Salyut-6 through the primary docking-port hatch, performed an 88-minute EVA to inspect and test the assembly, and reported that the docking assembly was in good condition and completely workable. Grechko also inspected exterior components of the station including the docking assist lights, the docking system antennas, and the solar panels, and reported them to be in working order. According to TASS, Grechko inspected the condition of the joints, sensor guiding pins, pushers, fasteners, and sealing surfaces of the docking unit. He also carried a portable color television camera to relay images of the assembly back to Earth. [redacted]

Soyuz-27, manned by cosmonauts Vladimir Aleksandrovich Dzhanibekov (flight commander) and Oleg Grigoryevich Makarov (flight engineer), was launched on 10 January 1978. The spacecraft successfully rendezvoused and docked with the Salyut-6 space station on 11 January, about 26 hours after launch. The operation proceeded smoothly, without any apparent difficulties. This marked the first time the Soviets had two Soyuz spacecraft simultaneously docked with a space station, and the first instance of a Salyut being manned by four cosmonauts. The four conducted several joint medical-biological and scientific-technical experiments and studies aboard the space complex. One of the missions of the Soyuz-27 flight was to exchange scientific equipment. [redacted]

The Soviets deorbited Soyuz-26 on 16 January, carrying the crew of Soyuz-27 (Dzhanibekov and Makarov). Dzhanibekov and Makarov had spent five days aboard Salyut-6. The crew of Soyuz-26, Romanenko and Grechko, remained aboard the Salyut-6/Soyuz-27 orbiting space station. [redacted]

The reason for returning the Soyuz-27 crew in the Soyuz-26 vehicle, instead of in their own, was that the secondary docking port of Salyut-6 must be free of obstruction, both during maneuvers performed by the two main engines of Salyut-6 and to enable a ferry vehicle to dock. The space station has a long-term mission and requires occasional maneuvers to maintain its orbit. A vehicle attached near the engines would be susceptible to damage during a maneuvering burn. The only previous maneuver performed after Soyuz-26 docked had been accomplished using the Soyuz main engine. Because of the low thrust and fuel limitations of this engine, only small maneuvers could be performed. Thus, the normal use of the secondary port may be only to dock a vehicle for a relatively short time. [redacted]

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[1] Kovalenok and Ryumin later returned to Salyut-6, Kovalenok as the flight commander of Soyuz-29, and Ryumin as the flight engineer of Soyuz-32. [redacted]

The successful docking of both Soyuz-26 and Soyuz-27 with Salyut-6 demonstrated the Soviets' ability to maintain a continually manned space station in orbit. Crews can be sent to such a station at regular intervals to carry supplies and to relieve the crew. [redacted]

On 20 January 1978, Progress-1 was launched (see figure 3), and docked with the orbiting Salyut-6/Soyuz-27 space complex on 22 January. Progress-1 docked automatically with the secondary docking port of Salyut-6. This was the first time the Soviets had sent an unmanned resupply vehicle to a manned space station. TASS stated that the mission of the "automatic transport ship" was to transfer fuel, life-support supplies, and scientific equipment to Salyut-6. TASS also stated that the "transportation of supplies by automatic transport ships will make it possible to considerably prolong the functioning [of] and increase [the] effectiveness of the use of manned orbital complexes." However, we believe that the primary mission of Progress-1 probably was to prove the feasibility of unmanned resupply vehicles, and that it provided another "first" for the Soviet space program as well. We do not believe it was essential to resupply the station at that time. [redacted]

The refueling operation is the most unique feature of the Progress resupply vehicle. It is performed automatically on command from either the ground or the cosmonauts. The following operations are involved: (1) a check of the hermetic seal of the propellant lines following docking; (2) reduction in the pressure of the Salyut propellant tank; (3) the transfer of fuel and oxidizer; and (4) a purging of the lines with nitrogen gas after completion of the propellant transfer. The Progress vehicle contains two fuel and two oxidizer tanks for resupplying the station (see figure 4). Each tank has sections containing nitrogen gas. Because of the potential hazards involved in handling the highly volatile propellants, the propellant transfer is accomplished through the docking seal. The docking seal of Progress is different from that of the Soyuz spacecraft in that extra locking latches are added to ensure a solid, hermetic seal. The propellant transfer lines probably are external to the Progress spacecraft to ensure maximum safety. Compressed nitrogen is used to pressure-feed the propellants into the Salyut fuel and oxidizer tanks. [redacted]

The Salyut-6 propellant system consists of three oxidizer tanks (two main tanks and one reserve tank) and three fuel tanks. Each tank is divided into two sections by a folded, flexible metallic membrane. During the refueling operation, compressed nitrogen at a pressure of 20 atmospheres was pumped from these tanks into nitrogen bottles until a pressure of 3 atmospheres was obtained. The propellant from Progress-1, at a pressure of 8 atmospheres, was then forced into the tanks. When the fuel transfer was complete, nitrogen gas was used to repressurize the Progress-1 tanks and to purge the propellant lines prior to undocking. The Salyut-6 tanks were then repressurized with nitrogen to force the propellants into the engines. [redacted]

The cosmonauts monitored the refueling process from the central control post of Salyut-6. The entire refueling operation took place over an 11-day period. One of the reasons for extending the transfer over this length of time was that this was the first time such a procedure had been undertaken in space. [redacted]

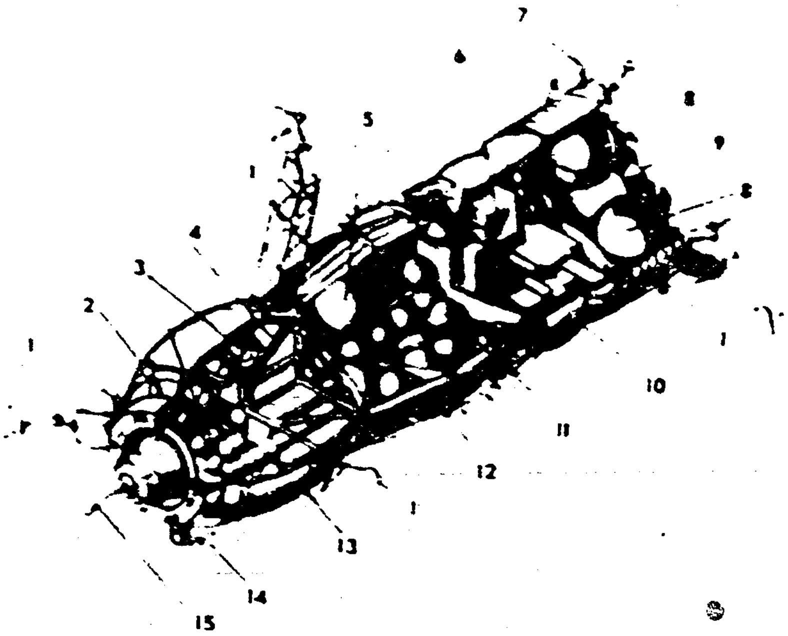
Progress-1 was docked with Salyut-6 for 15 days before undocking from the station on 6 February. During this time, it also was used in a series of engineering tests under the experiment called Rezonans. A TASS announcement on 6 February stated that, prior to undocking, Progress-1 fired its engine to maneuver Salyut-6 into a higher orbit. [redacted]

One revolution after undocking, Progress-1 again fired its engine, this time to "test the backup automatic search and approach system, which had never been tried in a real space flight before." On 8 February, the spacecraft was commanded to make a braking maneuver to put it on a descent trajectory, causing Progress-1 to reenter and burn up over a preset area of the Pacific. (The Soviets also use this method to dispose of their Salyut space stations when their useful life is over.) [redacted]

Soyuz-28, the last ferry vehicle to visit Salyut-6 during the first manned phase, was launched on 2 March 1978. It was manned by Aleksey Aleksandrovich

Progress Unmanned Cargo Resupply Vehicle

Figure 3

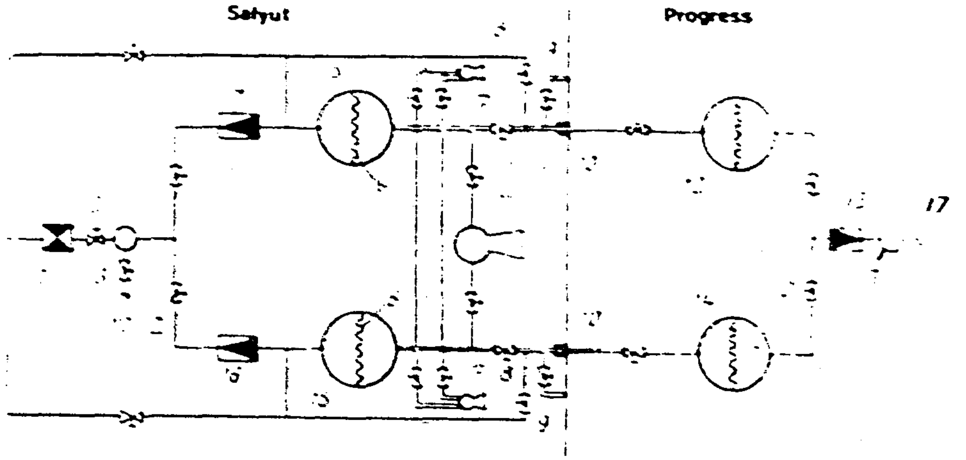


1. Antenna for approach and docking system
2. Light indicator
3. Cargo containers
4. Cargo fasteners within cargo compartment
5. Fuel tanks
6. Auxiliary on-board systems
7. Orientation engines
8. Fuel tank
9. Main propulsion system
10. Instrumentation and equipment compartment
11. High-pressure gas tanks
12. Fuel compartment
13. Cargo compartment
14. Scanning camera
15. Active docking assembly

[redacted]

Cross-Sectional Diagram of Soviet Orbital Station Refueling Process

Figure 4



1. Compressor
2. Stop valve/vent
3. Spherical high-pressure tank of fuel component expulsion system
4. Fuel-tank-repressurization line regulator
5. Salyut fuel tank
6. Elastic diaphragm (bellows)
7. Low-thrust engine
8. Purging line for consolidated fuel line
9. Evacuation line for consolidated fuel line
10. Hydraulic-connector sealing assembly
11. Main propulsion system
12. Progress fuel tank
13. Fuel-tank-repressurization line regulator
14. Progress oxidizer tank
15. Salyut oxidizer tank
16. Oxidizer-tank-repressurization line regulator
17. Connector (or nozzle) for refueling spherical high-pressure tank

[redacted]

Gubarev (flight commander), a Soviet, and by Vladimir Remek (cosmonaut researcher), the first Czech to fly in space. This was the first time anyone from a country other than the United States or the USSR had flown in space. [redacted]

Soyuz-28 docked with the Salyut-6 space station on 3 March. It ferried numerous replacement parts to the station, including photographic film, tape recorder cassettes, filters, experimental materials, and personal hygiene items. During the next seven days, the four cosmonauts (the Soyuz-28 crew and the original crew of Soyuz-26, Romanenko and Grechko) conducted several joint Soviet-Czech experiments including Earth observation and photography, the Extinctcia and chlorella experiments, and several metallurgical experiments using the Splav (alloy) electrofurnace. [redacted]

On 10 March, Soyuz-28 returned to Earth with its international crew, the results of the experiments, and exposed film. Six days later, Romanenko and Grechko returned to Earth in the Soyuz-27 ferry vehicle, marking the end of their man-in-space endurance record of 96 days. Before departing Salyut-6, the cosmonauts placed it in a standdown mode for automatic flight. [redacted]

Physical Description of Space Station and Resupply Vehicle

Salyut-6

Recent articles appearing in the Soviet press have provided a detailed description of the structural arrangement of the Salyut-6 space station. The station carries about one and a half tons of scientific equipment and has a total habitable volume of 100 cubic meters. It consists of three cylinders of differing diameters, which are connected by cone-shaped linking sections (see figure 1). The smallest cylinder, containing the transfer compartment, is the forward section of the spacecraft. The primary docking port (the "station's passive docking assembly") is at the front end of this cylinder. The middle cylinder contains part of the working compartment. The third and largest cylinder houses the remainder of the working compartment and part of an equipment compartment. This cylinder is connected to the middle cylinder by a linking section more than 1 meter long. At the rear of the spacecraft, attached to the largest cylinder, is the remaining portion of the equipment compartment—the only area which is not hermetically sealed. The secondary docking port is in the center of this compartment. [redacted]

The transfer compartment is separated from the working compartment by a pressurized airlock. The transfer compartment is used for conducting scientific experiments, and also as an airlock for EVA. On the exterior of the transfer compartment are telemetry and voice-communications antennas, beacons, ion sensors for the orientation and stabilization system, micrometeorite sensors, sun-position sensors, and compressed-air tanks. The interior of this compartment houses the EVA suits, photographic equipment, EVA and scientific control panels, and a station-orientation control knob. [redacted]

The cosmonauts spend most of their time in the working compartment in the middle cylinder. Among the items in this section are the central command post, the MKF-6M camera, the water-regeneration system, toilets, bunk beds, and a conical scientific apparatus compartment (the inner cavity of which is unpressurized and can be opened to space) that contains the BST telescope. This area also includes the dining area, an area for medical examinations and exercise, the treadmill, the bicycle ergometer, and a shower. The majority of the scientific equipment is also located in this compartment. Attached to the exterior of the compartment are three solar panels, placed 90 degrees apart that, once deployed, can automatically orient themselves toward the sun in such a way that maximum current is produced. With a total surface area of 60 square meters, they produce 4 kilowatts of electrical power. The central command post ("Post No. 1 consoles"), also in the working compartment, is perhaps the most important unit on the station. All data from the Salyut-6 instruments are relayed to these consoles. The cosmonauts control the station, monitor all systems, and receive and transmit data from the consoles. Voice communications with Earth, the Delta navigational system, and the teletype "Stroka" are also on the command post. [redacted]

The rest of the working compartment is in the third cylinder. This area has a movie camera, and heat pipes leading from the Salyut-6 heater. The unpressurized equipment compartment, which houses the propulsion and refueling system, occupies the remainder of the station's aft section. Solar-orientation sensors, orbital and attitude control engines, and antennas are on the exterior. The Salyut-6 propulsion system consists of two main engines and four sets of small attitude-control engines. The arrangement and location of the main engines of Salyut-6 had to be altered from the Salyut-4 configuration to accommodate the installation of the secondary docking port. [redacted]

The Salyut environment control system is an adaptation of the time-proven system used on Soyuz. The basic elements used for the control of atmospheric gases are potassium superoxide regenerators, lithium-hydroxide carbon-dioxide absorbers, and accompanying contaminant filters. Gas analyzers monitor oxygen, carbon dioxide, and water vapor levels, and control the operation of the regenerators and absorbers. Normal pressure maintained aboard Salyut is about 1 atmosphere (equivalent to 760 millimeters of mercury). Pressure control on Salyut is maintained by transducers, vents to relieve excess pressure, and a supply of compressed gas consisting of a mixture of 40-percent oxygen and 60-percent nitrogen to replace the atmospheric air lost from leakage, EVA, and operation of the Splav electrofurnace. Minor atmospheric air losses also occur during docking and waste disposal operations. [redacted]

The entire station is thermally insulated by multi-layered, vacuum-shielded insulation several microns thick, covered with additional layers of glass wool and aluminum foil. The station's interior temperature, as well as the thermal conditions of the instrumentation mounted on the exterior, is maintained by a network of radiators and pipes. The temperature control is effected by two independent systems: one, for cooling, having an external radiator for heat rejection; and the other, having an external collector for heating. In the cooling system, the circuit in the crew compartment picks up heat produced by the crew and equipment and transfers it to an intermediate circuit, from which the heat is transferred to the radiator circuit. A liquid-flow regulator in the radiator circuit controls the distribution of heat—some is rejected to space via the radiator, and the remainder is recirculated to the crew compartments. The heating system consists of an external collector of heat, an internal heat-exchange circuit, and heat exchangers which are used to keep orbital maneuvering engine and attitude control system temperatures within the required ranges and, if necessary, to supply heat to the crew compartments. [redacted]

Progress

The Progress resupply spacecraft is basically a modified Soyuz ferry vehicle (see figure 3). According to the Soviets, it can deliver 2,295 kilograms of cargo into near-Earth orbit, and its total weight at liftoff is 7,005 kilograms. This weight is about 400 kilograms heavier than that of the standard Soyuz, and approximates the full capability of the SL-4 launch vehicle to place a spacecraft into near-Earth orbit. The Soviets were able to add the 400 kilograms to the payload weight by eliminating the launch-escape system necessary for manned Soyuz launches. However, the entire payload fairing structure (that is, the shrouds and escape tower) was retained, so that the aerodynamic properties of the SL-4 would remain the same. [redacted]

Like Soyuz, Progress consists of three sections: the cargo compartment with the docking unit, the propellant compartment, and the instrument compartment. These are analogous to the Soyuz orbital, recovery, and instrument compartments, respectively. The docking unit of Progress is basically the same as the comparable unit on Soyuz. However, it contains additional automatic hydraulic connectors to ensure the hermetic coupling of the Progress propellant transfer system with the Salyut propellant connectors. [redacted]

The cargo compartment, with a volume of 6.6 cubic meters, replaced the slightly smaller Soyuz orbital compartment. Dry cargo is stored in this area. All small objects are packed in containers, and the large equipment is fastened on racks attached to the framework. The fasteners are specially designed bolts that release with a quarter-turn to speed unloading. [redacted]

The propellant compartment contains the basic components for refueling and gas supply operations. This includes four cylindrical propellant tanks, spherical tanks with compressed breathing air and nitrogen, hydraulic hardware for fuel-line coupling, sensors, and gauges. The total propellant and gas delivered on Progress-1 weighed 1,000 kilograms. [redacted]

The instrument compartment is basically identical to the Soyuz instrument compartment, containing the orbital maneuvering engine, attitude-control subsystem, and electronics. However, the volume of the Progress instrument compartment was increased almost two-fold. Progress is equipped with two instrument racks, while Soyuz has only one. Room for this additional instrument rack probably was provided by deleting the backup orbital maneuvering engine. The additional instrumentation probably was required to accommodate redundant electronics for the fully automatic rendezvous and docking system, and control systems for the propellant transfer function. Thermal control and life support are provided from the Salyut space station to the cargo compartment to permit the cosmonauts to work in a shirt-sleeve environment. [redacted]

[redacted]

The exterior of Progress, like that of Soyuz, has a telemetry antenna, a docking antenna, three lights, and two television cameras. The lights and cameras are used to monitor the approach and docking operations from Salyut. The data are relayed directly to the cosmonauts on the station, allowing them to monitor and control the approach phase, if necessary. While most of the Progress flight systems are functionally similar to those on Soyuz, there are some exceptions—in particular, the attitude and guidance system, the control area, and the thermoregulation systems—primarily because Progress was designed to operate automatically. [redacted]

Significant Experiments and Equipment

Medical and Biological

Perhaps the most significant experiments conducted on board Salyut-6 were the medical and biological studies. Among all the experiments conducted, these were stressed continuously, and consumed the most time. The Soviets have reported that additional study is needed to understand the effects of weightlessness on the body in particular, and the effects on mineral metabolism, hormonal changes, and cellular reactions. [redacted]

Every five or six days, "medical days" were assigned for (a) investigations of the cardiovascular system (including blood samples); (b) an experiment to study the redistribution of blood in the body and to assess the condition of groups of muscles; (c) the monitoring of calcium, potassium, and sodium levels in the body; and (d) monitoring for changes in the station's atmosphere. These tests were conducted before, during, and after various physical exercises (such as on the bicycle ergometer and the treadmill). They were also performed with the Chibis lower-body negative-pressure suit. The objective was to determine how much, and when, exercise was needed. The emphasis in the biomedical studies was on the cardiovascular system, the vestibular apparatus, respiration, body temperature, and metabolism (based on biochemical measurements of the blood). In addition to these studies, routine daily medical reports were made. Then, every two to three days, the cosmonauts used the Beta-3 apparatus for electrocardiogram and respiration-rate measurements. Body mass was recorded using an inertial massometer. Most of the data were telemetered back to the ground. Biomedical monitoring was also conducted during EVA. [redacted]

Polynom 2M Device. The Polynom 2M is a bioinstrumentation system that provides a reliable method for obtaining detailed data on the heart and blood vessels of each cosmonaut. By comparing the data received daily, the Soviet physiologists have considerable information on the changes in the cardiovascular systems of the cosmonauts under conditions of prolonged weightlessness. These data are essential for detecting the onset of adverse effects. Polynom 2M data also are used to evaluate the effectiveness of measures taken to counteract the undesirable effects of weightlessness. These countermeasures include the exercise program and the lower-body negative-pressure suit. [redacted]

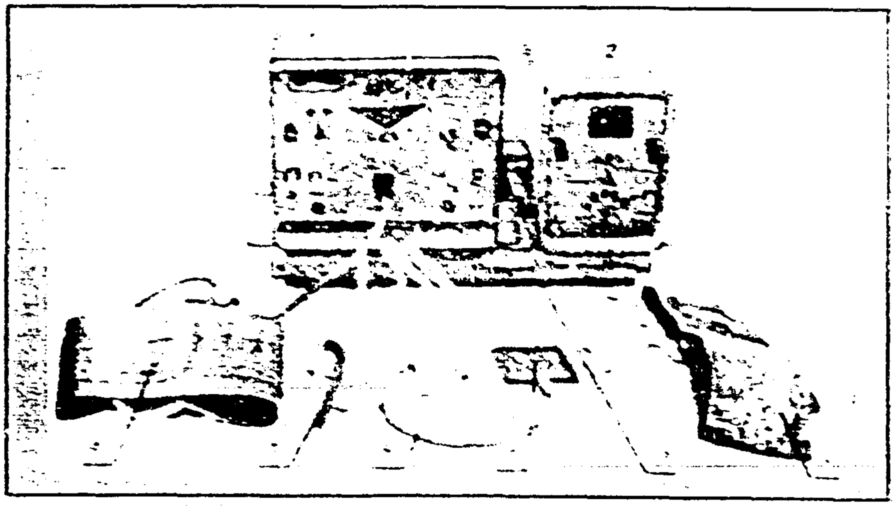
The Polynom 2M device consists of an amplifier and four sensor assemblies: a kinetocardiograph, a distal-perimetric oscillograph, a tacho-oscillograph, and a thigh cuff (see figure 5). The kinetocardiograph provides data from which most of the performance parameters are obtained. The distal-perimetric oscillograph senses the pulse in limb arteries, and the tacho-oscillograph is designed to provide blood pressure measurements. By comparing the tacho-oscillogram with the kinetocardiogram, data are provided from which Soviet physiologists can estimate the blood flow from the heart. Also, the tacho-oscillogram and the distal-perimetric oscillogram can be correlated in time to derive an accurate estimate of systolic blood pressure (that is, the peak blood pressure during the ejection of blood from the heart). [redacted]

The thigh cuff, a pressure cuff that contains a sensor, is used to measure pressure oscillations at a location on the upper third of the left thigh. The correlation of the traces from the thigh cuff and the kinetocardiograph provides the transit time of a pulse, an indicator of the smooth muscle tone in the large arteries. During extended space missions, the deterioration of the smooth muscle tone of the arteries has been one of the serious side effects experienced in weightlessness. [redacted]

[redacted]

Soviet Polynom 2M Device

Figure 5



1. Unit of measurement channels
2. Indicator unit
3. Pneumatic unit
4. Tacho-oscillograph cuff with sensor
5. Sensor for distal-perimetric oscillograph
6. Kinetocardiograph sensor
7. Kinetocardiograph detector
8. Thigh cuff with sensor

[redacted]

Biotherm-4 Incubator Experiment. The Biotherm-4 is a biological incubator used to incubate drosophila fruit flies. The purpose of the experiment using the Biotherm-4 was to gather data on how weightlessness affects breeding and heredity. The results of a similar experiment conducted on Salyut-4 showed that drosophila lay sterile eggs in space. The Salyut-6 crew was checking to see if the Salyut-4 test was an isolated case. [redacted]

In the experiment conducted on 18 February, drosophila larvae, formed from eggs laid on Earth, were pupated at 24°C in the Biotherm-4. The cosmonauts checked to see if the fruit flies born in space produced a third generation. The Soviets have not yet made that information public. However, if a third generation was produced, a comparison of the first- and third-generation characteristics was to be made to determine how space flight affects heredity. [redacted]

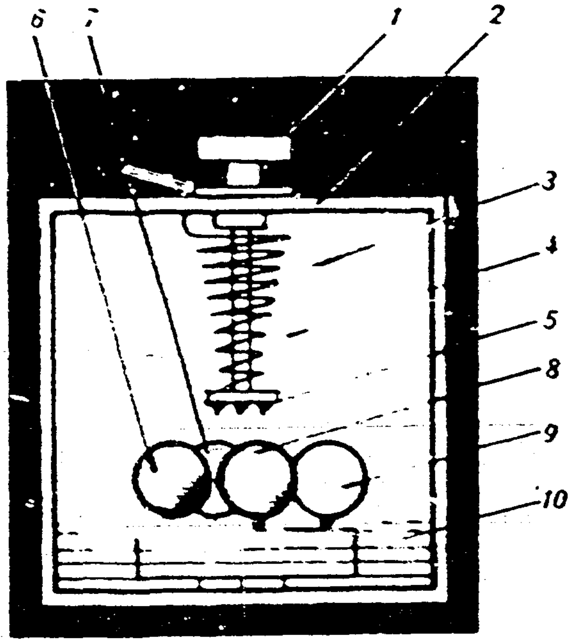
Chlorella Experiment. The chlorella experiment was a joint Soviet-Czech experiment to study the growth of different species of chlorella algae (unicellular plant organisms) in a weightless environment (see figure 6). [redacted]

In one part of the experiment, three different species of algae were put into a nutrient medium and allowed to grow. Growth competition among the three species was studied in space and, upon return to Earth, the resulting growth was compared with that of an Earth-grown version of the same experiment. [redacted]

Another test also involved three species of chlorella. The chlorella strains used were mutants lacking chlorophyll. Each species had two samples, one of which was allowed to grow while in orbit. Its corresponding sample remained in the passive state (the absence of the nutrient medium). Upon return to Earth, the samples were compared. [redacted]

Instrument for Soviet-Czech Chlorella Experiment

Figure 6



1. Housing and striker handle
2. Transparent hydrophilic inside walls
3. Spring
4. Protective rubber hood
5. Thrust head for smashing ampoules
6. Shell with chlorella
7. Shell with fixative
8. Shell with active physiological agent
9. Shell with "marker"
10. Food medium

By means of the striker, the cosmonauts can break any shell in conformance with the experimental program.

[redacted]

The Soviets claim chlorella is important because it will be used in future interplanetary ships and stations in "greenhouses" with a closed ecological system. In these greenhouses, the plants will absorb carbon dioxide from the air and enrich it with oxygen to serve as a food and water supply. Chlorella, which absorbs carbon dioxide and releases oxygen very actively, is rich in protein and matures rapidly. [redacted]

Medusa Experiment. Outside Salyut-6, attached to the transfer compartment, are special flasks containing amino acids which have been exposed to solar and cosmic radiation. When retrieved during EVA, the samples will be compared with biopolymers stored on board Salyut-6. Analysis should help to establish which changes in the living cultures have been caused by space radiation. [redacted]

Frog Eggs Experiment. The Soviets placed fertilized frog eggs aboard Soyuz-26 in what they described as a terrestrial pond. Once on Salyut-6, the cosmonauts put the frog eggs beside tadpoles that had been born on Earth, and compared their behavior. An obvious difference was that the tadpoles born in space moved in spirals, while the tadpoles born on Earth seemed disoriented. The tadpoles were returned to Earth for scientific study—particularly, study of their orientation organs. [redacted]

Cytos Thermostat Experiment. The purpose of the joint Franco-Soviet experiment using the French thermostat Cytos was to study the effects of space on the cell divisions of micro-organisms when each organism was separated from the others. The Soviets chose Amoeba Proteus (nondifferentiated nucleus) organisms for this experiment, and the French selected Paramecia (differentiated nuclei). The French scientific planning team was led by Professor Hubert Planel of the University of Toulouse, and the Soviet experiment was sponsored by the USSR Ministry of Health. [redacted]

Cultures prepared by French and Soviet biologists were made dormant in an ordinary refrigerator. The cultures were transported to the TTMTC in the Soviet transport thermostat Termokont-2. They were then placed aboard Soyuz-27 in a Soviet instrument called Biotherm-8, which maintained a constant temperature of 8° C to inhibit cell division until arrival on Salyut-6. Once on the station, the cultures were transferred to the Cytos thermostat where the organisms were activated and began multiplying. The thermostat maintained a constant temperature of 25°C, the heat providing the micro-organisms with the proper temperature for cell division. For four days, at 12-hour intervals, the cosmonauts extracted and fixed a sample, which was returned to Earth by Dzhanibekov and Makarov on Soyuz-26 for analysis. Thus, eight generations of the organisms were sampled. A control experiment was also conducted on Earth, and on 20 January the French organisms arrived at the National Center for Space Studies (Centre National d'Etudes Spatiales), in Toulouse. [redacted]

Geophysical

The cosmonauts aboard the Salyut-6 station devoted considerable time to observing the Earth and its atmosphere. Studies of the atmosphere were conducted using photography, sketches, and notes. Soviet scientists consider the results of the atmospheric studies significant in assessing the status of the atmosphere. Earth photography was obtained with numerous cameras including the MKF-6M camera, the Kiev hand-held movie camera, and the Kate topographical camera. [redacted]

Extinctcia and Refraction Experiments. On 6 March, Gubarev and Remek conducted the atmospheric experiment designated Extinctcia. The purpose of this experiment was to study the dust layers formed by micrometeorites in the Earth's atmosphere at altitudes in the range of 80 to 100 kilometers. During the experiment, the cosmonauts photographed selected stars as they set behind the Earth's night horizon. The photography was taken when the cosmonauts were over both land and ocean areas. By comparing the change in brightness of the stars, the Soviets hope to obtain micrometeorite layer data that could be used to improve long-range communications. The data could also be applied to weather studies. [redacted]

A related experiment, designated Refraction, had been conducted on 25 February. This experiment involved measuring the apparent angle between various stars and planets when viewed through the Earth's atmosphere. [redacted]

Grechko noted that he was particularly fascinated by the noctilucent clouds. He took several dozen photographs of these silver clouds, which usually hover over polar regions at altitudes of about 80 kilometers. The Soviets believe these clouds are formed from silicon or iron particles from volcanoes or meteorites. [redacted]

Raduga Experiment. The Soviets placed particular importance on the Raduga (rainbow) experimental series, the purpose of which was to obtain Earth resources photography using the MKF-6M cameras. (The "M" indicates a modified version of the MKF-6 camera.) The MKF-6 camera system is a six-camera multispectral system with narrow-band filters on each lens to provide photographs of various regions of the electromagnetic spectru[redacted] The six

Pages: 15

Exemptions: (b)(3)

cameras are aligned to point to the same area on the Earth's surface so that six simultaneously imaged frames cover the same area in six spectral regions. According to the Soviets, each camera can photograph a strip 165 kilometers wide by 115 kilometers long. Soviet sources claim the camera weighs about 170 kilograms and was designed and built by the GDR's Karl Zeiss Jena enterprise in cooperation with the Institute of Space Research (Institut Kosmicheskogo Issledovaniya) of the USSR. It was first used in space on Soyuz-22 in 1976 on an experimental basis. Tests were also conducted with the camera on an experimental AN-30 aircraft. [redacted]

According to the Soviets, the film is processed at Karl Zeiss Jena and sent to the Soviet State Scientific Research and Production Center Priroda, a branch of the Academy of Sciences of the USSR. When used with the MSP-4 multispectral projector, also developed by Karl Zeiss Jena, the film provides data on the size, configuration, structure, and texture of various regions of the Earth's surface. In addition, spectral characteristics such as gray tone, color, and radiation intensity can be determined. Photographs from the camera have a reported ground resolution of 30 meters.

[redacted]

The primary use of the MKF-6M camera on Salyut-6 was for Earth resources photography. Romanenko and Grechko photographed various areas of the world, including the USSR and the GDR. A team of GDR specialists led by Professor Hans Fischer was at the Kaliningrad Flight Control Center during the first manned phase of Salyut-6. In contrast to the MKF-6, the camera used on Salyut-6 was made more reliable—that is, a backup electronic system was added, and two additional film cassettes were installed. Each cassette has enough film to cover more than 10 million square kilometers of the Earth's surface. The long duration of the Salyut-6 mission has permitted multispectral photography to be taken at different times of the year. [redacted]

BST Telescope. The BST telescope operates primarily in the submillimeter and infrared ranges. On Salyut-6 it was used for Earth resources and atmospheric observations. The system can operate manually or automatically. When in operation, the infrared sensors are cooled to -269.2° C by a closed-cycle helium cryostat which draws about 1.5 kilowatts of electrical power. This is the first time the Soviets are known to have used a closed-cycle cryostat in space. However, they used open cryostats as early as 1974 on Cosmos-669, and on Salyut-4. [redacted]

The purpose of the cryogenic system is to cool the radiation sensors of the telescope, enabling the instrument to be more sensitive to infrared emissions. The sensors, 5 millimeters square, include indium antimonide and germanium boron, which also were on the Cosmos-669 BST. The closed-cycle cryostat operates with gaseous helium compressed to a pressure of 25 atmospheres. Helium is successively compressed, and then cooled in two gas-refrigeration machines and intermediate heat exchangers, before flowing through an expanding nozzle. [redacted]

According to Soviet sources, the BST telescope has a 1.5-meter-diameter mirror. This mirror is approximately five times larger than the main reflector of the Salyut-4 solar telescope. Its operational range, according to the Soviets, extends from several microns to 1 to 2 millimeters. The telescope, which weighs over 650 kilograms, is the largest research instrument on board Salyut-6. Romanenko and Grechko used it to study solar corona, to determine regions of high moisture content in the atmosphere, and to make measurements (with noncooled sensors) of ultraviolet radiation in the atmosphere for ozone-layer studies. [redacted]

Space Station Engineering Experiment Rezonans

One of the most important engineering experiments performed on Salyut-6 was designated Rezonans. This experiment was designed to study the amount and effects of various types of stress on the docking interface between Salyut-6 and a Soyuz or Progress spacecraft. Sensitive transducers were placed at critical points of the space complex and hooked up to a central monitoring and recording device. On a signal from the ground, one cosmonaut created vibrations while running, jumping, or walking on the treadmill. The pressure in the cavity between the seals of the docking assemblies was recorded by sensitive sensors before, during, and after the vibrations were produced. The Rezonans experiment was conducted with differing configurations of the Salyut-6 complex—that is, with one Soyuz vehicle docked, with the Progress-1 vehicle attached, and with two Soyuz vehicles docked. The results of these resonance experiments provided valuable information on the dynamics of a three-vehicle space complex under stress. This information will be used to determine the configurations of future Soviet space complexes. [redacted]

Delta Autonomous Navigation System

One of the unique features of the Salyut-6 station was the operational use, for the first time, of an automatic navigational system. The significance of this system is that it frees the cosmonauts of the burdensome task of controlling the space station—that is, it serves as an "autopilot." According to the Soviets, prior to Salyut-6, cosmonauts had spent up to one-third of their work time preparing and executing spacecraft orientation maneuvers to keep the vehicle on course. The Delta system automatically maintains the attitude of the station. In addition, it projects future orbital data, which include the beginning of each revolution, the equator crossing time, the times at which the spacecraft will enter and exit the shadows, and the equatorial longitude for each revolution. The Soviet press has described in some detail the function of the system components and the operation of the system as a whole. Some of the basic functions of the Delta system are:

- Automatic determination of orbital parameters, performed by an onboard computer receiving data from sensors on the space station and updated data from the ground. Orbital sensors aboard the space station include a radioaltimeter, a Doppler measuring device, and astronavigation sensors. The radioaltimeter measures the altitude of the space station at defined intervals. To do this, the altimeter axis must be aligned with the Earth's surface. Initially, the cosmonauts perform this alignment with the aid of an optical device. Once set, the attitude control system works autonomously. The Doppler device determines the radial velocity of the station as it passes over radio beacons in the USSR; and the astronavigation sensors register the rising and setting of celestial bodies, thereby providing the station its position in space.

- Automatic orbital maintenance, controlled by the onboard computer through the actuating mechanisms.

- Determination of the radiovisibility zones of the space station with the ground stations, and automatic switching on and off of the communications equipment as the station enters and leaves the zones. It also notifies the ground stations of the daily schedule. [redacted]

The Soviet press has described the computer's memory as a high-capacity unit, presumably electronic. The memory is used to store data from the measuring systems until the computer is ready for processing. It also contains preprogramed instructions for the cosmonauts. These instructions are printed out on a cathode ray tube. The Delta system also has a "Stroka" teletype for printing out data. An internal clock, which provides Moscow time on the control panel, may be used in conjunction with experiments to register the time of events. [redacted]

Although, as already noted, this was the first operational use of the Delta system, various components of the system were tested on previous Soyuz and Salyut missions. A semiautomatic model of the system reportedly was included on Salyut-1, and was improved upon in successive missions. The Delta autonomous navigational system has special significance to the Soviet manned space program. The capability of the space station to function with limited support from Earth-based complexes represents a great stride in efficiency. The Soviet space program is a very ambitious one with numerous satellites in orbit, and reducing command support from the ground for these manned missions frees command resources for other programs. Futhermore, automating the control of the space station frees the cosmonauts to pursue more meaningful tasks. [redacted]

Micrometeorite Observations and Experiments

The cosmonauts made visual and photographic observations of micrometeorites near the Salyut space station. As in previous flights, it was noticed that the windows were covered with a thin layer of dust. The cosmonauts described this layer, as well as scratches made by micrometeorites on the porthole glass. On one occasion, a scratch one and a half millimeters deep was noted. [redacted]

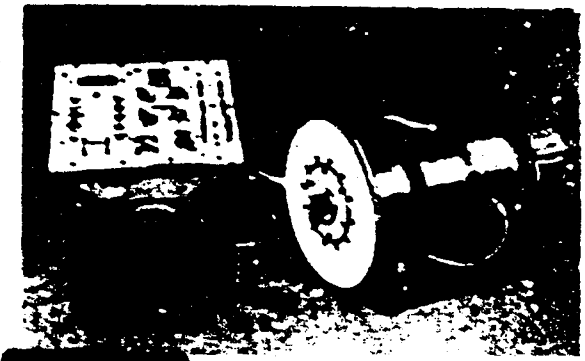
The cosmonauts also used the space station to study micrometeorite dust. These particles are known to cause gradual erosion of the solar-cell semiconductor coating and of other coatings on the exterior surface of the station. To study this phenomenon the Soviets designed three sensors, each with an area of 0.6 square meter, to measure the frequency of impact of dust particles. One sensor was placed on the transfer compartment; and the other two, on the working compartment. The sensors consisted of two charged-aluminum-foil electrodes with dacron between them. When a particle penetrated the upper plate, its charged trail closed a compactor circuit and registered a hit on a counter. Particles weighing as little as one-millionth of a gram were recorded. This information was passed in telemetry to Earth. The conclusion of this experiment was that the frequency of dust particle impacts is sporadic [redacted]

Metallurgical Experiments

One of the major pieces of equipment enabling Salyut-6 to be used as a platform to conduct materials science studies was the Splav furnace. The Splav furnace is a remote-controlled, multichambered electrofurnace used primarily to produce alloys in space, and to study welding and soldering techniques (see figure 8). The furnace was delivered to the station on Progress-1 and operated in the Salyut-6 transfer compartment. It was one of the most extensively used technological instruments on the station. [redacted]

The Splav furnace weighs about 28 kilograms, and was designed by A. V. Yegorov. It has a power requirement of only 300 watts. To prevent heat loss, there are molybdenum reflectors around the furnace to assure a temperature not exceeding 40° C on the outside of the unit when the interior temperature is 1,000° C. The furnace consists of three heating zones. One, the hot zone, maintains a constant temperature of up to 1,000° C, while another, the cold zone, maintains a temperature of 600 to 700° C. These two zones are used to form three-dimensional crystals. The central zone, used to form one-dimensional crystals, provides for a linear temperature cooling from the maximum temperature to the minimum temperature. A portable computer, weighing only 10 kilograms, is used to control the temperature of the heating chamber to within 5° C, and the entire process is preprogramed. [redacted]

Soviet Splav Electrofurnace Figure 8



[redacted]

During the Salyut-6 experiments, up to three capsules, each loaded with two quartz ampules containing various substances, were placed in the furnace. The cosmonaut then specified on the computer the maximum temperature, heating time, rate of cooling, and cooling temperature range. The airlock was depressurized and the furnace was turned on. The substances were heated to the required temperature, fused in the hot zone, and cooled in the cold zone, allowing crystalization to occur. The samples were then removed and returned to Earth on a ferry vehicle for examination. A low degree of sample impurity was expected (one part per hundred million). To minimize any disturbances that might affect the experiments during crystalization, they normally were conducted while the cosmonauts were sleeping. In addition, the Salyut-6 engines were always shut off during the experiments. [redacted]

The substances used in the experiments were aluminum and tungsten, molybdenum and potassium, copper and indium, indium and antimony, molybdenum and gallium, and aluminum and magnesium. All differ greatly in specific weights and do not form alloys readily on Earth. Additionally, semiconductor crystals were grown in the Splav furnace. The technical value of semiconductor crystals depends on their degree of purity and structural homogeneity. Theoretically, under the conditions of weightlessness, very homogeneous and pure semiconductor alloys can be produced. The semiconductor crystals included bismuth antimonide, lead telluride, and a combination of mercury, cadmium, and tellurium. The mercury/cadmium/tellurium crystals formed the first three-component alloy ever produced in space. Significantly, all of the semiconductors used are at present the best known infrared detectors. The military applications of infrared detectors range from thermal imaging devices to sensors on launch-detection or early-warning satellites. The results of these experiments should reveal to the Soviets if it is feasible to produce crystals of sufficient purity in space. If so, they probably will develop a process that will produce semiconductors in sufficient quantities for limited military applications. [redacted]

A joint Soviet-Czech experiment, Morava, also was conducted with the Splav electrofurnace to make semiconductors for possible use in optical electronics. Czech samples of silver and lead chlorides and copper and lead chlorides were melted in the furnace, and cooled. The resultant crystals were returned to Earth for comparison with crystals grown on Earth. The crystals grown in space were expected to have high electro-optical properties and to be unique in purity. [redacted]

Space-Suit Assemblies

Romanenko and Grechko used a new, semirigid EVA suit for the first time in space. This pressure suit consists of a rigid metal chest plate, a helmet, and a backpack life-support system (see figure 9). Its sleeves and trousers are soft. The suit has laces and can be adjusted to fit individual cosmonauts. Unlike previous models, the suit is entered through a clam-shell hatch in the back. A cosmonaut can dress himself without assistance in a few minutes. It is also more reliable, since it does not have external pneumatic and hydraulic lines connecting the backpack to the pressure suit. Furthermore, the controls are conveniently located on the metal chest plate. Mobility of the arms and legs is facilitated by the use of convoluted joints, sealed metal joints with ball bearings, and soft hinges. [redacted]

The cosmonaut and the suit's components are protected from the extreme temperatures of space by external layers of vacuum-shielded heat insulation. Oxygen is provided by a closed regenerating system that maintains a set pressure (approximately 0.4 atmosphere), suit ventilation, and the required composition of air for breathing by removing carbon dioxide and impurities from the air. [redacted]

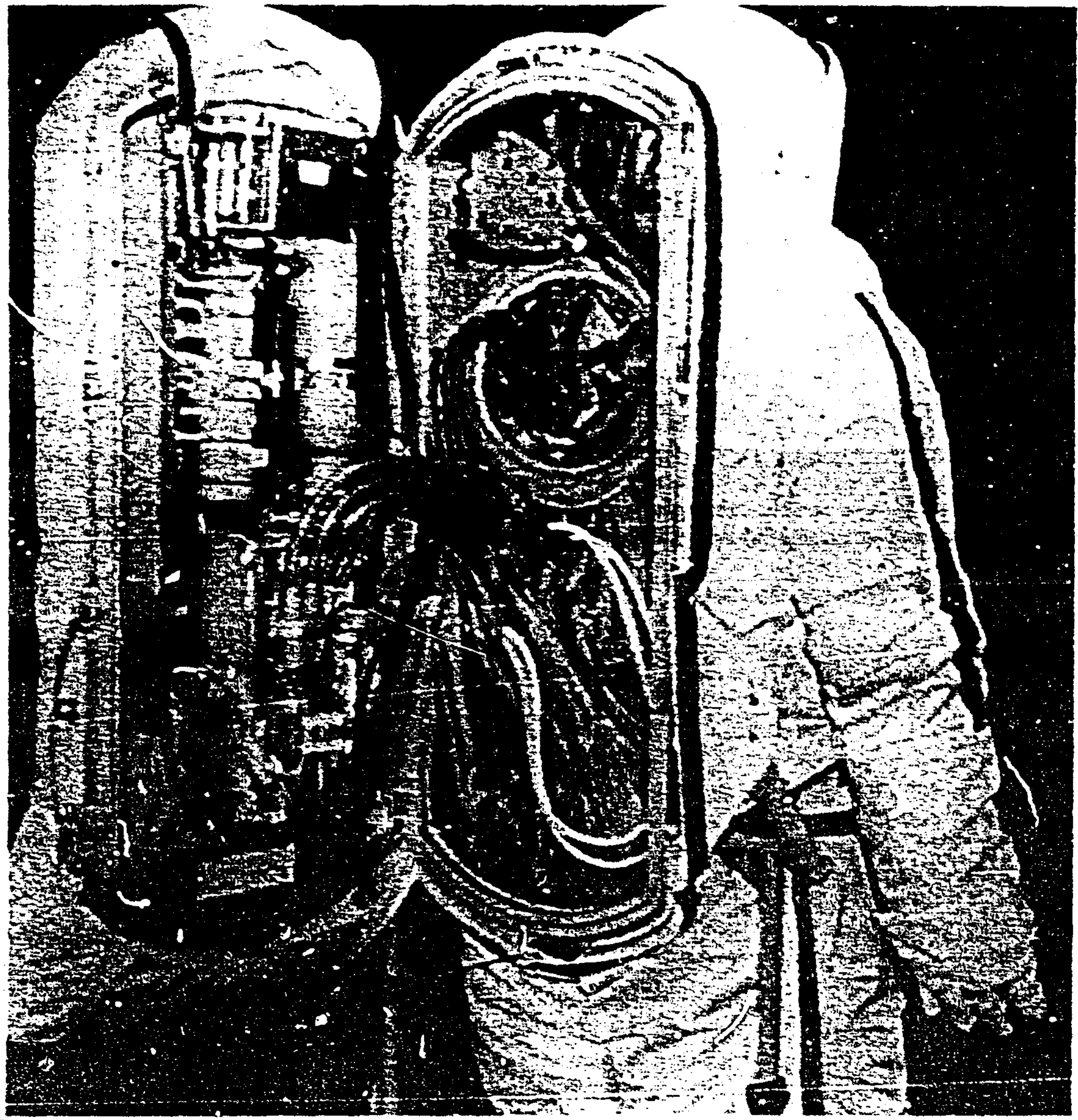
The suit's thermoregulation system consists of water-cooled overalls coated with highly elastic synthetic rubber into which flexible tubes are woven. Water fills these tubes so that the overalls act much like a radiator. The overalls are worn over the cosmonaut's underwear and rest tightly against the body. Water circulating in the suit is cooled in a heat exchanger which removes body heat and ejects it into space. This method provides a much greater heat-rejection capability than that of previous suits, which used a ventilating gas to remove heat. The cosmonaut can adjust the degree of heat removal by regulating the amount of water passing through the heat exchanger, thus allowing some degree of comfort to be maintained throughout its use. [redacted]

Electrical power to the suit is provided by a cable linking the suit to power supplies on the station. Power is needed for the pumps, and for the transmission of the voice communications and biomedical telemetry. [redacted]

Another suit used by all of the Salyut-6 cosmonauts was the Chibis lower-body negative-pressure suit carried to the station on board Progress-1. This suit was designed for use within the station only, to help the cosmonauts maintain a higher degree of muscle and circulatory functions. It consists of a trouser-like garment made of crimped elastic material, with a very tight waist and an attached top. When air is evacuated from the trousers, a negative pressure is created in the lower part of the body. This causes blood to be forced down toward the legs, and simulates gravitational conditions on Earth. Several days before deorbit, the crew exercised with this suit for one and a half hours daily. During these exercises, the cardiovascular systems of the crew members were monitored by telemetry. If the blood flow was too strong, the cosmonauts

New Soviet Extravehicular Activity Suit

Figure 9



[redacted]

became dizzy. A comparison of the distribution of blood with and without the suit enables Soviet physicians to judge how well the cosmonauts are adjusting to weightless conditions and to trace the physiological changes.[redacted]

To further simulate terrestrial conditions the cosmonauts wore a "penguin" suit virtually throughout the entire workday. These suits are laced with rubber strands which exert forces on the various muscle groups of the lower extremities.[redacted]

Future Trends and Developments

On 2 November 1978, the second active phase of the Salyut-6 mission was completed. This phase included visits by three manned Soyuz spacecraft and three unmanned Progress resupply vehicles. We believe that Salyut-6, with resupply visits, has the capability to remain in orbit and be manned for at least five years. To date, four international crews have participated in the Salyut-6 missions. Cosmonauts from seven additional countries—Cuba, Romania, Mongolia, Hungary, Bulgaria, Vietnam, and France—are or will be involved in similar training at the cosmonaut training center at Star City, which is to last 12-18 months. We expect cosmonauts from these countries to participate in future Salyut-6 missions.[redacted]

Salyut-6 will continue to be used as a platform for conducting scientific and technical experiments, and for further developing space technology. The experiments concerned with processing space materials conducted during the first and future phases of Salyut-6 will enable the Soviets to determine the feasibility of establishing space factories. We expect increased use and development of EVA capabilities for external maintenance, space rescue techniques and, ultimately, the construction of large structures in space. Biomedical monitoring and experiments will continue at a high level to acquire more data on the effects of weightlessness on man. The results will be used to improve equipment and conditions affecting the health, safety, and comfort of future cosmonauts on missions of long duration. Although Salyut-6 is primarily a scientific space station, we expect that additional military functions, such as launch-detection experiments, will be performed.[redacted]

Pages: 23-26

Exemptions: (b)(3) (b)(1)

Sources of Copyrighted Graphics

Figure 1. *Aviatsiya i Kosmonavtika*, No. 3; Voyenizdat, Moscow, March 1978.

Figure 2. *Aviatsiya i Kosmonavtika*, No. 6, Voyenizdat, Moscow, June 1978.

Figure 3. *Aviatsiya i Kosmonavtika*, No. 7; Voyenizdat, Moscow, July 1978.

Figure 4. *Aviatsiya i Kosmonavtika*, No. 7; Voyenizdat, Moscow, July 1978.

Figure 6. *Tekhnika Molodezhi*, No. 6; Izdatel'stvo TsK VLKSM "Molodaya Gvardiya", Moscow, June 1978.

Figure 8. *Aviatsiya i Kosmonavtika*, No. 7; Voyenizdat, Moscow, July 1978.

Figure 9. *Nauka i Tekhnika*; TsKKP Latvii, Riga, July 1978.

SALYUT-6 ORBITAL STATION FLIGHT COMMUNICATIONS COMMAND AND CONTROL

Figure 2