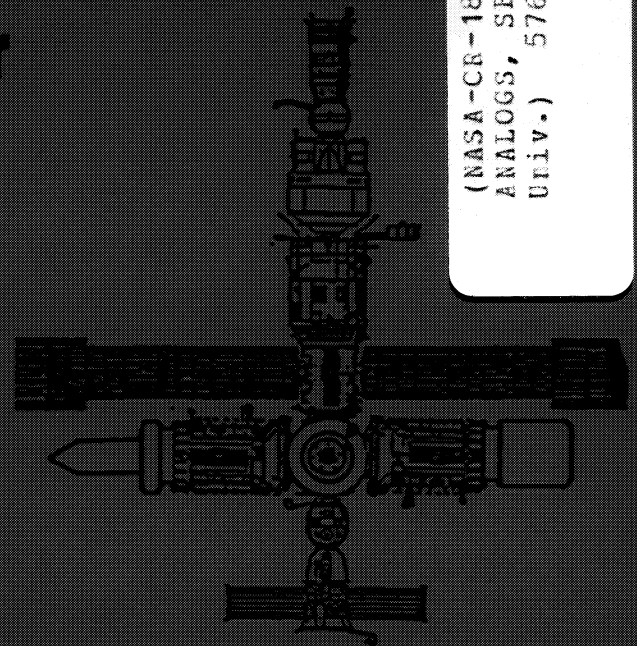
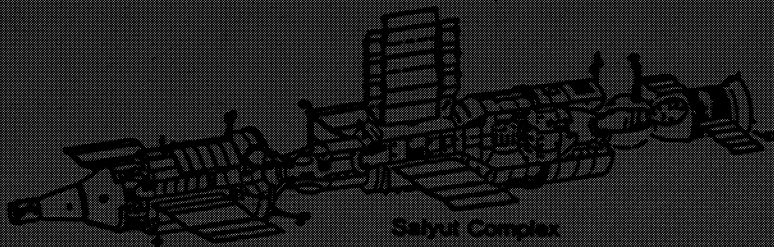


SOVIET SPACE STATIONS AS ANALOGS

2nd
Edition

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»Principal Investigator

Martha Helppie
»Research Associate



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Bibliography

INTRODUCTION

The Soviets have had a space station in orbit since April 19, 1971, when the Salyut 1 was launched. Since then, seven space stations have been launched. Salyut 2 broke up in orbit before it was ever occupied. On February 20, 1986, the core of a larger and more complex station system was launched: the third generation "Mir" (which means "world" or "peace").

This report will focus on the second generation stations, namely the Salyut 6 and Salyut 7. We have included a brief introduction on the Mir. In subsequent editions we will include more information on this third generation space station.

BACKGROUND

The Salyut 6 was launched on September 29, 1977. It was in orbit for 4 years and 10 months.

Salyut 6 was unique in that it introduced the use of two docking ports and handled a series of record-breaking long-term missions with main crews of two, as well as visiting crews who stayed for short periods of time (usually one week). Salyut 6 also introduced the Soyuz T and the Progress, multiple crew dockings, refueling in orbit, and the Kosmos (See 1.16.3 Kosmos.).

The Salyut 7 was launched on April 19, 1982, with the first crew beginning a 211-Day Mission on May 13. Improvements (as noted in Section 1.1) were made based on flight, long-term space living and crew experience. Its design life is listed as being four to five years, in contrast to the Salyut 6, which was initially designed for an 18-month use but whose life was extended due to onboard maintenance. (See Section 1.3.) Currently, indications are that the Salyut 7 will remain in orbit and continue its mission role. Indeed, on May 5, 1986 cosmonauts Kizim and Soloyev traveled 1,875 miles "commuting" to the Salyut 7 from the Mir.

The purpose of this report is to examine the available literature that discusses the various aspects of the Soviet Salyut 6 and Salyut 7 space stations as related to human productivity.

SOVIET SPACE STATION ANALOGS, Ed. II
Introduction

This report is an extension of the SPACE STATION HABITABILITY REPORT (NASW 3680/CC0081) and, as such, the numbering system is generally the same. However, categories have been added to compensate for the additional information the Soviets have released on long-term space productivity and habitability.

There is extensive medical information on long-duration space living and the physical condition of the cosmonauts inflight and postflight, which has only been highlighted in this analog, as a more in-depth analysis requires the attention of an experienced physician. The changing body functions are mentioned as they pertain to performance and readaptation, and should not be assumed to be complete.

NOTE ABOUT BIBLIOGRAPHICAL NUMBERS

Each reference has been assigned a number (or numbers) which is used to identify it as the source throughout the report. Pictures are from various Soviet sources.

When more than one number is listed, the information has been found in all the indicated sources. The amount of data from each source on the subject may vary.

METHODOLOGY

The methodology for this analog was a search of unclassified literature regarding the main missions of the Soviet Salyut 6 and Salyut 7 Space Stations. Additional information was obtained in interviews with cosmonauts and some Soviet space station personnel.

The majority of source material is derived from the translation of Soviet books, articles and newspaper stories related to space. Other sources are from English summaries of Soviet space sources, letters and interviews. Many of the ground-based experiments are included because they are cited by the Soviets as related to their space studies.

Some of the paragraphs have been rephrased for a clearer representation of the facts, particularly when multiple sources have been used. Other items have been taken from the source "as is," which at times may lead to some "awkwardness.". This is attributed to the problems of translating from one language to another.

CAUTION FOR SOVIET SPACE STATION ANALOG REPORT

There is considerable similarity between the Soviet Salyut Space Stations and the proposed American Space Station. However, it is important to treat all analogs with caution. Similarities are not complete, and variations need to be looked at carefully as they tend to change the context and complexion of a situation. Sometimes this may have minor significance, and at other times it may represent a major consideration.

Goals: (Similar/Dissimilar) The goals of Soviet Space Station missions are primarily governmentally sponsored and are scientific, experimental and/or military (though the extent of the military is not known). American goals are expected to include commercial paying customers, international participation, as well as projects by other governmental agencies and the university community.

Crew Composition: (Similar/Dissimilar) Soviet crews are composed of professional cosmonauts who are test pilots and/or engineers and scientists. Prime crew members are Soviets. Cosmonauts from other nations are only included in the visiting teams who stay only for a week. Prime crews are males. A single woman has been included in the visiting teams twice.

American crews will include professional astronauts, many of whom are trained in the various science, engineering, and medical disciplines. They are also expected to include Payload Specialists from industry, the academic community, and from other nations. American crews are expected to be composed of both men and women.

Mission Length: (Dissimilar) Soviet missions tend to be very long. (The longest to date is 237 days.) American missions are expected to run up to 90 days.

Escape: (Dissimilar) Soviet cosmonauts have a Soyuz Spacecraft attached to their space station at all times, and this capsule can be used to escape from the station if necessary, or can be used as a safe haven.

Currently there is an extensive review being carried out to evaluate various rescue and escape techniques for American Space Station crews. The Space Shuttle can be launched to save a crew if necessary. The time to launch will vary on Shuttle readiness. At present the longest possible time to rescue is considered to be 28 days.

Automation/Robotics: (Dissimilar) The Soviets have improved automation, but there is little evidence of any use of robotics or tele-operations, which will be considerable on the proposed American Space Station.

Culture: (Dissimilar) The Soviet culture is very different from the American culture in many ways. Thus Soviet cosmonauts may have different attitudes and expectations about life in such environments which could result in different reactions to situations and events.

SOME GENERAL CHARACTERISTICS
OF THE SALYUT SYSTEM

1. The Core vehicle of Salyut 6, Salyut 7, and Mir are basically similar in size, shape and pressurized volume.
2. The Salyut 7 has been designed for a four- to five-year life, the Mir for ten.
3. The windows on the Salyut 6 deteriorated over time so designers made improvements on the Salyut 7 for added protection.
4. The station's design uses a mixture of Earth (or 1-g)/and 0g orientation with orientation guides such as special light and color. The ceilings are used for exercise equipment and sleep accommodations.
5. The walls on the Salyut 7 are of washable leather for easier cleaning (which is important for keeping contamination levels down).
6. The Soviets continue to improve their facilities for growing plants. They hope to use plants as a source of food and oxygen for long-term flights.
7. Maintenance design is very important for the continued use of the station and for the safety of the crew. Each station design has been improved so that the crew can repair and replace parts. Access to the basic systems has been made easier. Panels can be removed easily.
8. Considerable time has been spent on the development of a set of standard space tools. The correct tools are mandatory for successful maintenance work and future construction.
9. Privacy is important, particularly as the mission length increases. Mir has private crew quarters.
10. The shower has been improved on the Salyut 7.
11. Exercise is of the utmost importance for maintaining physical capabilities during the flight and for readaptation. On the Salyut 7, cosmonauts are now given more individualized exercises to do. Exercises are done religiously every day for about 2 1/2 hours.
12. Lighting has been made brighter in the Salyut 7 through different spectral configurations and the placing of lights. There are also more sockets located throughout the station so portable lights can be used.

13. Color and music combinations are used as a form of relaxation and also for helping the crew maintain a sense of the Earth's seasons.
14. Music is used not only for relaxation but also as a work stimulant.
15. Each cosmonaut can now select what food items he desires for each day as long as he consumes the number of calories set for him by ground physicians. The crew does not necessarily eat every meal together any more. Most of the items are packaged in bite-sized pieces. Food is prepared to last for up to 18 months, although the Progress resupply ship regularly delivers new and fresh items.
16. Cosmonauts take a vitamin daily. They also use artificial stimulants, tranquilizers and sleeping pills at times.
17. Potable and wash water is supplied by Progress deliveries, and from water that is recycled through a condensate regeneration system. This system also produces oxygen.
18. The Soviets are still working on ways to decrease atmospheric and surface contamination that increases as each mission lengthens. The cosmonauts clean the station often with disinfectants to keep contamination down.
19. Reduction in noise continues, with more insulation and designing items to run more quietly. Excessive noise can lead to hearing fatigue, difficulty in communicating and irritability.
20. The temperature is maintained at approximately 20°C. The crew can change the temperature within certain limits.
21. Adequate living space is important as Soviet research has established that lack of space (volume) can lead to negative physical and psychological problems.
22. The Soviets feel that the Progress Cargo Ships have played an important part in the operation of the station by continuing to deliver fresh provisions, maintenance parts, new systems and emergency repair materials.
23. Underclothing is made of a cotton-rayon knitted fabric that does not wrinkle easily and has good ventilation. The cosmonauts participate in designing their own outerwear, which includes color preference and the location of pockets. Most clothing is worn for a certain number of days and then disposed of.

SOVIET SPACE STATION ANALOGS, Ed. II
Introduction

24. The role of the computer system in automation has been expanded on the Salyut 7 to include space navigation and communication controls. Mir has seven computers and is "scarred" for growth.
25. Two-way television has been incorporated and is used not only for transmitting work related material but also for "visits" with families.
26. Portable radio sets are used for IVA communication.
27. The EVA suit is semi-rigid and size-adjustable with a self-contained life support system. It has recently (October, 1985) been improved still further, with more flexibility in the arms and legs, a new helmet with lights on it, and a control system that is easier to use.
28. The time spent on EVA has been increased to 5 hours.
29. The safety of the crew is given top priority. If the cosmonauts would need to abandon the ship, they would go to the docked Soyuz ship. There are monitoring systems used throughout the station so that the crew and ground will know if there is an emergency situation developing (for example, fire, excessive contamination, radiation). Crew members are trained to deal cool-headedly in emergency situations.
30. Meteorites pose a real problem to the station, and its equipment is designed to withstand major damage.
31. The cosmonauts are allowed some autonomy in the scheduling of their work schedule. Scheduling now includes the same type of experiments being done several days in succession.
32. Workdays and sleep are structured around the usual Earth cycle and biological rhythm, with the day beginning at approximately 8:00 a.m. and ending at 11:00 p.m. All the cosmonauts are on the same schedule and split-shifts are not used.
33. Cosmonauts are now given two days (Saturday and Sunday) of rest. On these days, they continue to do their exercises and some light duties such as housekeeping. This is a change from the first long Salyut 6 mission, when crew members worked 6 days and had 1 day off. This was changed to five days of work and one day of rest, until finally evolving to the present 5 days on--2 days off schedule.
34. Leisure activities are structured around each cosmonaut's needs and desires. "Surprise" leisure activities are organized at times.

SOVIET SPACE STATION ANALOGS, Ed. II
Introduction

35. Scheduling personnel on the ground include psychologists, sociologists and physicians.
36. The compatibility of crew members is important. Crews train together and spend free time together prior to a mission so they can learn to understand all aspects of one another and learn to work together as a team. Crew members are trained to deal with conflict.
37. Women are currently training for missions. The attitudes with regard to female cosmonauts appear to be varied. There is some concern that accommodations onboard will need to be changed for women, or prophylactic measures may not be effective for long missions.
38. The visiting crews that spent time on the Salyuts were welcomed and gave the main crews a psychological boost.
39. Communications between the cosmonauts and their families are extremely important for maintaining morale.
40. Prior to flights, cosmonauts are trained in many areas: theory, all aspects of space flight and equipment operation, psychologically, and in group dynamics.
41. The psychological reactions of the crew are monitored in flights. One method is the use of speech to determine the kind of stress.
42. Cosmonauts are involved in space station design. Their ideas and suggestions are taken into consideration for improving the stations.
43. The Soviets are still working on ways to relieve motion sickness.
44. Cosmonauts who had been on flights -- even short-term flights -- prior to their mission adapted better to weightlessness. Prophylactic methods do help some of the physiological problems that occurred in Og. Studies are still underway to see what effect weightlessness has on heredity. Artificial gravity is being tested.
45. Improving work capacity and emotional stability are closely related, particularly on long flights.
46. Social psychology is very important in the USSR, both operationally and in terms of research.

SOVIET SPACE STATION ANALOGS, Ed. II
Introduction

47. A Psychological Support Group on the ground helps the crew by organizing special activities and monitoring the crew members' moods so that special means can be incorporated to maintain motivation and morale.
48. Restorative measures are used after flight so that cosmonauts can re-adapt to the Earth.
49. A crew replacement occurred in September, 1985, with one cosmonaut who had been living on the station since June returning to Earth with a visiting crew member. The other cosmonaut who had arrived at the station in June stayed with two new crew members. This is seen as the basis for a constantly operating station.

"It is necessary...that man cannot only endure prolonged flights in space, but also retain a high level of performance." Shatalov

"Man is the critical link in the man-machine system." (114)

As experience has shown, on a space flight no comfort is ever excessive." (188)

Spacecraft should be designed with the idea that it will be used by man. (237)

"How can we refuse to take advantage of such unique space conditions for technological and physical experiments, and for medical and biological research?" (587)

Academician Kotelnikov
April 11, 1986
Cosmonautics Day

RE: Permanently operating orbital manned complexes for scientific and national economic purposes:

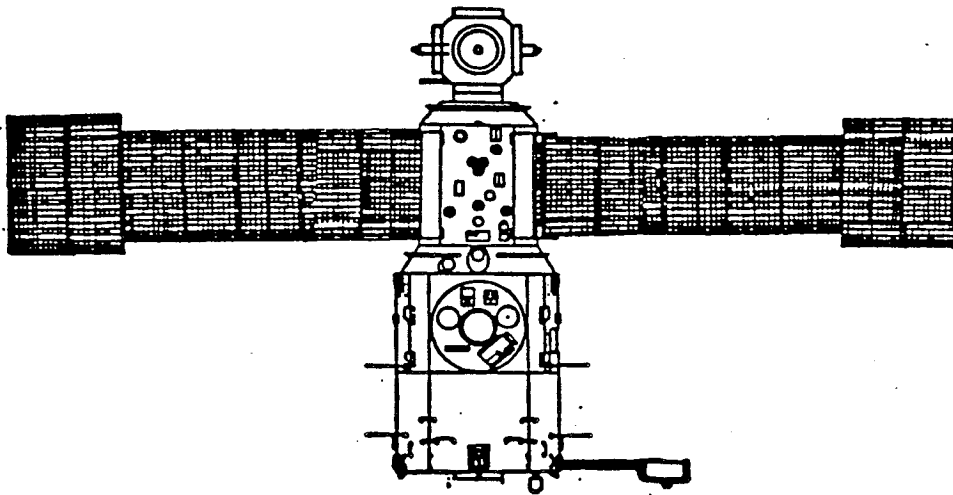
"In this sphere we are the most advanced
in the world:

We have no competitors here."

I. ENVIRONMENT

1.0 GENERAL LAYOUT AND DESIGN OF MIR

Launched:	February 20, 1986
Length:	56.0 ft. (13.13 m)
Width:	13.6 ft. (4.2 m)
Volume:	~110m ³ (Core)
PSI:	~14.7
Weight:	21 t
Power:	10+ KW
Solar Panel Span:	29.73m
Area of Solar Arrays:	76m ² (useful)
Power Voltage:	28.6±0.5 VDC
Crew Size:	2-6
Docking Ports:	6
Hatch Diameter:	0.8m
Main Engines:	2 x 300 kg
Reaction Control Thrusters:	32 x 14 kg
Pointing Accuracy:	
Rough	1.5°
Precise	15'



A. Improvements:

- Six docking ports capable of accommodating 6 spacecraft:
 - Two active axial ports (for crew and resupply ships)
 - Four passive lateral "berthing" ports
 - The axial docking units are intended for automatic and manual docking.
 - A special manipulator attached to the modules will be used to transfer modules from the active to passive docking ports.

- Enhanced automation: (see 2.1.1 Computers)
 - Seven computers:
 - Some self-test
 - One dedicated to documentation
 - One for station keeping

- Scarred for growth

- Power capacity increased to 10+ KW.
 - Two additional arrays will be added for ~7-8 KW
 - Truss will be erected to serve as strongback for arrays
 - Arrays are thought to be gallium arsenide

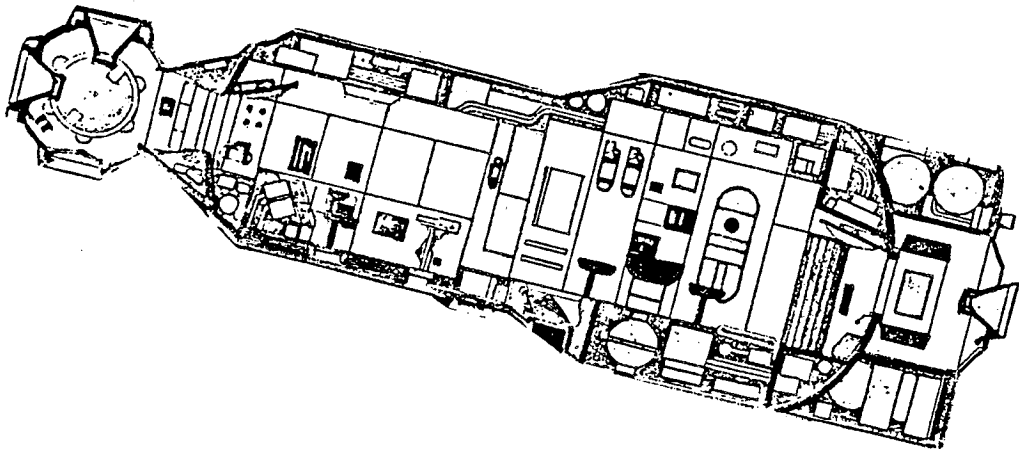
- ~90% of all equipment is designed for ease of replacement, repair, and/or maintenance.

- Improved conditions for cosmonauts in work and rest areas

- Improved communications with Earth
 - "Luch" relay satellite (similar to TDRSS)
 - Handles live television and data transfer

- Improved life support system
 - Recycles moisture condensate, wash water, and urine
 - Recycles O² by means of electrolysis (amount uncertain)

- Almost all signs of "clutter" removed



SOVIET SPACE STATION ANALOGS, Ed. II

1.0 Mir

1.1.1 Windows

Windows placed in the "floor"

Windows in crew quarters

- Use "iris" to shut out light

1.1.2 Separation of Work and Living

The Mir Core has private crew cabins that are clearly separate from the work area. (See 1.4.1 Private Quarters)

Unlike the Salyut, Mir will be used mainly for crew living, computer and communication control, and maintenance and repair. Experiments, etc. will be carried out in the attached dedicated modules.

1.1.3 Modularization

Total Modules in a Completed Mir Complex: 8

- One Core
- Five Laboratory Modules
- One or Two Soyuz-TM Crew Transport/Escape Vehicles
- Or One Progress Resupply Vehicle

1.1.9 Volume

The total pressured volume of a completed Mir Complex is estimated to be ~500m³.

- Mir Core: 110m³
- Kvant: 50m³
- Kosmos/Star 81m³
- Soyuz/Progress 6m³

--Volume on Kosmos/Star vehicles may vary based on the configuration selected.

1.3 Design for Inflight Maintenance and Repair

Almost all of the equipment on the station has been designed for quick refits and replacements.

Some refitting will be done on an established maintenance schedule.

Some crews will be dedicated to refitting the station and reconfiguring it for specific scientific missions.

1.3.8 Tools

In the main compartment a workbench has been added which includes:

- A Steel Table
- A Vise that can be mounted on it
- An extension for soldering

1.4.1 Private Quarters

The Mir has small but private cabins separated by soundproof curtains. In each "room" there is:

- A Desk
- An Armchair
- A Sleeping bag
- An Intercom
- A Porthole

1.10 Food

Indications are that the pantry system is still being used.

Most of the food is prepared by dehydration, removing 90% of the water through the use of deep cold and pressure.

2.1.1. Computers

Computers have been significantly upgraded, enabling the station to function automatically and autonomously:

- Station movement control and back-ups
- Onboard systems
- Research apparatus:
 - Systems which switch on and off in preparation for work
 - Systems which monitor, diagnose and recommend action for various situations
- Able to process scientific data before relaying information to Earth
- Capability for specialized orbital modules:
 - Each with own life support and power system
 - Capable of autonomous operation in space

2.2 EVA

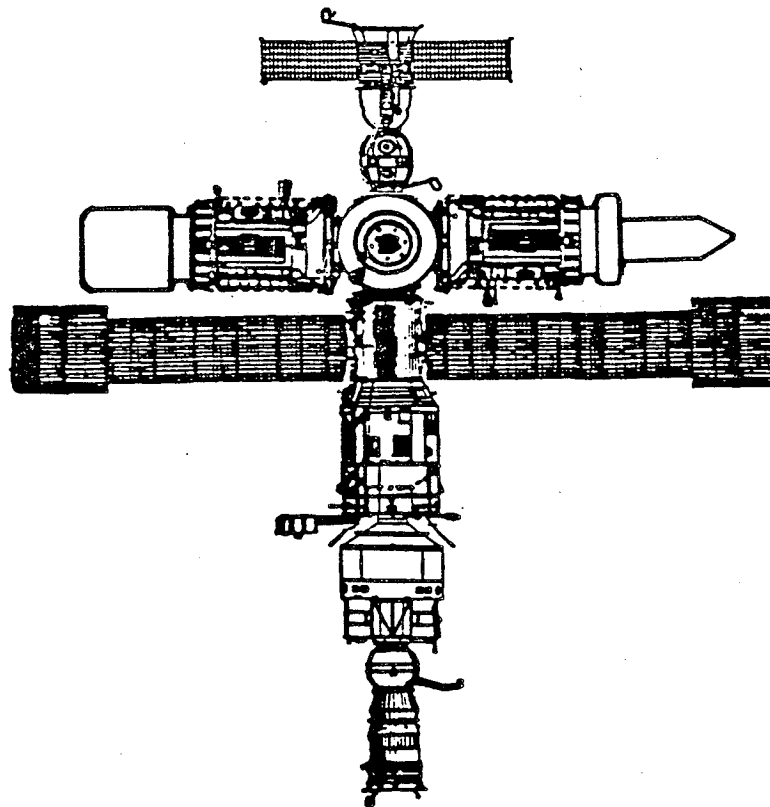
The aft portion of the Mir features many hand-holds for EVA.

SOVIET SPACE STATION ANALOGS, Ed. II
1.0 Mir

3.1.3 Experiments

Experiments will be performed in the specialized modules.

(71) (286) (343) (384) (440) (556) (563) (564) (567) (571)



4.1 ESTIMATION OF COMPLETED MIR COMPLEX CHARACTERISTICS

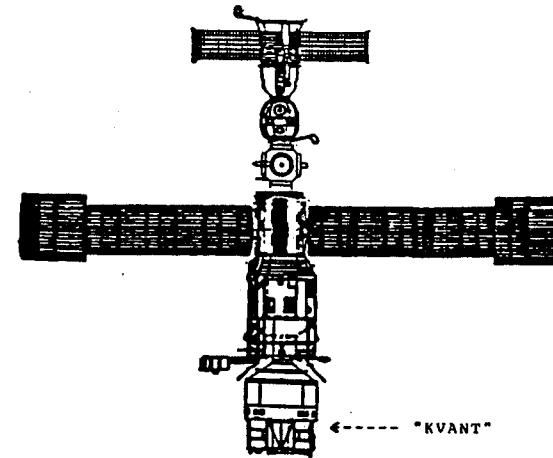
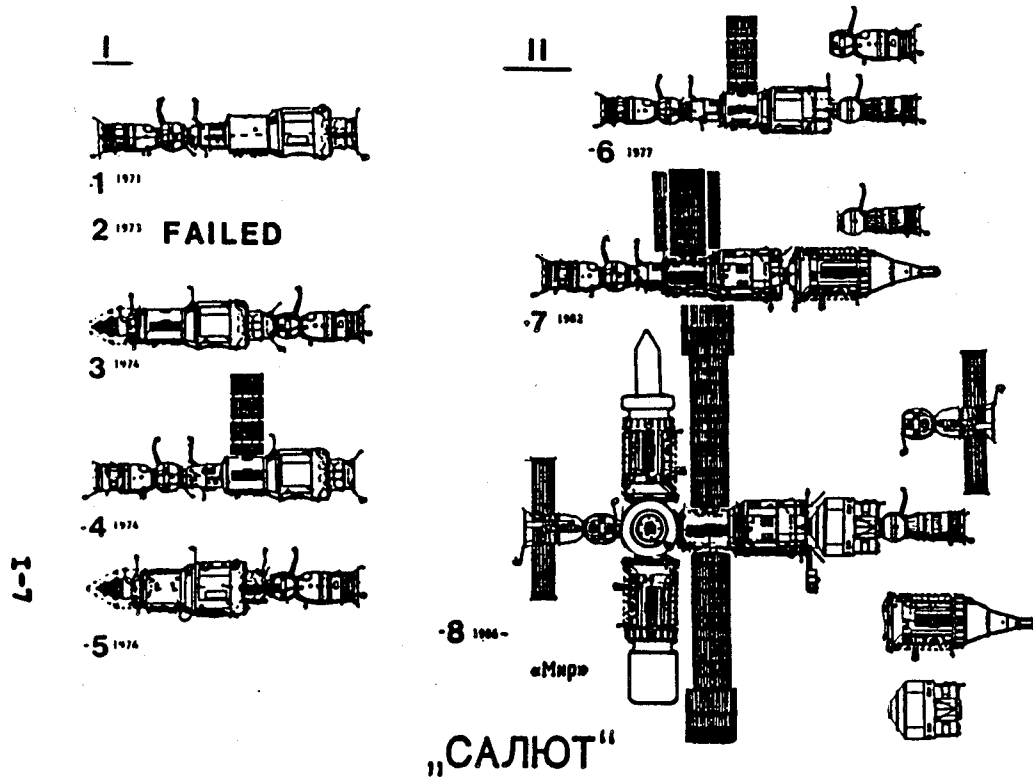
Modules: 8

- 1 Core
- 5 Dedicated Laboratories
 - Kvant/Astrophysics/Electrophesis Module
 - Technological Module
 - Biological Research Module
 - Medicine Module
 - Production Module
- 1 Soyuz-TM Crew Transfer/Escape Vehicle
- 1 Progress Resupply Vehicle

Power: ~25-35 KW
Volume: ~500m³
Crew: 2-6
Launches: 8
PSI: ~14.7

SALYUT EVOLUTION

1971 - 1987



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Launched: March 31, 1987

Docked: April 12, 1987

Total Weight: 20.6 metric tons
Module: 11 metric tons
Tug: 9.6 metric tons

Length: 5.8 m (19 feet)

Width: 4.15 m (13.6 feet)

Volume: ~50 m³ (1766 ft³)

Viewports: 4:
1 at 17 inch diameter
1 at 9 inch diameter
2 at 3 inch diameter

SCIENTIFIC EQUIPMENT:

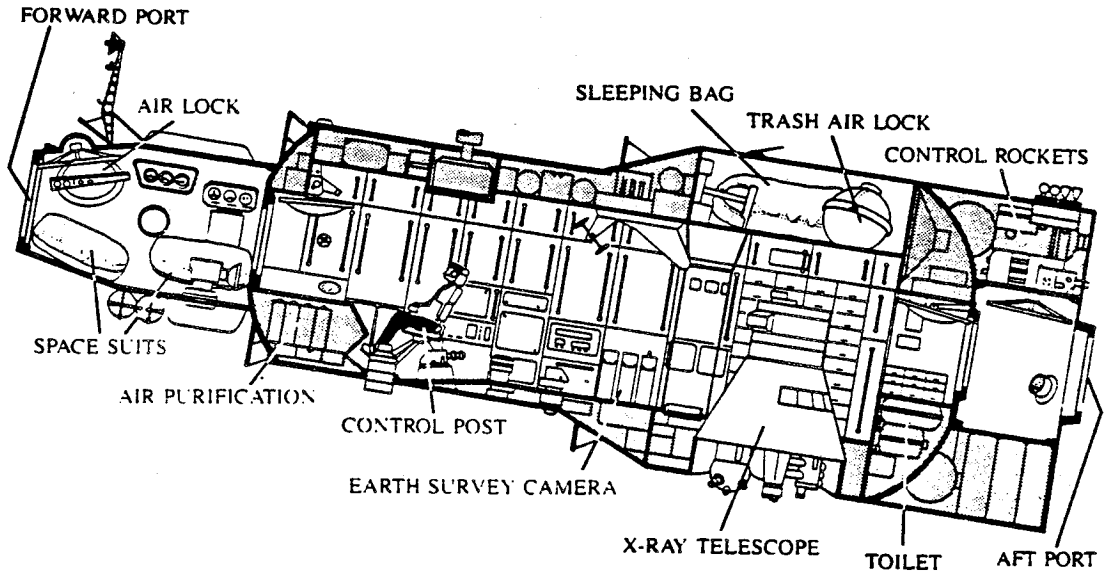
- Pulsar X-1 Hard X-Radiation Telescope/
Spectrometer - USSR
- Fosvich High Energy Scintillation Telescope/
Spectrometer - West Germany
- Coded Mask Imaging Spectrometer
- Holland and England
- Siren-2 Proportional Gas Scintillation
Spectrometer - ESA
- Glazar Ultraviolet Telescope - USSR and Switzerland
- "Svetlana" Automated Electrophoresis Plant

[Note: Information on the Mir complex is based on a "Best Guess" made from what is known about the Salyut7, the Kosmos, and what the Soviets have said in press releases about the Mir complex.]

SOVIET SPACE STATION ANALOGS, ED. II
MLF 1.0

1.1 GENERAL LAYOUT AND DESIGN OF SPACECRAFT SYSTEM

A. Basic Characteristics of Salyut*:



- Length: 13-15 m
- Width: 4 m
- Volume: 90-100 m³ usable volume
- Weight: 18,900 kg
- Diameter (maximum): 4.15 m
- Largest room: Working compartment, 40 m³

- Solar generator:
 - Surface area 60 m²
 - Power 4 KW (increased during flights to 8 KW)

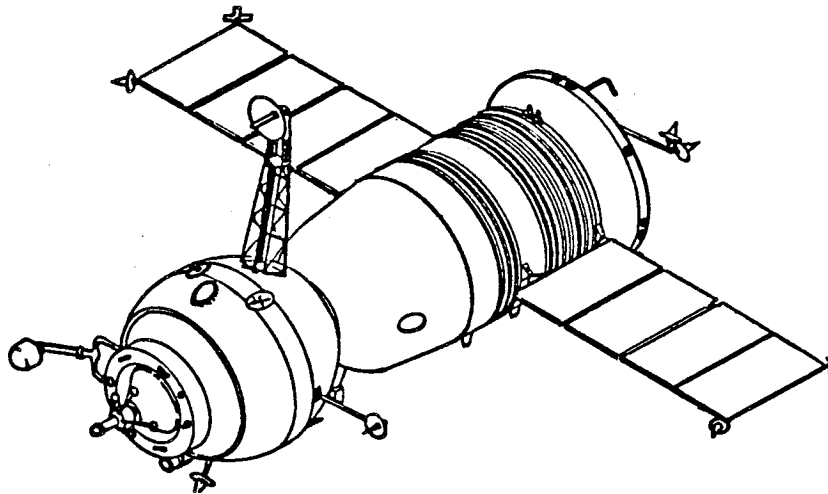
- PSAI 14.7
- Accessible orbits:
 - Altitude 300-400 km
 - Inclination 51.6°
 - Span 17 m

*Sources vary slightly with regard to the basic characteristics of the Salyut.

SOVIET SPACE STATION ANALOGS, Ed. II

1.1 Spacecraft System

B. Basic Characteristics of the Soyuz:



SOYUZ-T3

Pic. 548

The Crew Transport Spacecraft. The 'T' Stands for Transport.

-Length:	7 m (Approximately)
-Maximum diameter:	2.72 m
-Span:	10.6-12.8 m
-Overall weight:	6,850 kg
-Total mass:	6,557 kg
-Power:	1.3 kw
-Crew:	2-3

- Operational life when docked to the Salyut is about 90-115 days
- Has solar panels (so it can fly independently for longer periods of time than with batteries alone)
- Power from the Soyuz can be tied into the Salyut
- The forward docking port is used for the Soyuz (but the aft can be used as well)
- The Soyuz must be deactivated after cosmonauts enter the Salyut
- Capable of flying with or without crews

SOVIET SPACE STATION ANALOGS, Ed. II
1.1 Spacecraft System

- With a crew aboard for up to 30 days, capable of:
 - Orbital maneuvering
 - Rendezvousing
 - Docking
 - Solo flights
- Can transport as many as three people wearing pressure suits or two people and a cargo pod to the Salyut
- Has an automatic navigation control system that can be overridden for manual control, if desired
- Serves as an escape vehicle. Crews can be out and undocked from the Salyut in 15 minutes (although they prefer 90 minutes to shut down station systems)

Three main modules:

- Orbital module:
 - Is the working compartment and living quarters of the crew
 - Houses the instrument and devices of the radar approaching system, TV apparatus, and units of the life support system
- Equipment module:
 - Houses all the ship's main service systems
- Reentry vehicle

Improvements made on the Soyuz T (as compared to the earlier Soyuz):

- Automatic devices have been modernized:
 - Improved dynamic operations:
 - Maneuvers in orbit
 - Approach
 - Tethering and descent
- New TV system with image transmission
- Advanced radio telemetry system
- Radio program command link
- A general purpose computer complex to solve all problems of dynamic operations. The computer can be used for:
 - Determining flight conditions
 - Forecasting flight and attitude characteristics for some time ahead:
 - This makes it possible to use the incoming information efficiently by closely monitoring the functioning of the ship and equipment

SOVIET SPACE STATION ANALOGS, Ed. II

1.1 Spacecraft System

- The automatic device will cut in reserve devices on its own without interrupting the attitude control, docking or descent operations
- Computer complex could function either in automatic or semi-automatic mode

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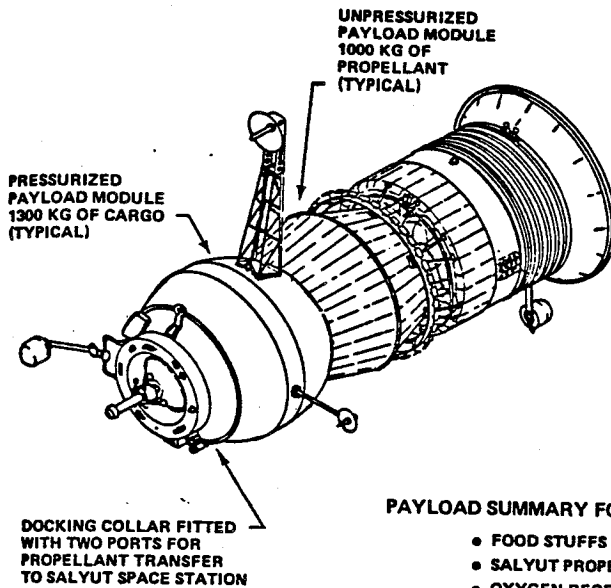
Improvements made on Soyuz TM (launched May 21, 1986):

- New systems:
 - Approaching and docking
 - Radio Communication
 - Emergency rescue
- Combined propulsion unit
- New parachute system

(646)

C. Basic Characteristics of the Progress:

A new Progress is sent to the Salyut approximately every three to six weeks. This ship delivers needed supplies.



PAYLOAD SUMMARY FOR PROGRESS 1-10

● FOOD STUFFS & WATER	11,375 KG
● SALYUT PROPELLANT	4,670 KG
● OXYGEN REGENERATORS	425 KG
● SPARE PARTS	870 KG
● RESEARCH EQUIPMENT	990 KG
● CAMERA FILM	225 KG
● AUXILIARY EQUIPMENT	115 KG
● PERSONAL EFFECTS	1,305 KG
	<hr/>
	19,975 KG

P.548

SOVIET SPACE STATION ANALOGS, Ed. II
1.1 Spacecraft System

- Maximum length: 7.94 m
- Diameter: 2.2-2.7 m
- Volume (with cargo): 6.6 m³
- Weight: 7,000 kg
- Weight of payload: Up to approximately 2,300 kg

- Propellant and oxygen: 1,000 kg
- Dry supplies: 1,300 kg

---A separate cargo compartment (volume of 6.6 m³) carries supplies for cosmonauts onboard the Salyut

- Temperature: +3 to +30 °C
- Uses internal batteries (It has no solar panels)
- Docks to the Salyut automatically
- Cargo is transferred manually
- Propellant is pumped automatically
- Can push Salyut into higher orbit (by using residual propellant. Usually done after the refueling process)
- Destroyed upon re-entry into the atmosphere (no descent module)
 - Used to dispose of trash from Salyut
- Has more automatic devices than the Soyuz
- Twice as much instrumentation in the instrument compartment as compared to the Soyuz
- Radio antennas, rendezvous apparatus, sensors and orientation engines are mounted externally
- Has no life support systems
- Has no heat shield or parachutes
- Has an independent flight capability of eight days
- Has a lifetime of up to 3 days in autonomous Earth orbit before docking
- Can be operated in an active operational phase for up to 30 periods of 24 hours after docking with the Salyut
- Has three compartments:
 - Freight
 - Refueling components
 - Instruments

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Similarities to Soyuz:

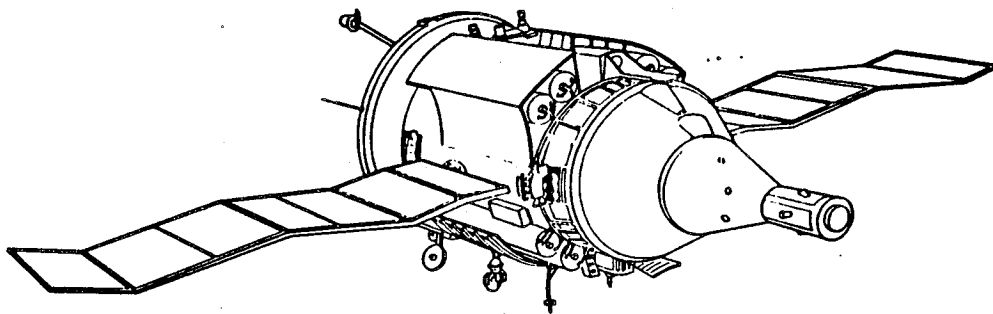
- Electric power supply system
- Radar and related equipment
- Tethering and attitude control engine
- Docking system and transfer unit:
 - The docking units are fitted with additional hydraulically actuated automatic connecting devices which link the mains of the refueling system with the propulsion system of the station.

SOVIET SPACE STATION ANALOGS, Ed. II

1.1 Spacecraft System

D. Basic Characteristics of the Kosmos:

Payload Return
Module: 1000 lbs



Solar Panels (2)

Power: 3kw

The Kosmos modules have been used to deliver supplies and expand the volume of the spacecraft system. The following information highlights the average characteristics of the Kosmos configuration:

-Length:	13 m
-Diameter:	4 m (at widest point)
-Weight:	20 tons
-Span:	16 m
-Solar generator:	
--Surface area:	40 m ²
--Power:	3 KW
-Pressurized volume:	70 m ³

SOVIET SPACE STATION ANALOGS, Ed. II
1.1 Spacecraft System

- Own control system:
 - Its control system has independent digital and analog circuits which back up each other. Other systems have been said to:
 - Diagnose the functioning of onboard aggregates and mechanisms
 - Solve unforeseen situations in the automatic mode

- Onboard computer
- Photoelement area: 40 m², generating 3 kw electricity

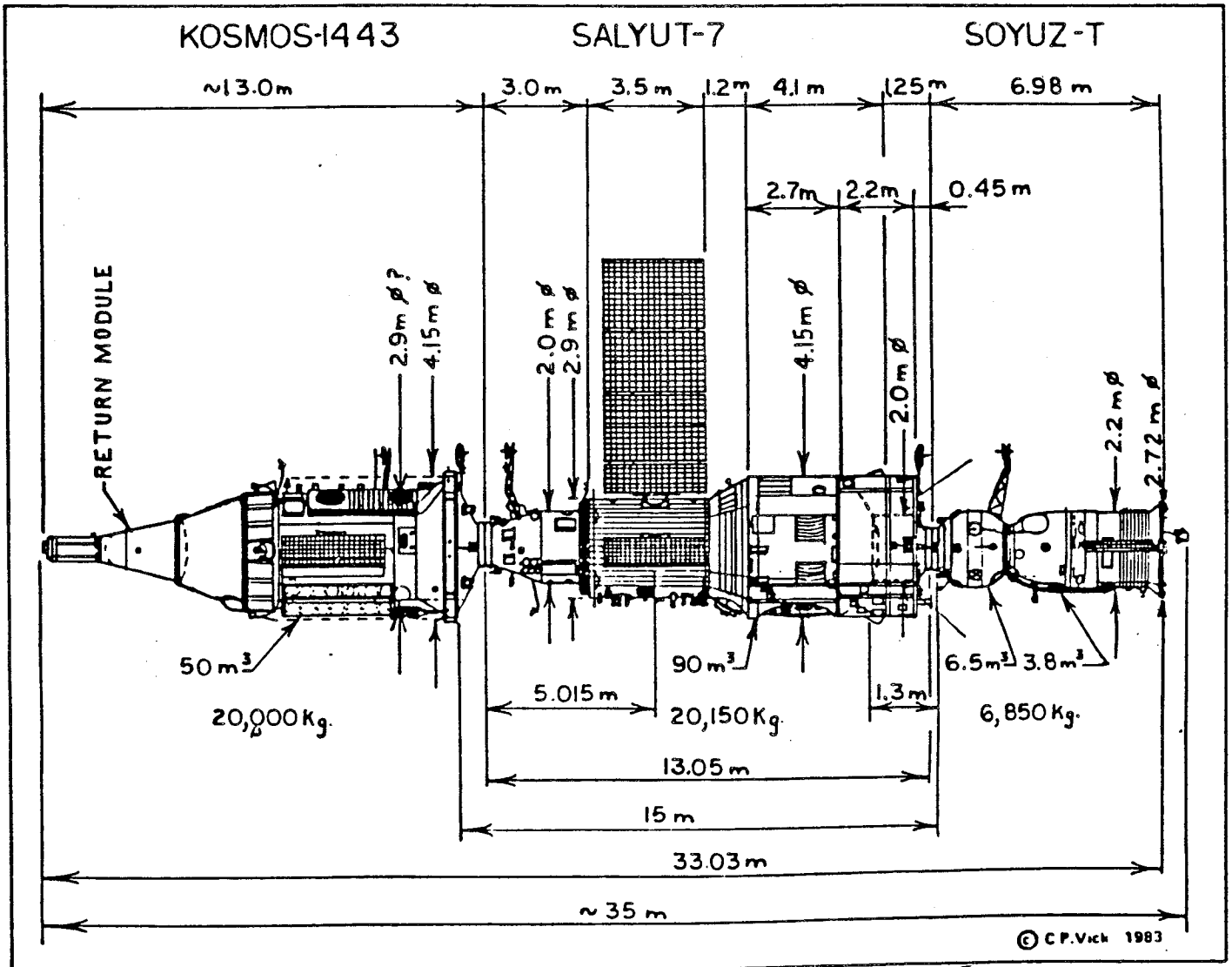
- Own power supply, propulsion, guidance and life support system
- has re-entry module
- Capable of delivering up to 7 tons of freight from Earth
- Holds reserves of food and water
- Gives more living space for the cosmonauts (When docked with the Mir, the Kosmos modules will be dedicated to specific functions such as:
 - Astrophysics
 - Technological Production
 - Biological Research
 - Medical
 - Other
- More investigations can be done when the Salyut's orientation operations are performed by the Kosmos:
 - On the Kosmos 1443, Earth photography was expedited because the Kosmos was used for stabilizing the complex and did not exhaust the Salyut's fuel supply or require the crew's time
- Used as a space tug:
 - The Kosmos can transfer the orbital complex from its nominal low orbit (at an altitude of 300-350 km) to higher orbits. This extends the complex's endurance limit by lowering braking power requirements and fuel consumption. The tug module then can permit redescent of the complex to the lower rendezvous orbit for linkups with the Progress or the Soyuz, neither of which can be injected directly into high altitude orbits.
- Can be flown without a crew
- Docks automatically
- Can house up to 6 crew members
- Designed with several docking ports and a "submodule" which is large enough to return the station's crew and/or heavy equipment to Earth
- Can be undocked from the Salyut, flown alongside the station and reconnected. (This configuration could be used for conducting experiments in materials processing. It could avoid perturbations caused by movements of the cosmonauts.)

SOVIET SPACE STATION ANALOGS, Ed. II
1.1 Spacecraft System

- Can transfer some electrical power and fuel to the Salyut
- Water recovery possible
- Fuel can be pumped in either direction
- Capable of a "soft" landing
- Has three sealed compartments:
 - Scientific compartment:
 - Houses crew during work and leisure
 - Cargo:
 - Holds some 600 objects of different kinds stored in mobile containers
 - Engine compartment:
 - Utilizes the unified thruster jet system
(These thruster jets can be activated by a remote command from Ground and are used to alter the orbit of the entire complex.)

(9)(11)(15)(16)(74)(124)(149)(211)(238)(331)(347)(367)(402)(406)(415)
(482)(498)(518)(537)(548)(572)(596)(629)

E. Total System Specifics:



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Pic. 61

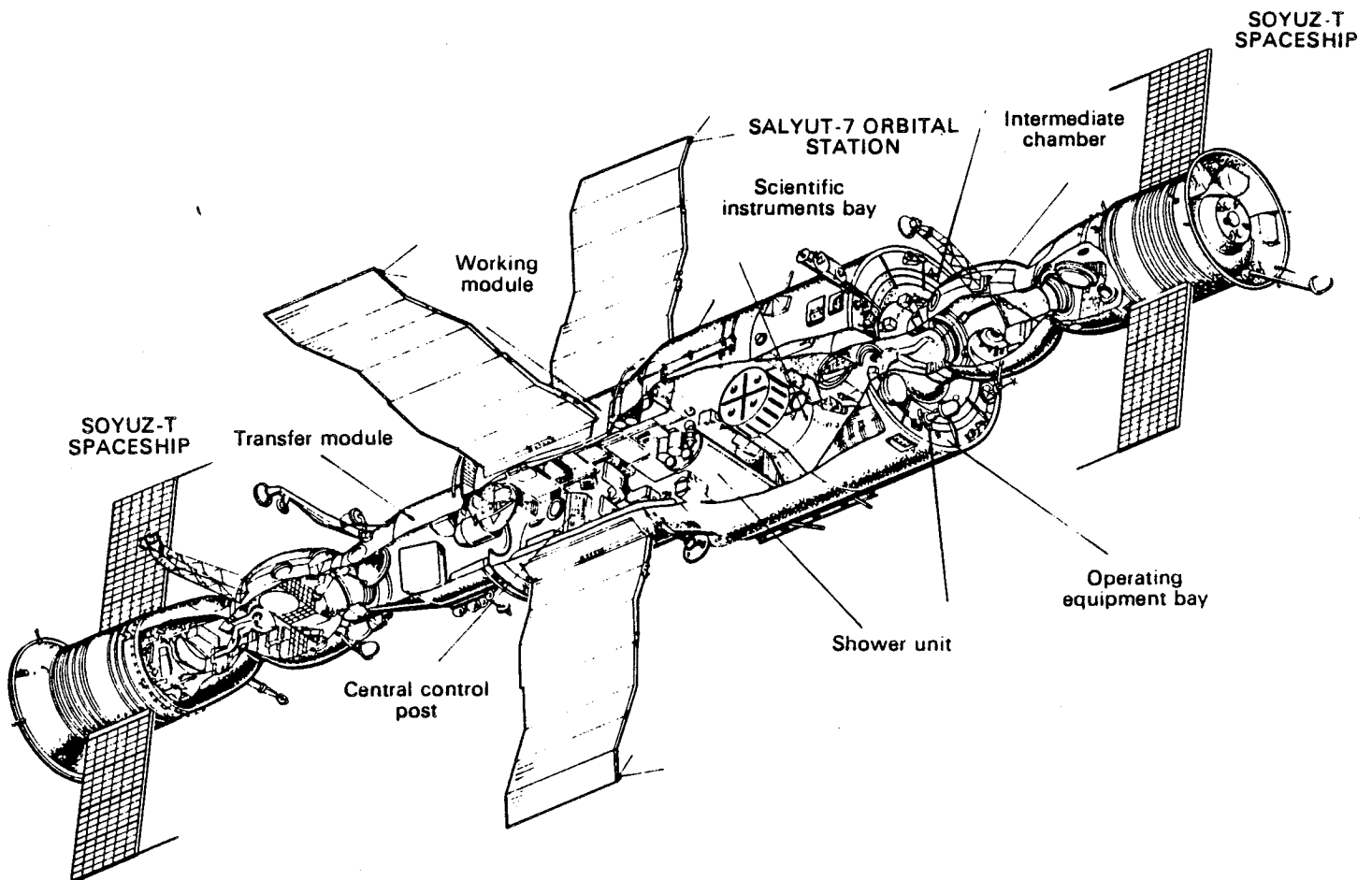
Salyut 7, Progress and Soyuz combined complex:

- Length: 29 m
- Weight: 32,720-32,770 kg
- Pressured volume (total): 106.9 m³

Salyut 7, Kosmos, and one transport ship:

- Length: 35-36 m
- Weight: 47 metric tons
- Volume (total): 187.2 m³
- Solar generator: 100 m²
- Surface area: 7 KW

PILOTED ORBITAL COMPLEX



F. Salyut 7 Compartments:

Three sealed compartments:

-Working compartment has:

- Two areas (instrument and living)
- Removable panels to partition instrument area from living area
- Station control panels
- Digital computer
- Controls for the power unit and its refueling
- Life support
- Heat regulation systems
- Scientific equipment
- Foldable shower unit
- Exercise and medical research equipment

There are six posts in the working module. All of them have communication facilities and lamps:

Post #1:

- Located in the fore part of the module
- Has two work places
- Has a main control desk:
 - With command signaling devices for transmission of commands
 - With two indicators: (1) shows the attitude of the station in relation to the Earth's surface (2) registers the fulfillment of automatic programs
- Optical instruments for visual attitude control are installed here
- Control panel of the onboard computer
- Information supplying unit
- Part of the air composition control system and the coolers and dryers of the temperature control system

Post #2:

- Located in the lower part of the working module
- Houses the astro-orientation and astro-navigational instruments
- The wardroom is located between this post and Post #1 (See 1.4.2 Wardroom.)

Post #3:

- For control of scientific instruments and equipment:
 - Includes x-ray and gamma ray telescopes (525)

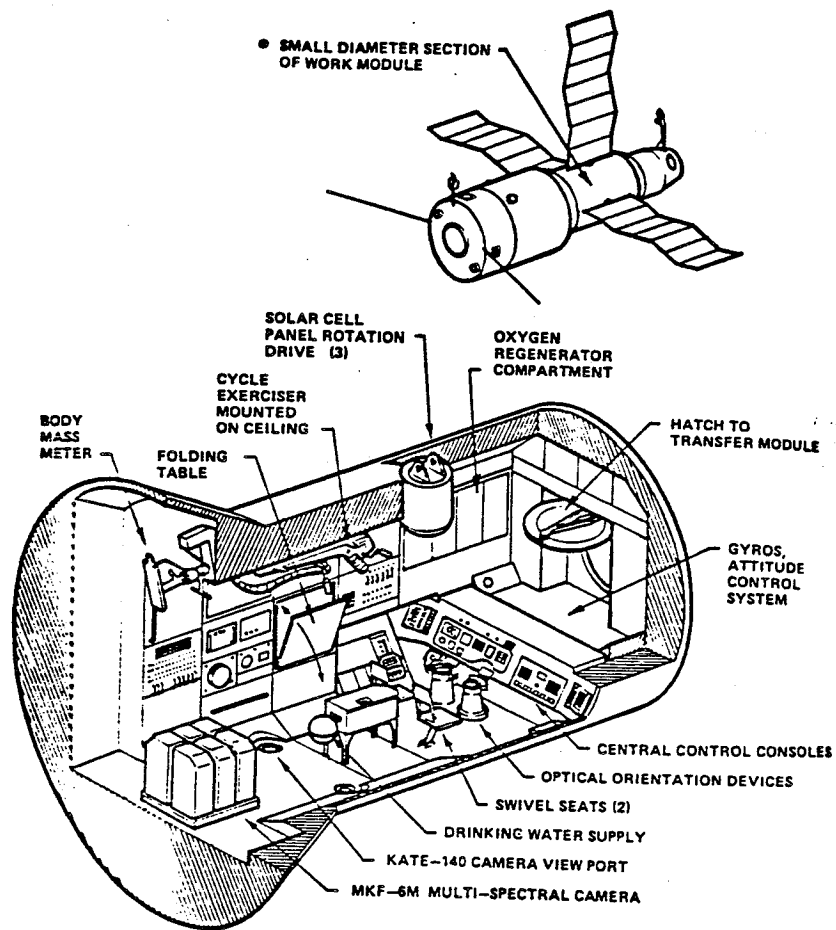
SOVIET SPACE STATION ANALOGS, Ed. II
1.1 Spacecraft System

Post #4:

- Located in the lower central part of the working module
- Equipment for medical biological experiments
- Exercise equipment

Posts #5 and #6:

- Fitted with control desks for the operation of scientific instruments and equipment
- Water regeneration system is here



Salyut Work Module

The crew gains access from the working module to the intermediate chamber through an airtight hatch. (525)

SOVIET SPACE STATION ANALOGS, Ed. II
1.1 Spacecraft System

The hull of the working module is designed to:

- Insure reliable pressurization
- Protect the crew and more sensitive instruments from the external vacuum and from micrometeorite attacks
- Is protected by screens which are installed at a distance from it

The equipment in the work module is arranged on the walls of the station and is separated from the living quarters by panels.

Instruments are grouped on the basis of the functional principle to form control posts.

The fore part of the working module has the shower.

The rear bottom part of the module contains the washroom and toilet unit.

A vacuum cleaner, dust filters, water tank, linen and underwear chest, two locked chambers for the removal of litter and waste are also in this part of the work module.

The solar battery panels are fixed to the shell of this working module. Each has an electric drive for automatic orientation on the sun in accordance with signals sent by sensors.

-Intermediate Chamber:

- Diameter: 2 m
- Length: 1.3 m
- This is the space between the working module of the main block and the transport ship
- Used to store cargo that has been delivered to the station
- Installation for scientific research
- Seven windows that provide almost a full 360° view (525)

SOVIET SPACE STATION ANALOGS, Ed. II

1.1 Spacecraft System

-Transfer Module and Airlock:

- Access for EVA
- A sealed section of cylindrical and conical shells:
 - Diameter: 2.0m
 - Length: 1.3m
- Used to carry equipment delivered by transport vehicles
- Two portholes used for visual observations, still and motion picture photography, and television reporting
- Houses the monitoring and control panels
- Spacesuits are stored here

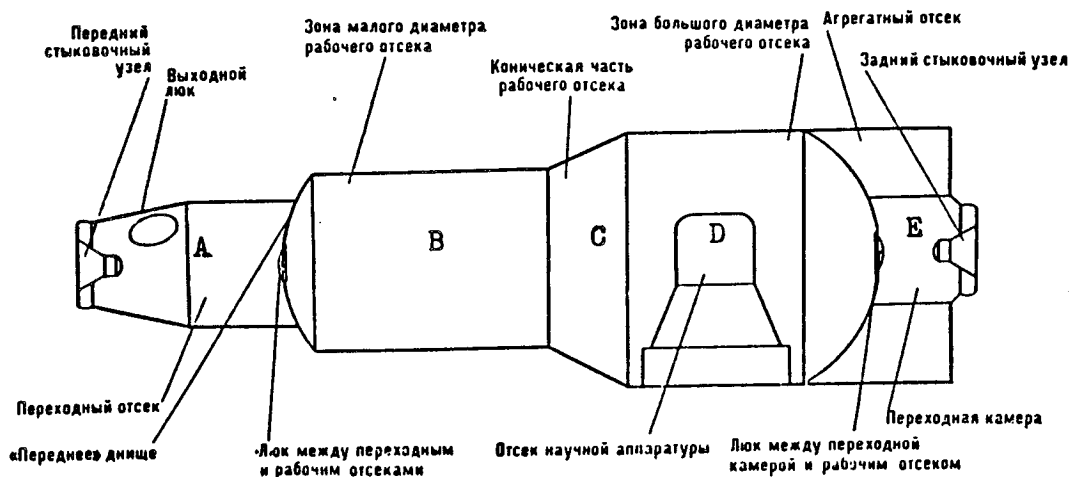
Two unsealed compartments:

-Operating Equipment Module:

- Houses the propulsion system, pneumatically and hydraulically actuated automatic devices, fuel and oxidizer tanks
- The aerials target and and luminous indices of the closing-in system are attached to the operating equipment module's shell

-Scientific Module:

- Part of the shell of the working module
- Houses the x-ray telescope
- Various provisions are stocked in containers in this section (525)



Salyut

- | | |
|--|---|
| (A) Forward Docking Module | (D) Workshop Module with BST-1M Telescope |
| (B) Command Section with Instrument Consoles | (E) Aft Docking Module |
| (C) Intermediate Section | |

G. Improvements:

The Salyut 7, as compared to the earlier Salyut 6:

- Second docking unit
- Combined engine (designed for multiple refueling and the prolonged storage of fuel)
- Increased crew comfort:
 - New ventilation system (See 1.4.7.2 Air Circulation and 1.13 Vibroacoustics.)
 - New color scheme (See 1.9.1.1 Color.)
 - New shower
 - Improved lighting
- Onboard battery and electrical system
- New scientific and medical equipment:
 - Submillimeter telescope was replaced with a group of telescopes for the study of x-ray sources
 - Onboard medical diagnoses and examination system improved
- Improved windows and window protection
- Refrigerator installed
- New computer-controlled materials processing furnace (operates automatically even when the station is unoccupied)
- New systems for medical examination and diagnoses
- Improved navigation system
- Strengthened forward docking port
- Modifications to the solar panels:
 - To permit the attachment of additional arrays

Cosmonaut Popov, who spent 185 days on the Salyut 6 crew, was the commander for a visiting crew on the Salyut 7: "Although the basic parameters of the Salyut 7 station were the same, it was much easier to work in it." (512)

Berezevoy (Salyut 7): "If I were to...describe all the improvements made in this station, the word would be modernization." (649)

H. Orbit

The orbit of Salyut 7 lies between 338-362 kilometers above the Earth's surface at about 51.6°. (537)

SOVIET SPACE STATION ANALOGS, Ed. II

1.1 Spacecraft System

I. Design

The design affects all aspects of the life and work of the cosmonaut:

- Interrelations of man-machine systems
- Life functions of man
- Psychophysiological and personality
- Safety

The creation of an orbital station requires:

- Necessary clearance dimensions for work quarters
- Consideration for work convenience and living comfort of the crew
- Separation of special work zones
- Active rest zones
- Areas for eating and sleeping (345)

Rational construction of the geometrical forms of the cabin (the object-spacial surroundings, work position) facilitates the retention of cosmonauts' work capacity and the increased reliability of long term flight. (114)

The Salyut stations are always being improved:

- Operationally
- Research capabilities
- Reliability
- Conditions for life and work of the cosmonaut (351)

(6)(7)(8)(9)(15)(33)(70)(72)(74)(114)(154)(167)(211)(216)(340)
(345)(418)(452)(476)(502)(525)(527)(537)(548)(596)

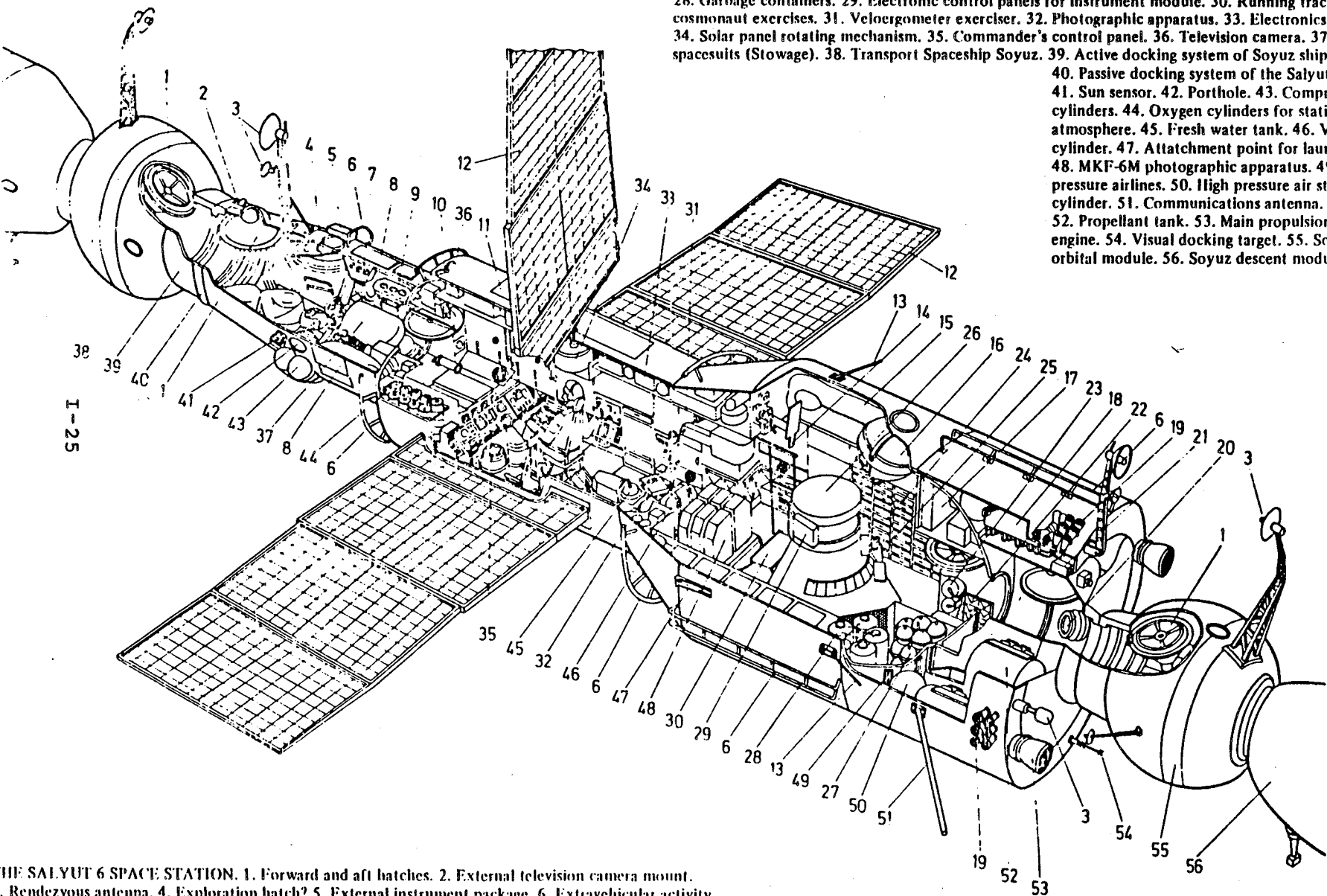
J. The Salyut Program

Characteristics of the Salyut program:

- Simplicity - Less complicated than western systems
- Commonality - Once a basic system or subsystem is developed it is used as much as possible thereafter. With this approach a relatively narrow technological base can serve much broader needs.
- Gradual change - This principle derives from the other two. Because each system is closely related to its predecessor, the risks attendant on innovation are reduced. (537)

(For further specifics on historical aspects of the Salyut series and crew members, see Appendix. For more details on the Soyuz, Progress and Kosmos 1443, see the 1.16 Logistics section.)

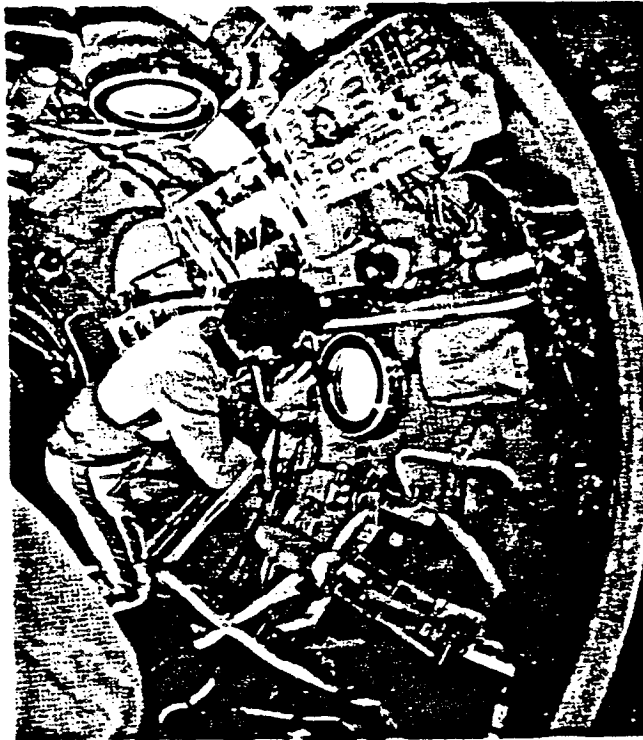
Key continued. 20. Air Ventilator. 21. Television camera for aft docking operations. 22. Sanitary facilities. 23. Toilet. 24. Food lockers. 25. Sighting device (12 x magnification, for aligning the BST-1M telescope). 26. Container for scientific instruments (BST-1M telescope). 27. Fresh water storage. 28. Garbage containers. 29. Electronic control panels for instrument module. 30. Running track for cosmonaut exercises. 31. Velocimeter exerciser. 32. Photographic apparatus. 33. Electronics bay. 34. Solar panel rotating mechanism. 35. Commander's control panel. 36. Television camera. 37. EVA spacesuits (Stowage). 38. Transport Spaceship Soyuz. 39. Active docking system of Soyuz ship. 40. Passive docking system of the Salyut station. 41. Sun sensor. 42. Porthole. 43. Compressed air cylinders. 44. Oxygen cylinders for station's atmosphere. 45. Fresh water tank. 46. Vacuum cylinder. 47. Attachment point for launch shroud. 48. MKF-6M photographic apparatus. 49. High pressure airlines. 50. High pressure air storage cylinder. 51. Communications antenna. 52. Propellant tank. 53. Main propulsion system engine. 54. Visual docking target. 55. Soyuz orbital module. 56. Soyuz descent module.



I-25

THE SALYUT 6 SPACE STATION. 1. Forward and aft hatches. 2. External television camera mount. 3. Rendezvous antenna. 4. Exploration hatch. 5. External instrument package. 6. Extravehicular activity handrails. 7. Airlock pneumatic controls. 8. External thermal control panel. 9. Airlock controls. 10. Sun sensor. 11. Protective screen. 12. Rotating solar arrays. 13. Telemetry antennae. 14. Zero-gravity cosmonaut weighing berth. 15. Sleeping berth. 16. Airlock for debris ejection. 17. Dust filter. 18. Pneumatic and hydraulic systems for attitude control and main propulsion engines. 19. Attitude control engines.

1.1.1 WINDOWS

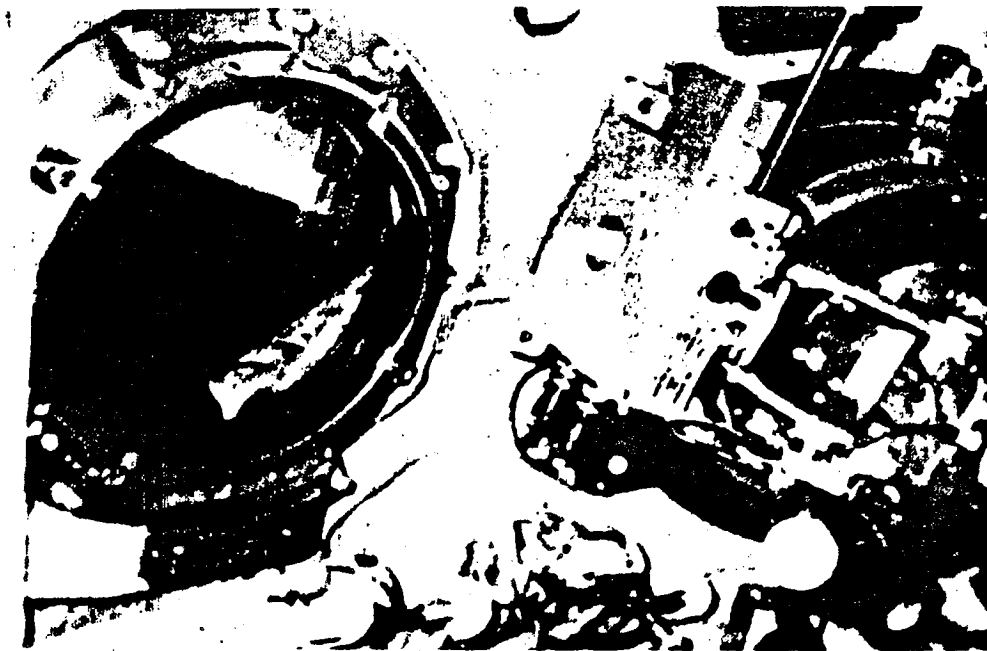


Ed. I

There are approximately 20 windows on the Salyut 7.
(124)(345)(366)(537)

Windows are made of two pieces of quartz glass each 14 mm thick that are hermetically attached to the flanges on a cylindrical ring. The cavities between the pieces of glass are filled with dry air. The insides of the windows are covered with thick, removable glass. Portholes for viewing have shades. Some windows have electrically driven transparent covers on the outside. (70)(145)

Provisions have been made so instruments can adhere to the windows. To limit damage to the glass (which occurred when cosmonauts would accidentally scratch the glass with instruments while working) there are now protective rubber rings and supports on the instruments, and layers of thin "glass" which can be peeled off. (75)(188)(502)



Looking out the windows is a favorite pastime and a form of relaxation (96)(170)(223)(226)(527):

Lebedev, Salyut 7, 211-day mission (three months into his flight as recorded in his diary): "It's getting increasingly difficult. Only the visual observations have a relaxing effect." (646)

"[Windows] provided the opportunity to take a breather from our work and relate one-on-one with the Earth." (417)

"We just like sitting at portholes...We watch things down on the Earth..." (366)

Portholes are used for investigations of the Earth using visual and instrument observation methods. This can lead to the creation of a data base on Earth and the data base can be used for the formation and processing for developing automatic systems for investigating Earth. (195)

A. Problems and Solutions:

Considerable changes were made in window features on the Salyut 7 station.

Problems on Salyut 6 included:

- Windows gradually lost their transparency
- Scratches appeared
- Tiny craters were caused by micrometeorites (one was 4 mm deep)
- Inside glass could be contaminated by particles and dust floating in the atmosphere
- Products from the combustion of fuel in the engines accumulated on the outside

Solutions to these problems were made on the Salyut 7:

- Insides of the windows are now covered with thin, removable pieces of glass. When instrument observations are needed, this removable glass is taken off.
- Several of the windows now have an electrically-driven transparent outer cover. When needed for an experiment, the cover is retracted by a push of a button. The cover remains in place the rest of the time in order to prevent contamination of the actual window glass.
- Two of the windows are transparent to ultraviolet lights. This:
 - Enlarges the station's investigative arsenal
 - Protects against the possibility of the development of pathogenic bacteria carried along from Earth
 - Is better for astronomical investigations
 - Allows cosmonauts to get a tanThese two portholes are located in a passageway and in the main compartment.

Lebedev, Salyut 7: "It is possible to get tanned...Since there is no atmosphere, two minutes under its rays (sun rays) produce the same effect as a day on the beach." (213)

(6)(8)(75)(163)(188)(336)(339)(502)(527)(649)

SOVIET SPACE STATION ANALOGS, Ed. II
1.1 Spacecraft System

B. Salyut 7 Unresolved Problems:

-Transparency of the glass decreases with time:

--This is a problem because this breakdown of the external heat control coating influences the operational quality of the film and photo equipment as well as visual observations. There are two views as to what causes this problem:

---Space radiation

---Residual matter from engines

-The film that coats the glass cannot be removed. During one EVA the cosmonauts were asked to remove a sample from a window, but they were unable to do so, as the film was glued fast.
(315)(374)(548)

-Meteorites:

--(See 2.5.8 Meteorites.)

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SOVIET SPACE STATION ANALOGS, Ed. II
1.1 Spacecraft System

1.1.2 SEPARATION OF WORK AND LIVING

There should be separation of:

- Work areas
- Active rest zones
- Areas for eating
- Areas for sleeping (114)

In order to facilitate the organization of a program schedule and reduce negative factors the station must provide specific areas for:

- Recreation
- Sleep
- Rest
- Privacy
- Areas where joint work is performed (548)



Ed. I

SOVIET SPACE STATION ANALOGS, Ed. II

1.1 Spacecraft System

1.1.3 MODULARIZATION

Modular construction is desirable because it reduces the time required for maintenance. (79)

1.1.4 MULTIDIRECTIONALITY

Soviet engineers have designed their stations with a basic Earth-orientation. (A horizontal layout with the floor and ceiling parallel to the station's longitudinal axis, although some exercise equipment and sleeping facilities are located "on the ceiling.") They have based this on observations of the cosmonauts which showed that, in general, they try to stick to their Earth habits--head up, feet down.

The floor, ceiling and walls are in different colors to make it easy for the cosmonaut to orient himself when moving. (6)(27)(70)

Although the stations are designed with an Earth orientation, the question of whether there should be an "up" and "down" in a spacecraft still appears to be controversial:

-There are fears that the symptoms that arise during the period of adaptation to flight conditions will grow stronger because of the disruption of accustomed concepts: (346)

--For example, experience has shown that an interior with a floor/ceiling emphasis helps to overcome vestibular discomfort. Such orientation is closely related to the process of controlling a space vehicle. (27)

-Other cosmonauts do not share these fears. Some feel that the freedom of movement and positions in space are positive. Some cosmonauts have reported that "up-down" becomes insignificant in weightlessness and during some kinds of activity. (For example, during observations made on a viewer when the concept of up and down is totally lost. (346)

"I am inclined to believe that cosmonautics should be ready to prepare, in the spaceship, conditions unlike those to which one is used to on Earth...Scientists are going to turn to this problem again and again in connection with the ever continuing space flights. The key problem, as it seems to us, may be the question that is crucial in cybernetics. It concerns the so-called "body aspect" (...with the relationship [between] body and the psyche...)...much remains to be done..." (257)

1.1.4.1 REINFORCING UP AND DOWN

Perception and orientation can be aided by:

- Locating equipment by using the principle of visual equilibrium
 - Heavy at the bottom, light at the top
- Use of artificial orientation guides
 - For example, light and sound stimuli. Smell could even be used.
- Downward light orientation

Floor and ceiling should be clearly marked. There should be special coloring of the quarters. (114)

SOVIET SPACE STATION ANALOGS, Ed. II

1.1 Spacecraft System

1.1.6 CEILINGS

On the Salyut 7 the ceiling is white. (188)

1.1.7 SEATS

In the main control station the seats are:

- Small
- Portable
- Removable (bicycle type)

The seats are set up in the working position only after the crew enters the station. Leg restraints are used.

(6)(8)(188)

1.1.8 WALLS

A. Improvements:

- The "hero" cloth that was used to trim all the panels and walls on the Salyut 6 was replaced with washable leather. (This is because the cloth used on the Salyut 6 mildewed.)
- In the working compartment, the left wall is apple green and the right one beige.
- The panels in the living compartment have been made easier to remove and clean.

(124)(188)(502)(649)

1.1.9 VOLUME

The interior of the Salyut 7 provides about 90 m³ of usable volume (100.3 m³ of pressurized volume). An additional 70 m³ pressurized volume was added with the docking of the Kosmos (See 1.1 and 1.16.3.).

During the Salyut 7, 237-Day Mission, a crew of six was housed for over a week (a visiting crew of three in addition to the three main crew members). Physical exercises were hampered because use of some of the machines shook the station, disturbing other crew members and experiments. (249)(368)

Volk, Salyut 7, 237-day mission, visiting crew member: "This means that spacecraft with larger interiors are needed." (249)

Other problems with lack of space:

- Hypodynamia (insufficient motor activity, leading to decreased work capacity and reliability of work):
 - As the space stations have progressed the working and living conditions for the crews have been improved (See information on the Mir.) It has been possible to counteract hypodynamia by enlarging the work and living quarters. (119)
- Negative psychological effects (for example, claustrophobia-- which should not be discounted in long-term flights)
- No place to store resupplies and new equipment:
 - Aleksandrov, Salyut 7, 150-day mission: "It is getting increasingly difficult to move around the working compartment--cases of food and various equipment are everywhere. And we still haven't taken out the containers with the additional solar batteries from the Kosmos or more than ten other large units." (249)(572)
- Atmospheric pollution:
 - Atmosphere pollution with noxious gaseous trace contaminants exhaled by man in an enclosure was investigated as a function of free volume per man. The parameter was shown to depend on the environmental conditions: with an increase in free volume the total level of atmospheric pollution decreased, being proportional to the concentration of gaseous trace contaminants in the exhaled air. (344)

SOVIET SPACE STATION ANALOGS, Ed. II

1.1 Spacecraft System

MINIMAL PERCENTAGE OF VOLUME THAT IS NEEDED
IN VARIOUS STATION ZONES

Work zones:	40%
Common zone:	25% (eating, rest, leisure, physical exercise)
Personal zone:	20% (sleep, privacy, personal space)
Service zone:	15% (washing, etc.) (188)

Soviet research has established that "isolation is harder to bear in cases when the test subjects are located in tight quarters which limit their movement." Comfortable conditions are important (to improve work capacity and reliability of work). (114)

"[The] problem of crowding is tied in with the problem of biorhythm..." (See 3.1.2.11 Biorhythms.) (257)

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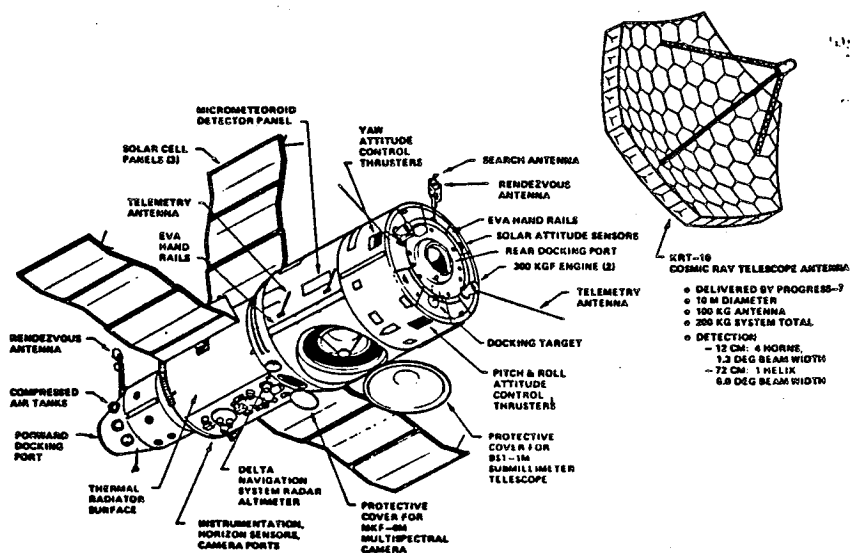
SOVIET SPACE STATION ANALOGS, Ed. II
1.1 Spacecraft System

1.1.10 EXTERIOR

A. Damage:

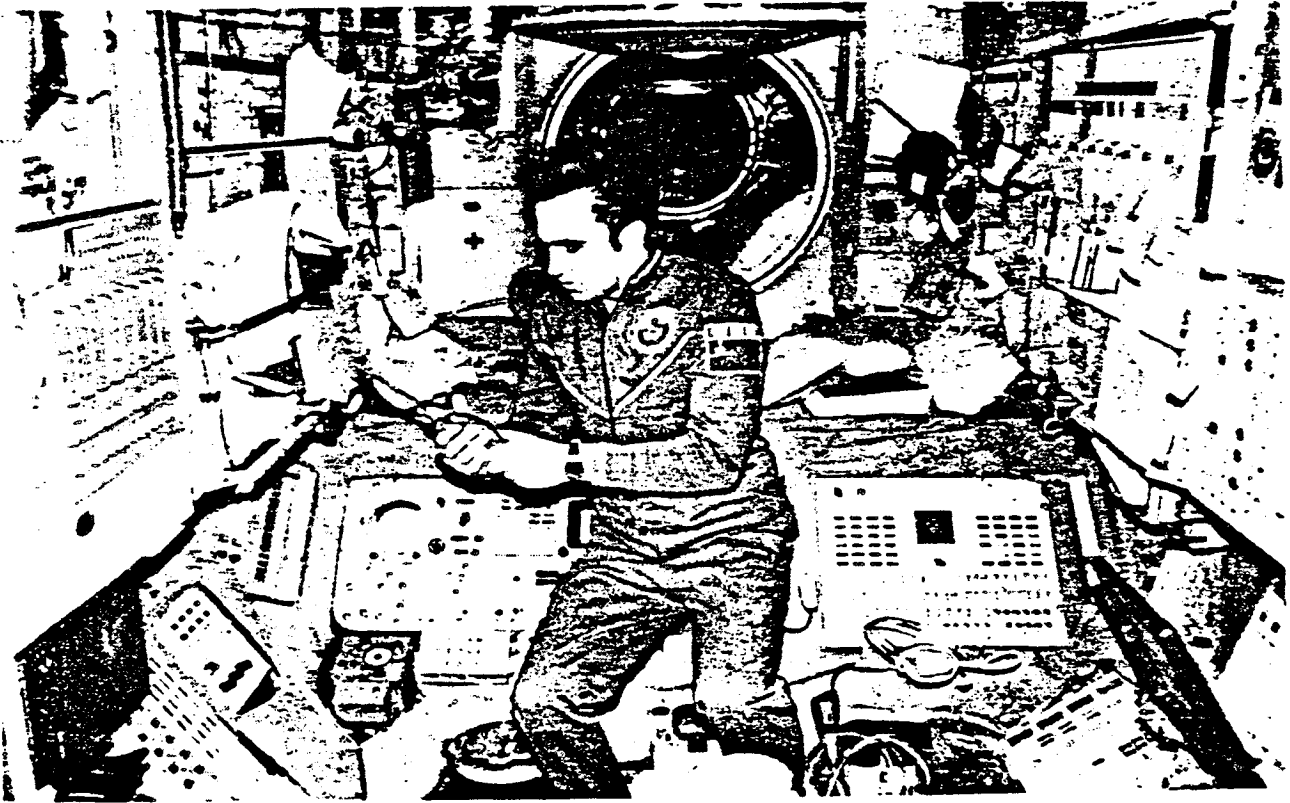
After three years in space Salyut 6 showed degradation of the exterior. The 20 portholes were covered with a film of dust. The vacuum insulation material was torn in a few areas (probably by micrometeoroid impacts). The solar panel coverings were splintered in areas, with some of the plastic broken off, exposing the silicon solar cells to damage from the reflected heat from the station's radiator. (168)

Special structural elements, attachments and attachment devices for EVA were included on the station hull when the Salyut 7 was created. (485)



Salyut 6

1.2 WORK STATIONS



Ed. I

Work stations have:

- Small portable tables
- Daylight lamps (See 1.7.1 Illumination.)
- Internal loudspeaker communication devices (188)(537)

Behind the crew armchairs are mounted collapsible eating tables with tanks of drinking water attached. (70)

There is a refrigerator in the working compartment. (75)

A. Recommendations:

WORK STATION DESIGN:
Minimum Requirements:

When working in the sitting position:

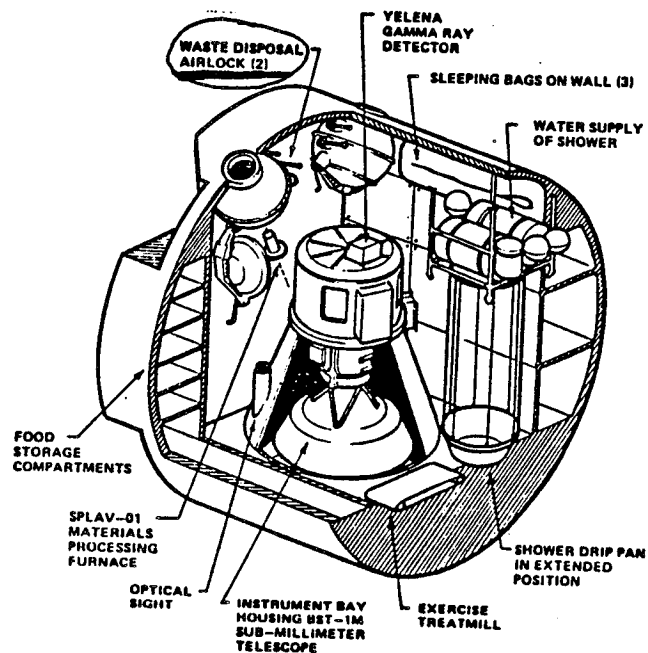
- The width of the work area: no less than 700 mm
- Depth: no less than 400 mm
- Height of the horizontal work surface above the floor: 700 mm
- Height of the horizontal wall surface to oversee the entire panel: its height should not exceed 1200 mm
- Best conditions for observations: a view angle of 30°
- Minimal distance between the operator and the indicators: 30 cm
- Recommended distance: no less than 50 cm (114)

1.2.5 AIRLOCK

In the Salyut 7, the small airlocks located in the stern behind the x-ray telescope have been standardized. Each can be used either for dumping garbage or for conducting experiments requiring a vacuum. (8)(188)

These airlocks use a spring-loaded ejection system.

WASTE DISPOSAL AIRLOCK (2)

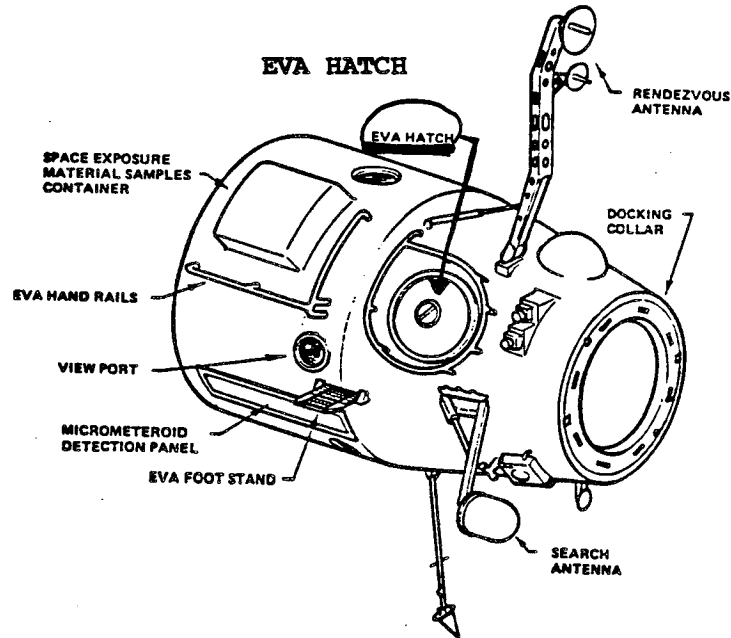


SALYUT 6

(548)

The "Splav-01" process furnace and other installations for scientific research can be placed in these airlocks. (6)(8)

EVA Airlock: Access is located in the forward transfer compartment. The forward transport compartment is approximately 8 cubic meters. There are 7 windows that provide almost a full 360° view. Spacesuits are stored in this airlock, plugged into a "support" system. (154)(348)(649)



548

1.2.5.1 AIRLOCK AND EXPERIMENTS

The Soviets put samples of tested materials in the airlocks, where they are exposed to all space factors:

- Radiation
- Temperature fluctuation
- Micrometeorite hits

After these samples are brought back into the station, they are photographed with an electrographical instrument. The pictures show all defects which have formed in space.

SOVIET SPACE STATION ANALOGS, Ed. II

1.2 Work Stations

Problem: It is important to get the samples from the airlock and examine them as quickly as possible since even a short delay will produce electrostatic charges which will distort the real picture. After six hours or so of exposure to space, the airlock freezes through and its inside temperature drops to -150°C . If it were opened right away, condensation would cause undesirable effects. So the cosmonauts have to keep the airlock closed for six hours to bring its temperature even with that of the air in the station. This slows down the work and affects its accuracy.

On the 237-Day Mission, a solution was found: when an experiment was drawing to a close, the orbiter was positioned so as to let sun rays heat the airlock with the samples to a temperature equaling that of the air inside the station. That made it possible to retrieve the sample right after the experiment was over and to study them at once.
(284)(456)(546)

1.2.7 ANIMAL LABORATORY

Quail egg experiment: On the Salyut 6, crew members took eight quail eggs and put them into an incubator to watch them develop. Control samples were kept on Earth. The control samples hatched normally, but in space the crew found that the chick embryos had developed far slower than on Earth and with a body but no head. Speculating on the results a zoologist said that artificial gravity may have to be produced to allow normal development. (350) (See 4.1.1.2 Artificial Gravity.)

Drosophila experiment: A new generation was born every two weeks for heredity studies. The flies had their own thermostat house which was maintained at a constant temperature of 24 ° Celsius.

Tadpole experiment: To see how tadpoles would adjust to the lack of gravity.

Two groups of specimens were used, one born onboard the space station and another brought from Earth.

The Earth-born tadpoles swam in a disorderly manner for a whole fortnight without knowing top from bottom, while those born in space swam in an orderly spiral pattern. (548)

Two monkeys were sent into space on July 13, 1985. The aim of the experiment was to:

- Study vestibular and hemodynamic responses of living organisms to weightlessness at the acute period of adaptation
- See if it was possible to take quantitative measures of the excitability of the vestibular apparatus and to take note of an increase in its reactivity
- Obtain data on the ration of the outflow and inflow of the blood to the head (433)

According to Dr. Gazenko, Director of the Institute of Medical and Biological Problems, there is a need to launch animals and insects into space because this will answer many biological and physiological questions. (433)

[The majority of Soviet animal experiments take place on their unmanned spacecraft.]

1.2.8 PLANT FACILITY

Plants can be used for:

- Food
- Oxygen production
- Enjoyment

(96)(114)(121)(170)(174)(294)(417)



Savinykh with Orchid

Lebedev, Salyut 7, 211-Day Mission: "It is amazingly pleasant onboard to look after plants and to observe them. I think that in future long flights there will be a lot of plants. They are simply essential to man in space." (208)

Lebedev, Salyut 7, 211-Day Mission: "I spent some of my relaxation time working with the biological experiments...Back on Earth I had never loved tinkering in a garden. But onboard the space station it was as if I woke up all of a sudden to the Oasis apparatus. A tiny leaf opened up and it seemed to fling open a bright window out into the world." (405)

Ryumin: "...the 'green friends' of man grown by the cosmonauts...are not only the subject of...study but also--and I stress this--a not unimportant psychological factor exerting a positive effect on...emotions..." (294)

A. Requirements:

Plant facilities require an exact regulation of:

- Temperature
- Light
- Moisture
- Mineral nutrient conditions

Optimal conditions still have not been created. Experiments are still being done. (92)

Plants grow best when they are put next to a window.

A fibrous material moistened with nutrients should be used for soil. (168)

B. Problems:

- Flowers had a tendency to wilt and die before reaching maturity. (164)(168)
- In the absence of gravity, water will not run to its lowest point:
 - This may account for the many reports of plant drowning
- Zero gravity reduces the exchange of heat, oxygen and carbon dioxide between the plant and its environment. All these factors may:
 - Impinge on proper metabolic gas exchanges
 - Result in the possible accumulation of toxic substances in the immediate environment of the growing plant.
- Theories on why plants will not blossom include:
 - Lack of gravity
 - Changes in the plants' mechanism of disposing of waste products (the wastes hang in zero gravity)
- Plants' metabolism stalls or discontinues entirely (548)

SOVIET SPACE STATION ANALOGS, Ed. II

1.2 Work Stations

1.2.8.1 EXPERIMENTAL GROWING CONDITIONS

Biogravistat:

- Has a small rotating centrifuge that produces artificial gravity
- Has a stationary area:
 - Tests have shown that the roots of the seeds on the centrifuge grew twice as fast as those on the stationary part. The root was directed along the radius in whichever direction the centrifugal force acted. (134)(154)(168)(269)(548)

Malakhit:

- Is designed to automatically provide water and sufficient light
- Takes time-lapse photography of growing plants
- First orchid in space grown here (157)(548)

Magnetogravistat:

- Provides an artificial magnetic field (154)(168)(208)(269)

Fiton Hothouse:

- Provides a nutrient medium which is isolated from the cabin by filters
- The production of seeds (Arabidopsis plant) occurred here (269)(548)

Oasis:

- A compact greenhouse
- Uses artificial soil (woven cloth in several layers that is saturated with nutrients)
- Possible to ventilate the plants' roots
- Meters the:
 - Moisture
 - Light (has 3 light sources)
 - Nutrients
 - Temperature
 - Ventilation
- Creates in the soil an electrostatic fuel that simulates terrestrial conditions (134)(190)(353)(548)

Vazon:

-This is a flowerpot unit in which plants such as onions can be grown

Klinostit:

-This is an instrument used to simulate zero gravity in terrestrial conditions (134)

A. Salyut 7 Improvements:

The growing apparati have been improved:

- Oasis now has a water dispenser and increased illumination
- Biogravistat has 3 speeds of rotation
- More light provided in Fiton (176)(269)

B. Future Developments:

Space greenhouses are being developed that are characterized by:

- Minimum weight and energy consumption
- More complete utilization of mineral fertilizers and sowing areas
- Continuity of the crop yield (2)

SOVIET SPACE STATION ANALOGS, Ed. II

1.2 Work Stations

1.2.8.2 TYPES OF CROPS

Plants can be grown and used for the production of oxygen and food products. Specialists are concentrating on the growing of higher plants aboard the space station. (164)(253)(269)(503)(537)

Plants that have been grown include:

- Chlorella (A species of algae. May be feasible as an oxygen source and for the removal of carbon dioxide.)
- Parsley
- Onions
- Dill
- Garlic
- Cucumbers
- Tomatoes
- Peppers
- Strawberries
- Radishes
- Wheat
- Carrots
- Oats
- Peas
- Kale
- Herbs
- Lettuce
- Arabidopsis

Not all plants grew equally well. (See 1.2.8.3 Mission Highlights for more details.)

(96)(127)(170)(213)(253)(269)(294)(341)(350)(353)(502)(503)(548)

The proper choice of crops is important. The choice should include:

- Both vegetables and cereals
- Individual daily requirements
- High productivity per unit area and nutritional value of the plant
- The growing requirements for the plant
- Reproduction capability
- Genetic stability under artificial conditions
- The simplicity of food preparation

Plants that can contribute proteins, fats, carbohydrates and vitamins should be included. Examples:

- Protein -- beans, peas, soybeans, peanuts, wheat, rice
- Fat -- peanuts, soybeans
- Carbohydrates -- potatoes, wheat, sweet potato, sugar, beets, carrots, cabbage
- Vitamin accumulators -- parsley, dill, sweet pepper, onion, lettuce, radishes, tomatoes, spinach

(164)(253)(273)

Subtropical and tropical crops should also be included. Additional study for growing them is required.

Non-traditional crops which have valuable nutritional qualities (for example, salad chrysanthemum) are being researched.

Space gardens of the future will be able to produce fruits and vegetables to the extent that 20-40% of the bulk food consumed in orbit will be grown in orbit. (273)

1.2.8.3 MISSION HIGHLIGHTS

Salyut 6 Missions:

Some of the plants on the Salyut 6 grew and some did not. On the 140-day mission, the crew produced vegetation (parsley, onions, dill, garlic) and used it as a dietary supplement. On the 175-day mission the crew planted onions, garlic, cucumbers, tomatoes, peppers, strawberries and radishes, but these plants all died at a certain stage. (253)(341)(503)

Short-stalked, heavy grain-yielding wheat was grown, taking 63 days to produce grain. (127)

A fern grew that is widespread in southeast Asia. "This plant is a little nitrogen factory." Like clover or leguminous plants, it improves the yield of other crops and fertilizes the soil. (50)

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1.2 Work Stations

Salyut 7 Missions:

The cosmonauts planted and harvested a dozen different plants. They first planted oats and peas which sprouted within a few weeks but did not seed. They grew garden pepper grass, dill, kale, parsley and radishes. (269)(502)

Cosmonauts noted that peas grow in an interesting way: they come out of the soil already robust, with a thick stalk and leaves, and they are densely packed. Wheat grows straight up. (213)

211-Day Mission:

For the first time, a plant went through a complete life cycle, up to and including the seeding stage. This weed, the Arabidopsis, grows most frequently in quarries, dumps and in the desert. It has a rapid cycle of development (as little as a month). It was grown in the Fiton system in a special nutrient medium. The plants were isolated from the station atmosphere by filters which stopped the penetration of impurities. (30)(54)(96)(176)(194)(294)(548)

237-Day Mission:

A cycle of research for the separation of fragments of DNA molecules was completed in the electrophoretic genom plant. The course of experiments was registered by means of photography and ultraviolet light. (456)

Visiting Cosmonaut Savitskaya was greeted by the main crew who handed her a bouquet of arabidopsis flowers that had been grown on the Salyut.

September, 1985:

Cotton shoots were planted in one of the space hothouses. (644)

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1.3 DESIGN FOR INFLIGHT MAINTENANCE AND REPAIR



Ed. I

"Repair work is vital. Repairs are costly but nowhere near as costly as launching a new station." (166)

"In a year, in any equipment, one can expect certain defects." (624)

Maintenance Design Necessities:

- The possibilities for construction must be incorporated in advance in the design of the station and its equipment (351)
- Modular construction (See 1.1.3 Modularization)
- Interchangeable parts:
 - Limits space usage
 - Minimizes weight
 - Simplifies overall task
- Sensing devices:
 - For the detection of malfunctions
 - Cosmonauts can make corrections before major problems develop
- Accurate inventory system
- Planned and scheduled preventive maintenance
- Active role of cosmonaut (See 1.3.1 Cosmonauts Role in Maintenance and Repair.)
- Easy access to units (See 1.3.3 Access and 1.3.7 Panels.)
- Adequate tools (See 1.3.8 Tools.)
- Training for maintenance duties

(79)(249)(261)(351)(363)(439)(548)

A. Inventory:

Prior to leaving the station, cosmonauts prepare a detailed inventory. One copy is left with the station and the other is brought back to Earth. (30)

NEED FOR ACCURATE INVENTORY

Salyut 7, 150-day mission: "We found a cable similar to the one they use for the shower unit. We started to install it but it was not the right one at all. We cut off the connectors so that it fit the receptacle. Then it turned out that it was meant for entirely different purposes. In the future, when we have doubts, we must certainly consult the center." (249)

B. Most Commonly Replaced Items:

Those items that are most frequently used also need to be replaced the most often:

- Cables for the portable television camera
- Headsets
- Ventilating fans (548)

C. Salyut Design Objectives:

The design of the Salyuts provide for the repairing and replacing of equipment components in flight by the crew. (363)

"There is no single mechanism which can sustain uninterrupted operation over the course of many years--not to mention decades. Therefore, it is necessary to learn how to service such stations, how to forestall and eliminate faults and disrepair in the operation of their systems." (373)

An increase in the life of a station is associated with an increase in the reliability of its system and instruments. Maintenance requires preventive maintenance and the replacement of parts. (351)(621)

Repair and restorative work improve the operability of systems, which is important for long term and economically justified missions. (155)(503)

In order to extend the operating period of systems, a capability for repairing the power supply, telemetry, television, communication and other systems has been provided. A special complex of instruments was developed for performing repair and maintenance work in weightlessness.

System maintenance operations, housekeeping and the performance of repair and preventive maintenance work occupy a large percentage of time. Thus as the duration of manned expeditions increases, the proportion of working time for research and experiments decreases. (76)

SOVIET SPACE STATION ANALOGS, Ed. II

1.3 Inflight Maintenance

Redundancy is built into the spaceship system. Much of the equipment can be repaired by the cosmonaut. Some of the equipment is functional even at less than optimum capacity so that if malfunctions occur in a support system it can still provide the environmental controls to effectively sustain life. There are sensing devices that detect potential emergency situations in order to give the cosmonauts time for remedial action. (548)

1.3.1 COSMONAUTS' ROLE IN MAINTENANCE AND REPAIR

Prior to leaving the station cosmonauts:

- Put movable equipment in its proper place behind panels
- Prepare a detailed inventory of the stowage
- Refuel the engine
- Replace worn out parts on ventilators and air regenerators
- Renew filters
- Turn off equipment that will not be used during the unmanned flight:
 - Air regeneration system
 - Water supply system
 - Some of the scientific equipment
 - Communication systems
 - The lighting system
 - Delta system (30)

"...the prolonged operation of the Salyut 6 station became possible only due to the cosmonaut. It has no equal with respect to the volume of preventive maintenance and repair restoration work carried out aboard it." (351)

The role of the cosmonaut is not just to observe and control, but requires an active participation in case of technical failure. This role requires:

- Alertness
- Memory
- Emotional stability
- Capacity for acting calmly in a difficult situation (114)

Equipment must be maintained in working order, which means that operator skills and high working capacity must be preserved. Technical maintenance should take into account the changes in the working capacity of the crew. These changes are a result of:

- Weightlessness
- Closed ecological space
- Stress (363)

SOVIET SPACE STATION ANALOGS, Ed. II

1.3 Inflight Maintenance

1.3.3 ACCESS

"...Experience has led engineers to design stations so that crew members can have easy access to any particular component or system so that they can be replaced by new ones...These repair methods will also be useful for flights to the planets." (548)

A. Salyut 7 Improvements:

-Easier access to many units:

- Reduces time needed to perform maintenance tasks
- Improves quality of work

-Several cumbersome units of the life support system have been separated into component parts:

- Makes it easier to handle (8)(75)

B. Placement:

All the basic systems and equipment are placed in the same compartment where the crew live and work so that the cosmonauts will have access to the station's basic equipment. Exceptions: pieces of equipment that, because of their functions, must be placed outside (for example, the power plant and the telescope operating in the submillimeter band). (345)

Replacement of onboard equipment requires less time and physical effort if all the equipment is placed along the axis of the station and not along the walls. This not only increases the convenience of maintaining the instruments but also makes it possible to create a system of monitoring and eliminating disruptions of the station's air-tightness as a result of meteorite strikes. (264)

Modular plug-in electronic units provide for the replacement and repair of the individual systems. (For example, ventilators in the thermal regulation system, lights, components of the veloergometer and the running track filters, and regenerators of the life support systems.) (174)

1.3.4 POWER

The capacity to install two additional gallium aluminum arsenide solar panels to each solar array was planned while the Salyut 7 station was under development. Provisions were made for special structural elements, fixtures and clamping devices on the station body: (See 2.2.1.2 EVA Missions.)

- A hinged bracket with a winch mounted on it
- Cable arranged in a special way
- Mounts for attaching the extra panels
- Corresponding attachments and instruments (designed to facilitate the assembly work)

The Salyut's three original solar arrays are sized so that even under worst lighting conditions (40 minutes dark out of every 90) they can provide sufficient power to the station. Under such conditions, the station would have to be running at about 55% of the panel's full output. The rest of the power would be channeled into batteries to be utilized during darkness. As the amount of darkness is reduced, the operating power levels can go up since less must be siphoned off during daylight to charge batteries for the brief nights. This means that if one of the three panels was taken off-line for maintenance or augmentation, the remaining two panels, by themselves, could provide the same steady state power output that required three panels during worst-case orbits. If the Soviet space mission planners needed to find times when one power panel could be disconnected without degrading total station power below tolerable levels, it had to be during those few brief phases when the orbit/Earth/Sun alignment provided less than 20 minutes of darkness and that is when these EVAs were conducted.

(380)(430)(554)

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1.3 Inflight Maintenance

1.3.7 PANELS

Removable panels partition the instrument zone from living space.

Control panels are either directly housed in the living zone or built into these removable panels. (72)

A. Salyut 7 Improvements:

All the panels covering the station service system and life support units are easily removed. Reason: On the Salyut 6 some panels were screwed so tightly to the walls that they were nearly impossible to remove. (168)(188)

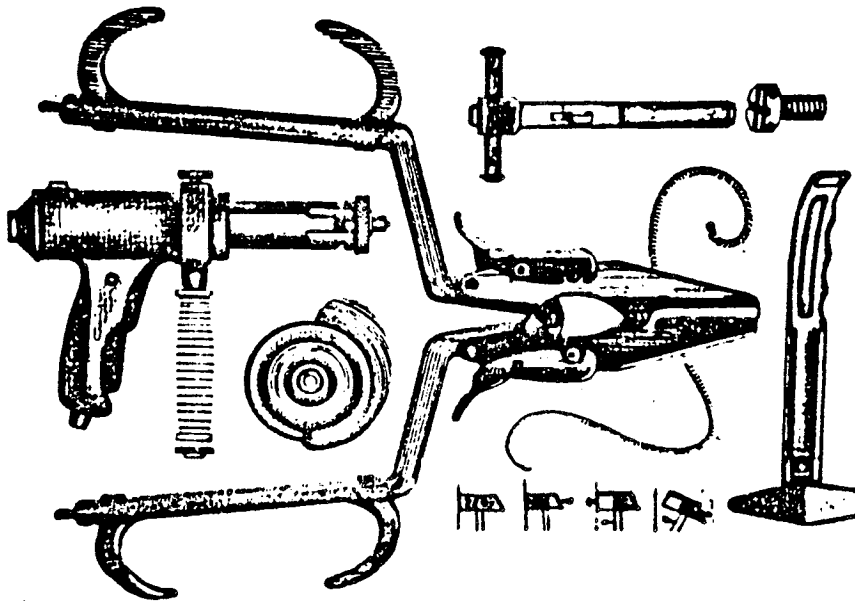
1.3.8 TOOLS

1.3.8.1 REQUIREMENTS

Requirements for space tools:

- They must correspond to man's functional capabilities
- Must insure a high productivity with minimum energy expenditures
- Universality
- Consideration for size and weight restrictions in the space vehicle
- Free of recoil during use (For example, the hammer used has a cavity which is filled with small spheres. Upon impact there is no recoil because the small spheres dissipate the recoil energy.) (205)

1.3.8.2 TYPES OF TOOLS



SPACE TOOLS

Tools are necessary for repair and for preventive maintenance work. They should be able to perform a wide variety of maintenance and repair tasks. Tools can be divided into two groups: the "most needed" and the "less needed."

A. Most needed tools:

- Screwdrivers
- Wrenches
- Adjustable wrench
- Shears
- Knife
- Pliers
- Awl
- Nipper

These are kept in the main control post not far from the crew commander's seat.

B. Less needed tools:

- "Keys" for electrical plugs
- Adapters and caps
- Flanges

These tools are rarely used and are stored in the living area near the equipment bay.

C. Tools for repair and preventive maintenance:

- Insulating and adhesive tapes
- Wire
- Straps
- Glue
- Filament
- Lubricants
- Rubber lines
- Lamps and fuses (205)

The station has both ordinary tools and tools of the inertialess type (tools not creating a reactive moment):

Screwdrivers - The "anchor" screwdriver has a unique design. It looks similar to socket wrenches. When the screwdriver is fitted into a screw, the spheres of a special lock enter into its recesses in the cylinder head. The cosmonaut only has to turn a control lever, the lock locks, and the screw--together with the tool--is transformed into a rigidly coupled system. Work with this screwdriver requires less effort and time than working with an ordinary Earth screwdriver.

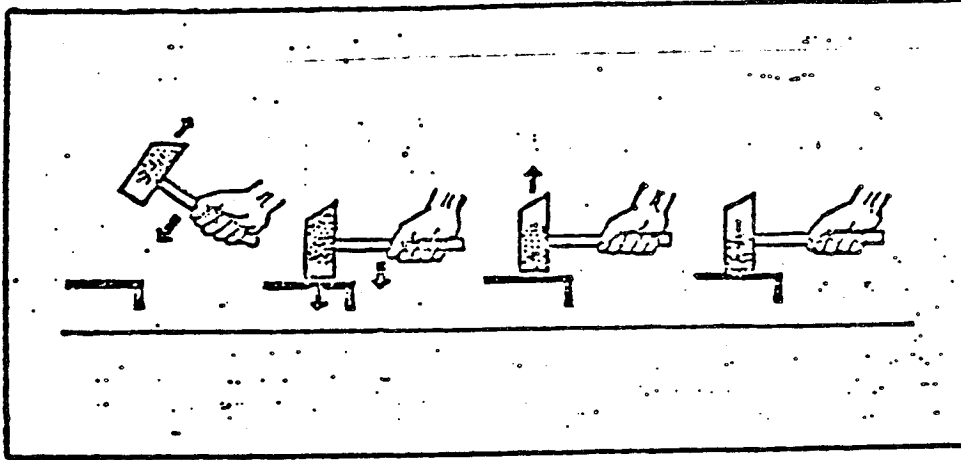
Soldering Gun - This looks like a ball point pen with an electric cord. As it is drawn over the metal, a special substance is ejected by capillary forces and the soldering is done. The soldering iron works without tin. Filters gather up the chips of metal and prevent them from getting into scientific apparatus or control panels. [Crew members have noted that solder can get into the eyes.]

Wrench - This has a guide rod in the center and balls along the sides.

Bolts - These have a socket in the head for the rod, and depressions on the sides for the balls. The bolt comes out much easier and no sharp chips can form.

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Cutter - This is used to cut lines, cables and other soft materials but it cannot even accidentally damage the surface of a spacesuit. Cosmonauts used it to cut and remove part of the station solar battery elements without touching them with their hands.



Hammer Used In Space Work

Hammers - "Recoil-less" (which prevents injury). Its head is partly filled with shot, which is what quenches the recoil. The handle can also act as a pinch bar.

Pliers - This tool multiplies the force applied.

Electromechanical Tool - This has a multipurpose recoilless drive with a system of attachments that can be used to:

- Remove screws
- Cut metal bars
- Trim metal edges
- Drill and do a number of other operations without any reactive effect on the workers

Safety Belt - This enables the cosmonauts to assume any posture. The belt also has pockets for storing tools and fastenings.

Bracelet - This has a chain and latch hook. It is used to hold a tool if it is accidentally dropped while the cosmonaut is working.

Bracing Elements - For use with tools and writing equipment.

Lathe

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1.3 Inflight Maintenance

Multi-Purpose Hand-Held Manipulator - Used for EVA (See 2.2.10 Reports on EVA Experience, Salyut 7 150-Day Mission, for example.)

Universal Hand-Operated Electron-Beam Power Tool - [Also known as General Purpose, Hand-Operated Tool; Multipurpose Hand Tool; URI]:

- Used in EVA
- Virtually noiseless and vibration-free
- Weighs 66 pounds
- Capable of fitting into a box a half a meter square
- Resembles a flare gun with two broad barrels:
 - Barrel One
This barrel has a lens on it. An electron beam generated inside this barrel is focused, with the aid of the lens, onto metal specimens which are then cut, welded or soldered.
 - Barrel Two
This barrel is used for spray coating. It has a built-in crucible for melting
- Used with four board-type holders for specimens placement:
 - Three of these holders hold specimens during cutting, welding or soldering. Each holder holds six specimens.
 - Fourth holder holds specimens that are spray coated
- Can be attached to a collapsible handrail by a cable
- Used for the first time on the EVA performed by the visiting crew of Savitskaya and Dzhanibekov
 - During this EVA, Savitskaya soldered and sprayed a thin layer of silver on an anodized aluminum plate (See 2.2.10 EVA Missions.)

Problems with URI:

- Complaints were made that it was difficult to handle (because the spacesuit was not flexible enough) (See 2.2 Spacesuit.)

Problems with Welding Outside the Station:

- The station's onboard voltage had to be converted into voltage sufficient to power the electron gun of the URI
- Methods had to be developed for controlling the high temperatures generated by this unit. (The tool gets too hot at times.)
- Methods had to be developed for protecting the fabric of the cosmonaut's spacesuit against high temperatures
- Size and weight of units employed in the experiment had to be minimized

Jaw Instrument - Used for pinching off a pipeline during an EVA. (See 2.2.12 EVA Missions.)

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1.3 Inflight Maintenance

Non-contact Infrared Thermometer - During the welding of several specimens in succession, the temperature of their holders was monitored with this pistol-shaped thermometer.

Piercing Tool - Used to make holes.

Reducer Wrench - Has a system for increased force on the nut.

Pneumatic Press, Hand-Held - Has a cylinder containing air under a pressure of 250 atmospheres. Capable of exerting a force of 5 tons.

Fuel Repair Tool Kit - With 25 specially made tools. Weighs (with tools) 40 kg. Used for EVA repair of disabled fuel system.

Industrial electron accelerators in the development of radiation resistant materials are used.

There are objects which are specially adapted for disconnecting electrical plugs.

Tools for either cutting or burning through building materials have been used in EVA.

Interface connections are used to join large structures. These joints are thermomechanical and have threaded connections from different metal pairs.

Tools must be convenient and safe. There should be no danger of cutting the spacesuit.

(8)(125)(141)(142)(154)(168)(174)(204)(205)(230)(244)(265)(284)(309)
(313)(318)(413)(429)(456)(530)(568)(577)(646)

D. Comments:

Lebedev, 211-Day Mission: "The most important instrument onboard the station is the scissors. Everyone has a pair tied to his pocket with a long string. The scissors are indispensable in preparing the food, repairing equipment--anywhere anything must be opened or tape must be cut." (45)

"Studying its results [results of the multipurpose electron beam power tool] one must not disregard the anxiety of persons who were working in open space, and the setting, which was entirely different from that of an Earth pressure chamber, as well as the very fact that such welding was being performed in orbit for the first time.

"...It is not a simple matter to burn through a thin sheet of metal in zero gravity. In these conditions, the cutting of plates requires good focusing of the electron beam, steady movement of the tool, and, in some cases, returning to sectors that have been cut poorly.

"It is encouraging that the cosmonauts handled the cutting of metal well. The soldering process proved to be more complex. But even here the cosmonauts managed to obtain several good specimens. The spraying of coatings did not present special difficulties for the cosmonauts and the specimens obtained in orbit at least externally can satisfy the requirements of the most rigid standards." (117)

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1.3 Inflight Maintenance

1.3.13 MAINTENANCE ACTIVITIES

The Salyut 6 station passed through several cycles of automatic and manned regimes. The telemetric data arriving at the Earth when the station was flying on automatic indicated that many of its systems were in good condition. However, at that time a number of the systems were shut down so that the electrical power would not be expended and the reserve would not be lost (for example, the life support system, most of the scientific instruments, and communication facilities). Because of this, some crews had to be trained to diagnose whether the station was reliable or not prior to leaving for their long-stay missions. They had to be capable of evaluating the technical state of the station. Training included practice work on stands at the training center and performance in a hydrolaboratory on a station mockup. (See 3.4.1.4 Training Equipment and Facilities, 3.1.1.1.1 Automatic Mode, 3.4.2 Onboard Training.)

The repair-restoration work aboard the Salyut is monitored by specialists at the FCC. They monitor the cosmonauts and suggest how repair should proceed. Simulations are also performed on ground before crew members attempt particularly difficult tasks. This is necessary because everything has not been provided for in advance. (204)

The Salyut 6 was used longer than the Soviets had anticipated. This led to some complications for the repair, maintenance and replacement of some systems:

HYDRO-PUMP

After three years of continuous use the hydro pumps gave out. The life of the pumps had been designed for no longer than two years based on the estimated use of the Salyut 6. Therefore, to replace the hydro pumps it was necessary to saw off one of the metal supports. The replacement pump contained a liquid coolant and the cosmonauts had to be sure that no coolant was spilled. This repair was one of many made in 1980 on a 13-day mission dedicated to maintenance and repair. (166)

SEWING

Salyut 7, 211-day flight:

The strap of the damper that holds the seat on the physical trainer was ripped off. The crew had to sew it back on. It was not easy to thread the needle because the thread had no weight. The thread became tangled, so the cosmonaut had to hold one end in his teeth and put the other end in the needle. It worked.
(213)

Some maintenance activities were for repairing equipment, and for adding new equipment:

ANTENNA

Salyut 6 175-Day Mission:

Cosmonauts Lyakhov and Ryumin assembled a 10-meter diameter antenna (KRT-10) which was delivered in a dismantled form. They installed a stellar orientation system, the radio telescope control panel, data recording system and exact time unit. (295)

At the end of the observation program, the KRT-10 was supposed to be cast off to allow other spacecraft to use the rear docking assembly. However, during this operation the structure experienced vibrations and the mesh became entangled outside the station. It was finally decided that the cosmonauts would have to manually release the antenna. (FCC was concerned about such a difficult task so late in the flight because they worried about crew fatigue. Simulations on ground proved that it could be done, though, so the repair mission proceeded.)

Ryumin worked outside the station, cut four cables with nippers, and then with a special lever removed the antenna of the KRT-10 radiotelescope and insured further operation of the orbital station.
(34)(76)(163)(205) (See 2.2.10 Reports on EVA Experience for more information.)

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1.3 Inflight Maintenance

Salyut 7 150-Day Mission:

The special crew that was to have been sent to install the solar arrays were forced to abort their mission due to a launch pad fire. Lyakhov and Aleksandrov had to repair the solar arrays even though they had no training for this situation.

The crew members used detailed instructions read from the ground. At the same time the crew worked outside the station, two ground-based cosmonauts worked on the hydrobasin simulator, duplicating the tasks to provide procedures support if the crew had trouble.

This crew also:

- Repaired the Delta computer. This system had begun to:
 - Send new data to storage locations which were not called for by the program
 - Would sometimes erase information
- The crew installed a new memory unit
- Installed a new console in the manual orientation system:
 - This was to help control the engines more smoothly and precisely (235)
 - Previously, orientation engines burned according to commands for a prescribed period of time. With the new instrument it was possible to fire these engines for very brief instances and with this series of bursts to set the complex in the desired position. Much less fuel was consumed and the precision is said to be ideal.
- Replaced the radio command link:
 - It was decided that the service life of the new link that had been installed by the previous crew could be saved by replacing it with the old link which had been left on the station and was still in working order
- Replaced a storage battery in the station's power system:
 - This system has several units containing 18-20 storage battery boxes. Instruments indicated that one of these boxes was out of order. The cosmonaut found and disconnected the dead box. (148)

- Replaced the filter of a gas analyzer
- Installed a new purifying unit in the system for regenerating water from atmospheric moisture (636)
(See 2.2.12 EVA Missions for the additional maintenance activities performed in EVA. (423) (467)(530)

Salyut 7 June-September 1985 Mission:

When Dzhaniybekov and Savinykh arrived at the Salyut 7 on June 8, 1985 they found that it was without electricity, water and that it had frozen instruments. The storage battery's voltage was at zero. The reserves brought from Earth were limited and the air atmosphere inside the Salyut appeared to be below zero. The station work module was completely dark. The portholes were covered with frost.

Before entering the Salyut, the cosmonauts sampled the air for impurities, then put on gas masks. This was a precaution in case:

- There was an ignition inside the station as a result of a short circuit
- The air might be filled with toxic substances

The cosmonauts created a makeshift ventilation system which enabled the first generator to operate. Working with a flashlight and in 40 minute segments, they first assembled a bypass to connect chemical batteries to the feed bus bars of the solar arrays. The faulty chemical batteries were identified and bypassed. When the voltage started to rise, the crew charged one battery after another directly. The cosmonauts determined that the power failure had occurred because one of the batteries was found to have a gauge that was stuck in the fully charged position. Because of this, the solar batteries were automatically disconnected, and the chemical batteries gradually discharged entirely.

Two days after their docking the station was habitable. (See 1.16.1 Soyuz.) (71)(654)

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1.3 Inflight Maintenance

1.3.14 REDUNDANCY

Duplications of all Salyut elements could lead to an increase in weight. The presence of a crew onboard makes it possible to increase reliability by a simpler method: restoring the capacity for functioning of the most important elements during the operating process. Therefore, both the crew and a large part of the equipment are placed in the station's pressurized module, to be accessible for maintenance, repair or replacement. (27)(354)

1.3.15 CONSTRUCTION

Soviet space scientists believe that technology already exists for space factories in space.

They point to the structural activities of Salyut 7, 237-day mission: (See 2.2.12 EVA Missions.) (53):

CONSTRUCTION IN SPACE

During this flight crew members tested new tools and materials for future space construction. Dzhanibekov, visiting crew member: "...It is difficult here to even briefly state the range of future research that is proposed in the construction of space objects...The construction of this is perfectly possible [complex space structure]..." (568)

There are some structures which, because of their large size, will exceed the dimensions of the holds of booster rockets. Because of this the assembly and possibly even the fabrication of individual elements will have to be done in space. (118)

There are experiments done to decide on the advisability of using certain types of material in space. It is known that there are several destructive factors affecting materials and structures in open space:

- Irradiation from ultraviolet radiation quants
- Proton electron flows
- The influence of meteorites
- Drops in temperature
- Interaction with the chemical substance in the station's ambient atmosphere

Work is being done on kinetics of the degeneration of materials in space to enable space technology designers to select materials capable of serving reliably in abnormal conditions. (466)

SOVIET SPACE STATION ANALOGS, Ed. II

1.3 Inflight Maintenance

1.3.15.1 REQUIREMENTS

Construction needs of the future:

- Apparatus to improve communications
 - Use of large onboard antennas
 - Use of relay apparatus
 - Use of satellite systems
- Large radio antennas:
 - For high quality relaying of signals to Earth
- Devices for detecting electromagnetic radiation
- Space antennas
- Solar cells of different types (panel, rolled, extra)

Construction in space is different from that of construction on Earth. There will need to be consideration for:

- Design peculiarities
- Construction technology
- Construction materials

1.3.15.2 METHODS

Methods for construction can vary:

- Completely constructed on Earth and put into orbit in an already finalized form
- Completely constructed on Earth and put into orbit in a packaged form and automatically deployed
- Assembled in orbit from ready-made components
- Constructing in orbit from raw materials delivered there (118)

1.3.15.3 AUTOMATION

On Salyut 6 nearly all operations needed constant supervision by the crew. Now many of the processes have been automated. (53)

The productivity of assembly work in the future will be increased by the use of remote controlled manipulators. Using television cameras will enlarge the work-object image and help the cosmonaut control the remote manipulator.

Remote controlled manipulators: Depending on their purpose manipulators may be of different complexity:

- Remote manipulator - This is a lever to which a tool is attached to one end
- Manipulator simulating a human hand with arm, elbow and wrist parts:
 - To the wrist part would be attached a tong or replaceable tool
 - A television camera could also be placed at the end of the remote manipulator to see the object from a close range

To lighten the structure of this proposed remote manipulator its supporting frame should be fabricated from hollow tubes (with the use of composition materials) connected by joints supplied with servodrives. Estimates show that such a remote manipulator with a characteristic mass of about 400 kg is capable of moving loads in orbit with a mass up to 30 tons with a speed 0.6 m/seconds.

All remote manipulators developed for construction work in space differ with respect to:

- The mobility of the lever
- The number of levers
- Location of the cosmonaut

If there is a lot of assembly work the control panel should be in a pressurized cabin. The cabin would have:

- Life support system
- System for movement of the cabin
- Control panels (118)

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1.3 Inflight Maintenance

The use of reliable automatically locking connections would simplify operations for assembling and repair in orbit. The only problem is that there would be a great reliance on automation in the construction process. (118)

1.3.15.4 MATERIALS

Construction materials should:

- Retain performance in a wide range of temperatures (in some cases varying from -150 to +150 ° Celsius)
- Have a low coefficient of linear expansion
- Have a relatively high thermal conductivity (to reduce temperature stresses and strains)
- Have oscillations that attenuate rapidly

Important aspects of construction:

- Welding
- Different kinds of separable connections (cylindrical joints, turnbuckles, flange joints, conical and ball fittings, etc.)

The performance of these connections in open space is dependent to a high degree on the choice of corresponding lubricants so as to prevent the vacuum diffusional welding occurring with the contact of metal surfaces in a deep vacuum.

Some of the experiments on construction material are directed to the creation and the future of large station and multipurpose production complexes. (See 3.1.3 Experiments.) (118)

SOVIET SPACE STATION ANALOGS, Ed. II

1.3 Inflight Maintenance

1.3.15.5 PROBLEMS

Problems for future large construction projects:

-Supplies for maintenance

-Welding:

--High temperature

--Voltage

--Protecting spacesuit

-Size of materials

-Weight of materials

-Performance of friction surfaces:

FRICTION

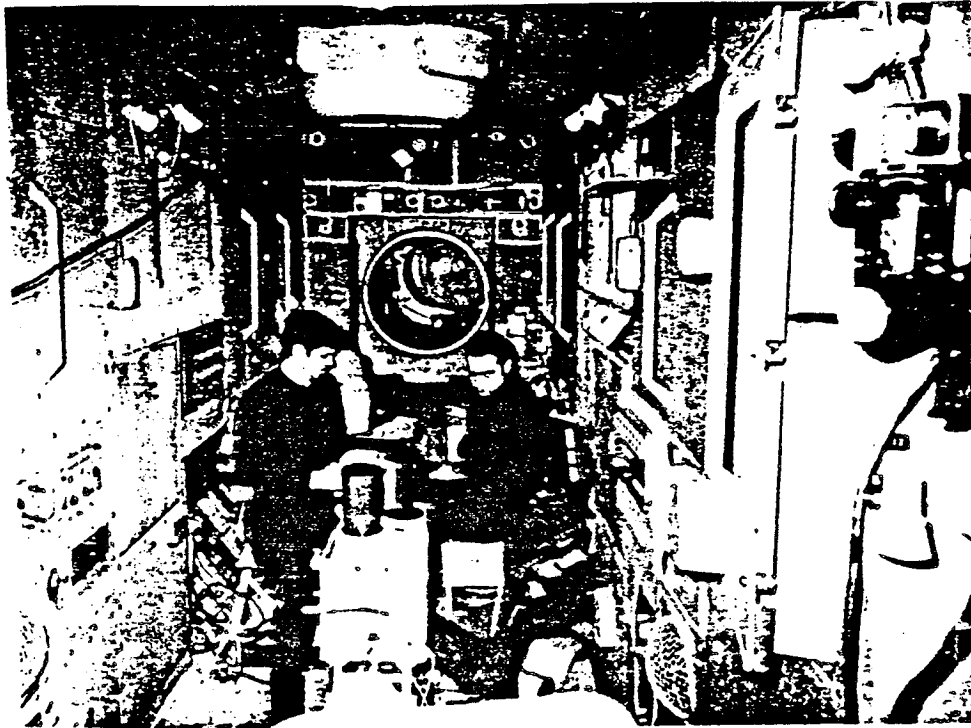
A special problem in space construction is the performance of friction surfaces under the conditions of a deep vacuum.

With prolonged presence in a space vacuum the surface of metals loses the absorbed gases and oxide films, which under terrestrial conditions play the role of a lubricant. As a result of the high degree of purity of the surfaces of space constructions an unforeseen diffusional welding of the frictional parts can arise. A number of methods have been proposed for eliminating this harmful influence of a space vacuum: these are based both on design decisions and on the use of hard coverings with a low friction coefficient (for example, molybdenum disilicide or fluid lubricants with a low vapor pressure). (118)

(118)(368)(374)

SOVIET SPACE STATION ANALOGS, Ed. II

1.4 CREW FACILITIES



Ed I

1.4.1 PRIVATE QUARTERS

Most of the literature indicated that the cosmonauts desired to have privacy, particularly as the mission lengthened.

On the Salyut, there are blinds supplied to close off areas of the living quarters. (127)(154)

Several Russian studies have shown that when individuals are observed by outsiders, they exhibit extreme negative reactions. (58)

SOVIET SPACE STATION ANALOGS, Ed. III
1.4 Crew Facilities

Points of view vary:

150-Day Mission, Lyakhov: [In answer to a question of whether there should be separate cabins made for each member of the crew]: "...going off [by oneself] during the flight when there are only two men aloft, and...leaving your comrade alone would be wrong. Each of you has to be visible and not hide away somewhere...In other words, we have to see each other all the time and that helps us work together. If we go off and hide somewhere...there is a lack of confidence that arises." (481)

Cosmonauts use the area around their "beds" to hang pictures of loved ones or other personal items. (213)

One solution to lack of personal privacy was solved by the keeping of diaries which were read together after the flight. "...it is important to have the opportunity to be alone with one's thoughts for a certain time and on a certain day. And different rooms and isolated compartments are not obligatory for this." (346)

Separate, private crew quarters have been provided in Mir. (See Mir).

1.4.2 WARDROOM

This room contains:

- Buffet table for eating:
 - The table in the wardroom is fitted with a range for heating the food and with devices for keeping the food in place. The table can also be used as a workbench for minor maintenance or repair jobs. (525)
- Set of table accessories
- Two food heaters (which will heat several tubes at once) (70)(206)(320)
- Facilities for sanitary cleaning of the table accessories
- Bags for collecting the food leftovers and packaging (320)

1.4.3 WASTE MANAGEMENT SYSTEM

Waste is collected in hermetically sealed containers. These metal containers are ejected from the station through a special airlock chamber. (177)(213)(385)(537)(548)

Packets of waste are usually launched once a week. (45)

The Progress cargo ships are also used by the cosmonauts to dispose of waste materials. (See 1.16.1 Progress Cargo Ships.) (62)(154)(265)

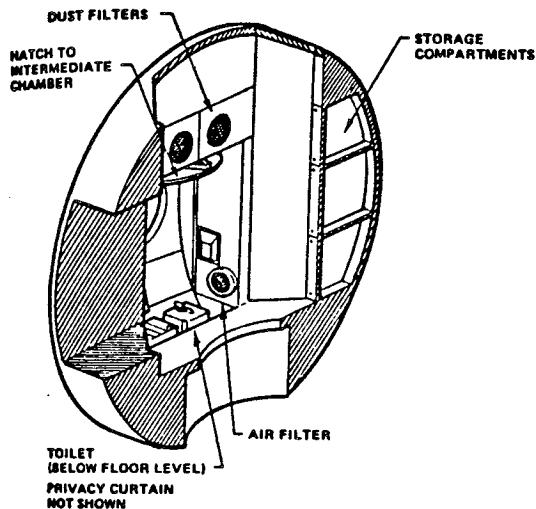
On the Salyut 7 the waste management system did not present any problems for Savitskaya, the female cosmonaut. (361)

TOILET

The compartment between the working compartment and the passageway to the docking unit is sectioned off by a rubber curtain with a zipper.

The toilet bowl is standard with one exception: the urine dispenser is separate and attached to a vacuum. A plastic insert with a bottom filter is put into the bowl.

When used, a rubber valve momentarily seals it, and the feces are packed away in hermetical rubber bags, which are put into a plastic container and ejected into space. (365)



SOVIET SPACE STATION ANALOGS, Ed. II

1.4 Crew Facilities

1.4.4 PERSONAL HYGIENE

"The communal hygiene of the spacecraft inhabitants must be given serious attention in view of the rather confined living quarters aboard a spacecraft. This is necessary not only to provide comfortable living conditions, but also to reduce the risk of transmission of pathogenic microorganisms amongst the inhabitants of the cabin." (See 1.11 Contamination.) (548)

Sensations of body contamination may have a negative psychological connotation. (79)(297)

Washroom and Toilet Unit:

- Isolated from the rest of the working module
- Has forced ventilation (525)

A. Teeth cleaning:

- Electric toothbrush (probably battery-driven)
- Non-foaming toothpaste
- Gums massaged with fingers wrapped in tissue or a cloth made of antibacterial material moistened with sanitizing lozenges
- Special chewing gum (used after meals)
- Masticatory elastic (for prophylactic effect)

(45)(206)(213)(338)(365)(366)(385)

B. Shaving:

- Normal electric razor with rotating heads:
 - It has a nozzle to suck in the shaved whiskers. (This vacuum system removes both hair and cornified epidermal cells and collects them in a chamber.)

(168)(206)(213)(365)(366)(548)

C. Skin Cleaning:

- Towels made of antibacterial cloth that have been saturated with a disinfectant solution are used. The cosmonauts wet them with water
- These towels are stored in polyethylene wraps
- The area of the skin where electrodes have been applied for monitoring vital functions is cleansed with towels that are fastened to a massage brush
- It is reported that utilizing germicidal lotion did not adversely affect skin
- Ground-based studies indicate that for long missions there has to be even better techniques for cleaning the skin, particularly areas covered with hair
- Products must be developed that have sufficient detergent properties to remove lipid accumulation on the skin. These products must have bacteriocidal properties to maintain relatively normal skin function and microvial flora

D. Hair Washing:

- Towels are fastened to a massage brush and used to "shampoo" hair

(45)(123)(213)(338)(365)(366)(385)(540)

E. Haircuts:

- The Cosmonauts put the vacuum cleaner in the foot restraint of the ergometer and turn it to collect hair as it is being cut

SOVIET SPACE STATION ANALOGS, Ed. II

1.4 Crew Facilities

1.4.4.1 MEDICAL KIT

These kits consist of medication used to counteract:

- Motion sickness
- Fatigue
- Nasal congestion
- Bacterial infection
- Pain
- Diarrhea
- Minor lacerations (548)

Also included in the kit are:

- Vitamins
- Heart drugs
- Medicines for respiratory irregularities
- Tranquilizers
- Sleeping pills
- Drugs to reduce internal stress (such as Trioxazin)
- Biphidumbacterin
- Lactobacterin (for prevention of changes in the lactofloras during antibiotic therapy) (340)(476)

There is a miniature dentist drill on the station. (366)

Once a week there is a medical day. Cosmonauts take turns at being doctor and patients. (366) [On the 237-Day Mission, there was a medical doctor onboard who took over all medical duties.]

Pills have to withstand vibrations during launch. This is accomplished by joining pills together in sets on transparent sheets.

Disposable syringes and other instruments are attached by Velcro to the side of the medical box. (168)

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SOVIET SPACE STATION ANALOGS, Ed. II
1.4 Crew Facilities

1.4.5 SHOWER



A. Shower Days:

Cosmonauts generally take a shower once every ten days. (Although one source [168] indicated that on the 185-Day Mission, crew members showered monthly.)

In between showers, cosmonauts wipe themselves with hygroscopic towels that have been wetted with hot water. (See 1.4.4 Personal Hygiene, C. Skin Cleaning.)

On shower days, the cosmonauts prepare the shower unit for use immediately after breakfast. It is a complicated undertaking so most of the day is spent taking showers. (365)(366)(548)(589)

SOVIET SPACE STATION ANALOGS, Ed. II

1.4 Crew Facilities

B. Shower Facilities:

On the ceiling of the station is a light disk placed horizontally. On it are white spherical vessels, each containing five liters of water.

Cosmonauts switch on the electrical heating system and then lower the polyethylene cylinder from the disk to the floor.

The shower booth is an elastic cylinder with two end caps that contain devices for mixing and spraying hot and cold water, supplying hot air, and removing the expended mixture of gas and liquid. The booth has a waterproof zipper seal.

Atomizers from above feed directed water into the stall.

Warm air is pumped through the stall. As a result, the water is carried into a collector.

Fastened at the bottom of the shower are rubber slippers to keep the cosmonaut from floating upward.

Above the cosmonaut's head are cellophane bags containing napkins and a towel.

The cosmonaut will put a pipe that leads outside the chamber into his mouth and put a clip (like a snorkel) on his nose before turning on the water. Then he opens a package that contains a soap-filled cloth and switches on the water.

Water comes out in a fine needle-like spray. The water air aerosol passes through holes in the floor and into the waste container.

Afterwards, the cosmonaut rubs himself and the cabin walls dry. When all the cosmonauts are finished, the shower is then raised up accordion fashion to the ceiling. Showers are about 15 minutes long.

(2)(6)(8)(76)(177)(206)(345)(365)(366)(385)(468)(548)

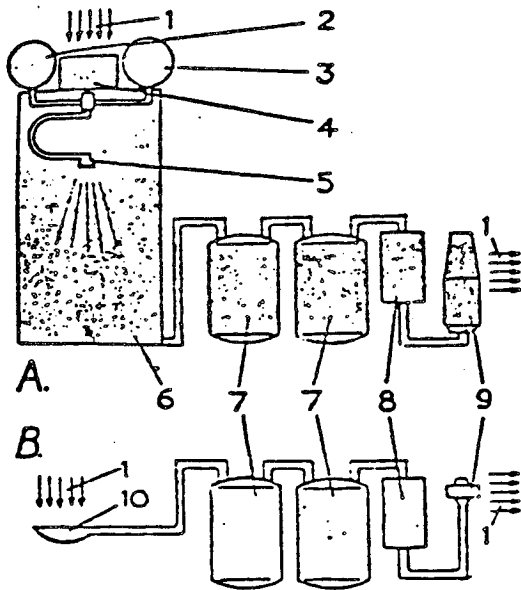
C. Suggested Improvements:

Lyakhov, Salyut 7, 150-Day Mission: "...It would be a good thing to have...a shower on Kosmos....a special shower which is always assembled and ready for use." (See 1.16.3 Kosmos.) (535)

D. Problems:

WATER PROBLEM

On the first long flight on the Salyut 6 crew members noted that the water clung to the walls of the shower cubicle. They had to use towels to mop it up. Water also accumulated on the skin and formed a layer that was hard to remove. Popov and Ryumin (185-Day Mission) were the first to try a specially designed toweling fabric for after shower drying. It fully absorbed the beads of water on their bodies and the shower cubicle walls. (114)(168)



Key:

- A. Shower unit
- B. Waste management system
- 1. Air flow
- 2. Storage tank with hot water
- 3. Storage tank with cold water
- 4. Air heater
- 5. Moisture sprayer
- 6. Shower stall
- 7. Replaceable (disposal) tanks
- 8. Air filter
- 9. Pump
- 10. Collector

Ed. I

1.4.5.1 IMPORTANCE OF SHOWERING

Showers are important:

- Help maintain psychological comfort
- Ease tension (79)(114)

In evaluating living conditions in an experimental chamber, out of 19 irritating factors of life in a small restricted space the cosmonauts rated the absence of water for washing as one of the four most irritating factors. (79)

SOVIET SPACE STATION ANALOGS, Ed. II
1.4 Crew Facilities

1.4.6 EXERCISE EQUIPMENT

A. Exercise Needs:

The equipment for exercising needs to take into consideration:

- Body types
- Stimulating the desire for exercise
- Inflight and postflight conditioning (See 5.1 General State of the Cosmonauts.)

Extensive exercises in flight preserve the crews' health and physical tone and also lead to a quicker readaptation after the flight.

(20)(264)(281)

B. Salyut Equipment Includes:

-Bicycle Ergometer:

- Has 5 degrees of load, from 750 to 1200 kgm/min. at 60 revolutions of the pedal. This imparts a load on the leg muscles and the cardiovascular system. (With an increase in the frequency of revolutions, the load can be increased to 2000 kgm/min.)
- Conditions arms and legs (The Salyut 7 150-day crew was the first to turn the pedals with their hands as well as feet, to build up wrist and forearm muscles.)
- Can be tailored to the individual cosmonaut
- Is located on the ceiling, upside down

-Treadmill/Running Track:

- Conditions respiratory system and the lower limbs
- Turned by a motor at speeds as high as 12 kilometers per hour
- When the motor is turned off, the track can be turned by the cosmonauts' own steps
- Performed under load conditions by utilizing tension straps (bungee cords) of about 50 kg along the longitudinal axis of the body

SOVIET SPACE STATION ANALOGS, Ed. II
1.4 Crew Facilities

- Cosmonauts are monitored telemetrically:
 - To make sure the load is being utilized
 - Check distance covered
 - Check vital signs
- Cosmonauts spend about 1 hour a day on this
- Rate of intensity individually determined by trainer

-Pressure Suits/Vacuum Trousers:

- These subject the muscles to stress that corresponds to the load on Earth:
 - Gravity is simulated by fluctuation of barometric pressure
- There are several of these

-Muscle-exercise Equipment:

- To maintain muscular strength of the arms and shoulder girdle
- There are several of these:
 - One example: a rubber absorber with strap loops and a spring stretcher
- Cosmonauts spend about 15 minutes a day on this type of equipment
- These exercises are also used prior to EVA for conditioning purposes

(20)(38)(47)(70)(114)(136)(176)(206)(264)(302)(345)(365)(366)(385)
(541)(548)(603)(608)

After exercising, cosmonauts use moistened towels made of antibacterial cloth to wash up. (See 1.4.4 Personal Hygiene, C. Skin.) (385)

The cosmonauts on the Salyut 6 were prohibited from using the running track at certain speeds while other vehicles were docked to the Salyut, because potentially dangerous vibrations could have occurred.(600)

SOVIET SPACE STATION ANALOGS, Ed. II
1.4 Crew Facilities

C. Yoga:

During the flight of the visiting Indian cosmonaut an experiment was done called "yoga." Static yoga postures (asanas) were used which involved the large group of muscles of the thigh, the back and the lower leg. These are the muscles which have the least of all to do in weightlessness. The straining in the yoga postures were objectively recorded by measuring their electric potentials. Results showed that static postures helped to overcome the physical underloading of certain human muscles. It was noted that yoga might prove beneficial for overcoming the problems that occur because of weightlessness. One major benefit is that yoga does not require much space. (546)

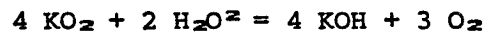
Indian Cosmonaut Sharma on use of the yoga (See 3.1.3 Experiments, Yoga experiment.): "...preliminarily I may add that these exercises helped me withstand weightlessness well." (454)

1.4.7 ENVIRONMENTAL CONTROL LIFE SUPPORT SYSTEM (ECLSS)

1.4.7.1 ATMOSPHERIC REGENERATION

Atmospheric regeneration guarantees the stable composition of the gas medium.

The atmosphere regenerators are nonreusable chemical cartridges in which carbon dioxide is absorbed and oxygen generated in accordance with the following reaction:



The system also contains pressure sensors that alert the crew if pressure drops unexpectedly. (206)(345)(543)

Some drops in pressure occur when the crew opens an airlock for EVA or when they dispose of garbage. The air is replenished by cargo ships. (See 1.4.7.2 Air Circulation.)

Air is regenerated through a fan (another fan is kept in reserve) and the regeneration units, where it is enriched with oxygen and where carbon dioxide is absorbed.

The atmospheric regenerators are used to maintain the proper air composition:

-Atmospheric pressure:	700-960 mmHg
-Partial oxygen pressure:	160-240 mmHg
-Partial carbon dioxide pressure:	no more than 7-9 mmHg

Oxygen is generated by utilizing oxides and superoxide of alkali metals. The generated air in the working and living compartments is usually of two gaseous mixtures, nitrogen and oxygen. The carbon dioxide content is routinely monitored and regulated by means of a gas analyzer. (548)

SOVIET SPACE STATION ANALOGS, Ed. II

1.4 Crew Facilities

Advantages to the chemical generation of oxygen:

- Reduced weight requirement
- Less complicated and less prone to malfunction
- Less flammable

Disadvantages:

- Lacks flexibility in altering the gaseous environment for environmental purposes and in emergencies (548)

A. Air Use:

- Every cosmonaut uses about 25 liters of oxygen and releases 20 liters of carbon dioxide per day
- Equipment and the cosmonauts also release 400 chemicals and metabolites into the ambient air (which are captured by filters)
- Consumption of air per person per day: 1 kg of oxygen
- As soon as an airlock is opened, some air escapes
- Air is lost during EVA

Air is not recycled aboard the station; it must be periodically renewed.

Loss of air is unavoidable and that is why there is a need to resupply the station with air brought in by the Progress. (See 1.16.1 Progress.)

About 130 kg of air is needed to renew the entire atmosphere inside the Salyut station. (542)(543)

1.4.7.2 AIR CIRCULATION

Blowers are used to move the air from the central post in the working compartment to the opposite part of the station, where it is filtered through intake gratings. The flow then returns to the central post through the instrument area along the left and right sides.

When it passes through the regenerator cartridges, the air is enriched in oxygen and enters the crew quarters through air ducts, which are made broad so there will be no drafts. The rate of air movements are:

0.1-0.8 m/s.

(206)(345)(542)(543)(548)

SALYUT 7 ANALYSIS

Investigation of air movement aboard Salyut 7 with concurrent analyses of the gas atmosphere for oxygen and carbon dioxide levels revealed that there is non-uniform distribution of air currents in different zones (from 0.00 to 0.32 m/s).

Minimal movement of air was found in sleeping places, which cosmonauts felt were poorly ventilated.

Oxygen and carbon dioxide content in the tested zones during the period of sleep was in the range fluctuating from 168-172 and from 3.0-3.5 mmHg.

Analysis of the significance of different factors revealed a correlation between:

- Changes in temperature and performance of several technological experiments
- Uneven distribution of air flow
- Presence of zones with low circulation of air (392)

150-DAY MISSION PROBLEMS

There was an acrid odor that nearly exceeded the crew's tolerance level before it was corrected. The odor was irritating to the eyes and was believed caused by a problem in the environmental control system. (59)

SOVIET SPACE STATION ANALOGS, Ed. II

1.4 Crew Facilities

1.4.7.3 FLUID AND GAS SYSTEMS

The gas composition support system, which is monitored, is intended to liberate oxygen and absorb carbon dioxide and other impurities. The system includes:

- Chemical oxygen regenerators
- Chemical carbon dioxide absorbers
- Gas analyzers
- Harmful impurity filters
- Dust filters
- Gas stored in cylinders

Additional regenerators, absorbers, harmful impurity filters and gas are delivered by transport and cargo ships to replenish the supplies and allow continued operations of the system.

The system can maintain the parameters of the atmosphere within assigned limits:

- Carbon dioxide: 0.9 mmHg
- Oxygen: 160-280 mmHg
- Total gas pressure: 760-960 mmHg
- Partial pressure of O₂: 160-240 mm mercury column
- Partial pressure of CO₂: 1.23-9.00 mm mercury column
- Partial pressure of vapors of water: 7.0-16.4 mm mercury column
- Air temperature: 19.0-24.5° C (206)(345)(385)(537)

A. Operation Parameters:

MEAN VALUES OF MICROCLIMATE PARAMETERS DURING PERFORMANCE
OF SOME OPERATIONS ABOARD THE SALYUT 7 OS

Operation	Air Temperature		Air Humidity	Gas Composition of Atmosphere, mm Hg	
	°C	°C		O ₂	CO ₂
	Mean	Range	%		
Technological experiments	23.9	23.0-25.6	40-60	160-188.1	1.76-5.60
Television Broadcasts	23.3	22.0-24.7	40-70	159-198	1.2 -5.90
Visit by Rendezvous Crew	23.7	23.0-25.5	50-60	156-183	3.7-5.7
Mean Parameters During Period of First Prime Mission	21.8	17.0-25.6	40-80	152-200	0.5-6.0

B. Future Systems:

It is difficult to maintain the necessary oxygen/carbon dioxide balance in the space station. This is because:

- Air has to be regenerated
- Have to get rid of excess carbon dioxide

The Soviets have said that a definitive solution would be to create a biologically closed cycle onboard. (548)

SOVIET SPACE STATION ANALOGS, Ed. II
1.4 Crew Facilities

Soviet studies have pointed toward the use of altered gas atmospheres (gaseous mixtures differing from those found on Earth) to prevent or diminish the effect of deconditioning brought about by hypokinesia and Og.

In Og there is a decrease in oxygen intake and an increase in carbon dioxide output. Other physiological parameters also decrease:

- Basal metabolism
- Blood pressure
- Heart stroke
- Minute volume of the heart
- Nitrogen balance
- Muscle mass
- Plasma
- Erythrocyte volume (548)

1.4.7.4 WATER RECLAMATION

A. Rodnik Water Line:

The "Rodnik" water line supplies cold water. It has a reservoir consisting of two tanks holding about 400 liters of water. These tanks are located in the service module and supply water to the kitchen through a faucet. On the Salyut 6, the tanks were in the living compartment. By placing the Rodnik system in the assembly compartment, the small living space has been freed from excess equipment. The reservoir is refilled from tanks carried on the Progress. (6)(8)(75)(345)(548)(594)

B. Atmospheric Regeneration System:

Hot water is produced by the atmospheric moisture regeneration system, which removes water vapor from the air and readies it for consumption. This water vapor is produced by breathing and perspiration.

Every 24 hours a person releases 1.5-2.0 kg of moisture, which is regenerated. (543)

The reconstitution water system produces about 0.85 liters of water per person each day. The quantity of water obtained from the condenser depends upon the intensity of physical exercise and perspiration rate. (341)

The System:

- Water formed in the atmosphere as a result of breathing and perspiring condenses on the cold surfaces of cooling and drying units and is then collected in storage tanks. A cooling/drying cycle is used to separate water from the station's atmosphere as the gas passes through the first stage.
- The moisture collected is then passed via pumps into storage columns containing ion exchange resins (anionites and cationites) and activated charcoal for purification.
- The water is then passed through filters containing fragmented dolomite, artificial silicates and salt.
- Minerals are added:
 - Calcium
 - Magnesium
 - Bicarbonate
 - Chloride
 - Sulfate

SOVIET SPACE STATION ANALOGS, Ed. II

1.4 Crew Facilities

The water regeneration system includes in it a block of five cylindrical columns for purifying atmospheric moisture:

THE WATER REGENERATION SYSTEM

CYLINDRICAL COLUMN	PURPOSE
(1)	-Is intended for purifying the organic and inorganic foreign bodies
(2)	-For conditioning the water designed for decontamination and artificial mineralization of the regenerated water
(3)	-The drinking water container
(4)	-The container for industrial water
(5)	-The block for delivering and heating the water

Each of these columns has a volume of 1.5 liters each.

The first two columns are filled with a mixed effect filter and the third, fourth and fifth columns are filled with activated carbon.

In the first column there is a chamber for disinfection. This contains a layer of granulated sterilizing agent. (385).

The moisture condensate, wash water, and urine are all recycled to a potable state.

Crew members prefer not to drink the recycled urine water for "psychological reasons" (though they have done so on occasion).

The recycled urine water is separated and kept in a specially colored container as a backup system. (33)

Benefits:

-Regeneration systems make it possible to recover almost all the oxygen and water. It also makes it possible to decrease the weight of the water supply system and to remove the excess moisture from the equipment.

-The use of this system makes it possible to reduce the weight of the stored substances from 10.7 to 2 tons. (2)(206)(345)

Fifty percent of the water on the Salyut 6 was recycled. (273)

1.4.7.5 POWER

The station itself can generate 4 kW of power; Kosmos 1443 (See 1.16.3 Kosmos.) contributed 3 kW from its own solar panels while it was attached to the Salyut. (537)

Recent additions of six small gallium arsenide solar panels were added to the Salyut 7 solar arrays, providing an additional increase of approximately 4 kw, giving Salyut 7 \$11 kw.

A. Power Sources:

Transistorized photoelectric cells of silicon or gallium arsenide are used to transform solar radiation directly into electrical energy to provide the power supply for space equipment, along with electrochemical sources of current and radio-isotope and other electrical generators. In about 8 minutes, free energy from the reactor (sun) reaches the solar battery panels. (379)

SOVIET SPACE STATION ANALOGS, Ed. II
1.4 Crew Facilities

Solar Panels: The Soviets are still analyzing the processes of the aging of solar cells. Ryumin, Director of the 237-day flight: "There are many factors which we cannot reproduce on Earth for various reasons...We want to obtain a live piece of solar battery [cell] so that a qualitative analyses can be carried out in terrestrial conditions." (470)

Solar Cells: Solar panel elements gradually lose their productivity when they are operated in space because of:

- Radiation
- Micrometeorites
- Dust
- Internal atmosphere of the complex

These solar cells need to be replaced and/or increased. (See 1.3.13 Maintenance Activities, 150-day mission.) (139)

B. Power Efficiency:

Two ways to increase the efficiency of the solar power:

- Increase the efficiency of the photo cells used on them
- Increase the total area of cells operating in space

(74)(379)(416)

C. Problems:

Problems in power usage that have occurred:

- Cosmonauts have had to stagger the use of some instruments:
 - For example, heavy power users such as the KRT-10 radio telescope and the BST-1M optical telescope
- Flashes of sunlight can interfere with the orientation of the station's solar array
- Products of combustion from the engine settle on the surfaces of the solar array and reduce their efficiency (31)(175)(380)

SOVIET SPACE STATION ANALOGS, Ed. II
1.4 Crew Facilities

D. Solutions to Problems:

- Design the station for the future, with planned installation of solar panels
- For sunlight flashes, install screens on the panel for protection (as done during Salyut 7, 150-Day Mission) (175)(380)(416)(589)

E. Installing Solar Panels:

Installation of Solar Cells on the Salyut 7:

First stage:

- The solar panels are prepared for transport and installation on one of the arrays
- The orbital complex is oriented so that the work place of the cosmonaut-assembler is illuminated and the arrays on which the additional panel to be placed is in a fixed position
- The crew then carries the panel along specially installed railings on the outer side of the station's body to the place of installation.

Second stage:

- Installation of the additional solar panel in the intended place:
 - The panel is freed from the transport container and mechanical and electric connection with the main panel of the solar array
 - Using two fixing pins, the cosmonauts mount the cell on the face of the solar array and manually connect the sockets of the power supply system. They then fasten the end of the main panel cable to the holding pin of the supplemental one.
 - The crank of the winch is turned and the supplemental panels expand along the web of the main solar panel. The fixing pins of the supplemental panels go into the latch opening at the top end of the array. Installation is complete.

Third stage:

- The additional solar panel is connected to the system for the integrated electrical supply within the station. (See 2.2.10 EVA Experience and Missions, 150-Day Mission.) (74)(379)

1.5 RESTRAINTS

Around the bottom of the main array there is a rubber cord under which a cosmonaut can place his legs so as not to float around. Everywhere along the walls there are many rubber tapes, pouches and shelves for convenient storage. (188)

Supports ought to be:

- Specially provided for during the design stage
- Convenient

There should be:

- Fixed supports
- Protrusions and handles for hand manipulation
- Toe holds for when hands are occupied
- Various other holds and fixators (114)

SOVIET SPACE STATION ANALOGS, Ed. II

1.7 LIGHTING

1.7.1 ILLUMINATION

1.7.1.1 INTERIOR

The Salyut 7 is brighter than the Salyut 6 inside, although the total number of illumination lamps has not been increased. Instead, the lamps are placed differently. The spectral composition of the light has been changed in order to insure better light transmission when surveying with color photographic and moving picture film. (6)(8)(124)(502)

The Salyut 7 has more sockets for portable working tables and lights. (188)(502)

There has been concern that space flight could cause injury to eyesight because:

- There is no atmospheric absorption in space
- There is a higher brightness level
- Abrupt contrast effects (sudden glaring)

There should be individual light controls on all principle instruments so that adequate visual acuity can be maintained in case of sudden light flashes or extreme vibration. (58)

There are daylight lamps at every working location. Other lamps are used to create general illumination in the living space.

During still and motion picture photography and television reports, the cosmonauts turn on additional lights to provide the necessary illumination for the cameras. (537)

1.7.1.1.1 GENERAL REQUIREMENTS

The most general requirements for functional illumination during long term space flights:

- The lighting on the spaceship must be combined (direct and dispersed; general and local; floodlighting and lighting with the aid of pinpoint light sources)
- Coefficients of reflection for walls, ceilings, floors and equipment must be used
- The lighting must facilitate the performance of various functional processes (work, sleep, eating, etc.)
- Lighting must provide optimal conditions for visual perception with consideration for changing conditions of the external illumination under various flight regimes
- The lighting must be adjustable

A. Basic Factors:

To be considered:

- Quality and color of light
- Intensity
- Distribution
- Pleasant appearance (should give a feeling of comfort)

SUGGESTED ILLUMINATION

Functional Process	Level of Illumination, lux
Work at the control panel	400-500
Rest	200
Food intake	150
During physical exercise	200
During recreation	400
In passages, air locks	100
Sanitation and hygiene (shaving, doing laundry, washing)	400-500

B. Work Area:

A sufficient level of illumination in the work area during waking periods is important.

Reflective surfaces need less intense light sources. The following reflection values are recommended in the work area in various zones:

-Console details:	20-40%
-Instruments:	80-100%
-Floors:	15-30%
-Walls:	40-60%
-Ceilings:	60-95%

Studies indicate diffused or reflected lighting reduces eye fatigue.

The visual perception of any object depends on its brightness.

Glare from lighted surfaces at eye level is particularly undesirable.

Excessive illumination does not compensate for small object size or low contrast.

Light is perceived most naturally when it is directed from the top.
(114)

The quality of light should be of natural colors (particularly natural skin color). (297)

Distinction of an object on a background of other objects is determined by the degree of the contrast. (114)

SOVIET SPACE STATION ANALOGS, Ed. II
1.7 Lighting

The illumination of the work area should not blind the eyes nor create sharp shadows. (114)

READING

During reading, eyes become less tired with yellow and green light than they do with red light. Since the photoreceptor cells of the human retina react more strongly to yellow and green light, light sources which radiate a maximal light energy within this segment of the visible spectrum are used most often: 500-630 nm. (114)

Cosmonauts have found that the longer the mission, the more light they want to have.

Under isolation, a sufficient level of illumination is important as a prophylaxis against the disruption of psychology functions and for increasing work capacity.

OPTIMAL ILLUMINATION

On the basis of numerous studies it was established that the optimal intensity of illumination for most types of human activity must correspond to 1/100th the illumination on a bright, sunny afternoon under an open sky: approximately 400-1000 luxes. (114)

ILLUMINATION TABLE

Work Conditions	Type of Illumination	Level of Illumination
Fine details, light contrast, long time periods, high speed, high precision.	Additional illumination. Special devices such as table lamps.	1,000 lux
Fine details, medium objects are at close range, speed is insignificant.	Additional illumination.	500-1,000
Routine work (writing, making diary entries, etc.)	Localized illumination. Ceiling illuminators located directly overhead.	200-500
Short-term assignments with non-work intervals.	Random general illumination.	100-200
Observation conditions are not constricted, good contrast, the object is sufficiently large.	General illumination.	50-100
Normal observation conditions for man's movements and for working with large objects.	General or additional illumination.	20-50

Flight control in a nominal regime may be implemented at an illumination level with white light in the amount of 0.1 millilamberts.

Intensity of lighting must be constantly modified depending on cosmonauts' needs. (540)

SOVIET SPACE STATION ANALOGS, Ed. II
1.7 Lighting

C. Ground-Based Studies:

Various lighting regimes have been studied in several experiments. One example:

ILLUMINATION EXPERIMENT

The first series of experiments imitated the initial stage of orbital flight (the first four orbits). One operator worked under conditions of acoustical monotony with maximal load on hearing, while the second operator worked under conditions of intense visual work.

During the first hours, they were satisfied with a minimal level of illumination. As their fatigue increased, both increased their lighting. The operator with the monotonous auditory load required more light.

Operators worked for three days without sleep and with breaks only for dinner. The result was the same: as fatigue grew, the operators increased their illumination.

Results: Lighting on a station must be adjustable. (114)

1.7.1.1.2 PROBLEMS AND SOLUTIONS

Problem	Solution
Excessive external illumination	<ul style="list-style-type: none"> -Illuminate main instruments with individually adjustable light sources -Filters or shades on windows -Painting all inside ship surfaces with diffused shades of light gray
Ineffective lighting	<ul style="list-style-type: none"> -Selected paintings of ceilings, walls and floors
Vibration, which causes a decrease in visual acuity	<ul style="list-style-type: none"> -Increase illumination level of the display system screens
Power shortages	<ul style="list-style-type: none"> -Use of luminescent lamps
Shadows	<ul style="list-style-type: none"> -Exact placing of lights
Overabundance of instruments	<ul style="list-style-type: none"> -Careful distribution of lamps
(58)(114)(540)	

At "night" cosmonauts cover the portholes with blinds so that it is darker in the station.

Aleksandrov, 150-Day Mission: "...sometimes there are no nights here. The sun shines all the time through the ports...it is very difficult to get used to the situation in which in a short period of several orbits it is possible to see the change in the time of the year and the day and night periods..." (109)

SOVIET SPACE STATION ANALOGS, Ed. II
1.7 Lighting

1.7.1.2 NATURAL LIGHT

If it is necessary to perform observations outside the cabin, filters of various thicknesses may be used for protection against outside lighting.

Natural light is less tiring on the eyes than artificial light (especially colored artificial light).

The spectral characteristics of artificial light should not differ too greatly from natural light. (114)

SOVIET SPACE STATION ANALOGS, Ed. II

1.9 DECOR

Monotonous surroundings lead to boredom, fatigue and reduction in psychophysiological tone. This may lead to:

- The loss of job interest
- Reduction in overall interests
- Physical anestheization
- Appearance of certain psychic disorders and altered behavior

These changes reduce operational reliability. (114)

1.9.1 COLOR AND MUSIC

The Soviet Union has experimented with combining musical works and color images. They recommend that:

- Music be selected first
- The appropriate slides or films that complement the music be added. (Something similar to videos with music using relaxing images.)

Ground-based studies indicate that these color-music films improve operator activity. Work production is increased 1.5 times and the number of errors is reduced by 1/4. (114)(297)

A. Ground-Based Studies:

An example of a color-music film is the Psychological Relief Room:

PSYCHOLOGICAL RELIEF ROOMS

These are used in industry and could be used on spaceships.

The psychological relief room (PRR) sessions are conducted on neuropsychical relief. The effect is the creation of the illusion of being in nature. This is achieved by using large slides depicting scenes from nature, with birds singing and music. It has been shown to be effective for relieving visual fatigue and nervous emotional loads.

To provide this, there is light-projecting, sound-producing and odor-generating apparatus. The first session begins three hours after the start of the shift. At this time, the workers exhibit the first signs of fatigue and their work capacity decreases. The workers come into the room and are seated comfortably in front of large screens. Workers cannot see one another.

Slides are shown with illustrations of, for example, a flowering meadow, a birch grove, or a pond. The lights are turned on under the slides and room lights are dimmed. The illusion of being in nature is created. The entire session lasts ten minutes.

For the first two minutes there is a sound of slow music and the singing of birds can be heard. The task of this period is to distract the workers from the shop surrounding.

The second period is a soothing one. Pleasant music is turned on and a soft, soothing light is turned on the color wall panel. After 3-1/2 to 4 minutes, the music becomes bolder and a stimulating, arousing light is turned on the wall panel.

At the end of the session the room lights are turned on and invigorating music sounds. Data shows that after these sessions the workers are in an improved state of mind; their work capacity, attention and reaction speed are improved; the overall state of the central nervous system is improved. In the opinion of specialists, this method of psychological relief can increase work productivity up to 17%, while at the same time reducing traumatism.

Color and music can increase the motion stability of cosmonauts.
(114)

1.9.1.1 COLOR

Color affects:

- Degree of motion sickness (See 3.6 Motion Sickness for results). (179)
- Work capacity (297)
- Psychological state (177)(606)

Salyut 6: The interior was in soft pastels. This was meant to give the station interior a homey atmosphere. The interior coloring was recommended by a team of psychologists. (177)

Salyut 7: There is a new color scheme to provide a brighter and more pleasant working environment:

- The ceiling is white
- In the working compartment, the left wall is apple green and the right one beige (188)(527)
- Bright accent colors in orange, blue and white are used

1.9.1.1.1 GENERAL REQUIREMENTS

- Light and color time-indicators:
 - Can be used to reinforce habitual biorhythms (See 3.1.2.11 Biorhythms.) (114)
- Color to alleviate sensory deprivation:
 - Color can have psychophysiologic and aesthetic functions without negative psychopharmacologic qualities
- Colored light and music programs:
 - To maintain an awareness of months and the change of seasons (See 1.9.1.1.2 Light and Color Programs.) (297)

A. Color Preferences:

Experiments indicate the following color preferences:

- Blue
- Red
- Green
- Violet
- Orange
- Yellow (yellow and yellow-green sometimes lead to negative emotions) (114)(297)

SOVIET SPACE STATION ANALOGS, Ed. II

1.9 Decor

Warm tones (red, orange, yellow) stimulate the nervous system. Cool tones (blue, green, violet) soothe it. This should be taken into consideration in selecting the color scheme for the spaceship interior. (114)

Violet is undesirable when a crew shows signs of depression. (297) [Another source (114) indicated that violet can be cool, calm and restful.]

Saturated colors are preferred in small areas; shades and tints in large areas.

Color having a high reflection is recommended for the ceiling (to reduce the contrast between the light source and its background). (297)

B. Color and Mood:

Studies indicate that the following conditions can improve the mood of cosmonauts:

- Uniform color can become monotonous so active color accents should be used
- The attractiveness of a color depends on the size of the color zone:
 - Small area: Bold colors are preferable (red, orange-red, green-blue)
 - Large areas: Shadings and tones are preferable
- Colorful items such as wall hangings, weavings, etchings and drawings can add color
- Colors which are cool, calm and restful: blue, green and violet (as well as their shadings)
- Color formulations should be in contrasting tones. Examples:
 - The interior living quarters should be in warm, sunny tones: light yellow, straw, orange, pale yellow, green
 - In rest and recreation areas: warm, relaxing colors with a color contrasting trim
 - For sleeping quarters: muted, cool color tones. (This will create a feeling of coziness and the impression of increased space.)

- In work areas: calm, unsaturated tones
- In a living area: a considerable percent must be comprised of bold, eye-catching colors

-Changeable color panels (114)

1.9.1.1.2 LIGHT AND COLOR PROGRAMS

Light and color programs help the crew maintain the customary changes of months and changes in seasons of the year. Such programs are on daily and seasonal rhythms of illumination and coloration. An example of a recommended color scheme is as follows:

Winter: neutral coloration with a predominating contrast of light and dark and an absence of any brightly expressed colors.

Spring: clear, bright colors are used.

Summer: color masses with three characteristic colors predominating.

Fall: the color schemes for this time of the year would have to vary, depending on where the cosmonauts came from. (114)

SOVIET SPACE STATION ANALOGS, Ed. II

1.9 Decor

1.9.1.2 MUSIC

Music:

- Modulates noise levels about the station (See 1.13 Vibro-acoustics.)
- Affects physical health
- Affects psychological health
- Stimulates work capacity (114)(174)(219)(548)

The cosmonauts are supplied with a cassette recorder and many cassettes (they had 64 cassettes on the Salyut 6). Other music is transmitted to the station by radio and television channels. (325)

The music used does not require intense attention.

Special significance has been attributed to the novelty of music programs without repeating specific works. In addition, audio background to conversation (the sound of rain, birds singing, city noises) is sometimes included. (See 3.1.2.4 Leisure.)

A. Ground-Based Studies:

Ground-based experiments involving prolonged isolation and sensory deprivation show that a decline in body activity leads to a search for stimuli. Because of this, background music has been used continuously to counter this response and thus becomes an inseparable component of activities. (256)

1.9.1.2.1 GENERAL REQUIREMENTS

The basic principles of selecting musical programs for use in long-term space flights:

- Programs are structured for maintaining the biological rhythms of the cosmonauts
- Structuring musical programs according to the principle of imitation by means of musical images of diurnal and seasonal cycles of nature
- Compiling musical programs according to the principle of maximal diversity to prevent sensory deprivation on long-term space flight

For compiling music programs, psychological analysis should be conducted of the cycles of activity.

The possibility of influencing the cosmonauts' state of health with the aid of music is based on the practice of music therapy. There is a significant difference in the conditions for using music therapy on Earth and in space. The basic difference is the emotional background of space missions. Under these conditions the traditional means of musical therapeutic works may turn out to be ineffective in principle since they do not correspond to the uniqueness of the psychological state of the cosmonaut.

When persons who find themselves under conditions of solitude are not able to listen to music, they try to find some kind of substitute for it.

The concentration of attention is worse without music. (114)

1.9.1.2.2 EFFECTS

Music helps preserve high work capacity. (174)(219)

Music can be used as a means of psychological support. (See 4.1.3.1 Psychological Support, Salyut 6 inflight study.) (97)

Experimental data shows that music is a strong emotional and rhythmic stimulus and has a great affect on the central nervous system, heart activity and the muscle system of man. Most significant is the tempo, timbre, orchestration and volume of the musical productions.

Experimental analysis has demonstrated that work capacity is highest when cheerful music is used.

A stimulating effect can be achieved by the unexpected mix of musical numbers. Programs should alternate between quiet and loud, fast and slow, major and minor keys. (114)

SOVIET SPACE STATION ANALOGS, Ed. II

1.9 Decor

There are examples of the negative influence of music. It depends on the proper selection of musical programs. The rhythm of the musical number is the basic stimulator of work capacity. Music may act not only as a stimulant, but also as a hindrance, being in some cases a form of background noise which distracts attention away from work. (114)(548)

Available data show that the perception of music in the process of operator work works in two ways:

- As the activity becomes more complex, the music becomes bothersome or the operator is so absorbed in work that s/he simply ceases to pay attention to music. (114)

Russian experiments on the use of music in confinement conclude that unfamiliar and unusual music have a positive effect on all confined people as far as productivity and activity. (58)

1.9.1.2.3 SELECTION

Music selection requirements:

- Type of work being done:
 - Simple jobs (for example, taking movies and photographs of space): energetic music
 - Complex work (for example, work at the control panel): a calm, neutral music background
- The psychophysiological condition of the cosmonaut:
 - If there are signs of fatigue and irritability, musical works should be of a calm nature
- Individual perceptions of the music
- Personal choice
- Duration:
 - One song should be 3 to 5 minutes
- Overall duration of the music program:
 - Must comprise no more than 25% of the cosmonauts' work time (114)

During rest periods, individual tastes and personal preferences are important. If cosmonauts are homogeneous in national and age composition and in the level of music training, a single program may be used for everyone. If the cosmonauts differ, there should be consideration for individual tastes. (114)(548)

The schedule of musical transmissions is determined by the work and rest regime and by the number of crew members. If cosmonauts rest at the same time, music to suit each cosmonaut's musical taste is selected. If they rest at different times, earphones are used.

Experiments have shown that dodecaphonic music acts on the cardiovascular system in a negative physiological manner, while classical music has a positive effect.

Dodecaphonic music can cause irritation and fatigue in a listener. It can also be used as a musical emotional shock, jolting a person who is in a state of stupor out of his boredom or apathy. (114)

A. Ground-Based Studies:

MUSIC AND WORK CAPACITY

In an earth simulation, (imitating long-term isolation) music that was unexpected in form and content turned out to be significantly greater in increasing work capacity than that of music selected according to request. Electronic music had the effect of an emotional explosion, which was better in removing nervous tension of the test subjects than ordinary music. (114)

Visiting and international crew members bring along their own musical selections. (454)

1.10 FOOD

Experience has shown "...that both a proper schedule of feeding as well as acceptable foods are very important for the maintenance...of an optimum work capacity." (548)

"[The] nutrition process goes beyond the bounds of physiology and hygiene; here the social psychology of man becomes dominant." (297)

1.10.1 TYPES OF FOOD AND PREFERENCES

Diet differs little from an Earth diet. (603)

As missions have evolved, the diet has become more varied, tastier and nutritive. (576)

About one-half of the items are eaten hot. (385)

There should be natural, fresh products (vegetables and fruits). (297)

A small amount of vodka is allowed onboard. (159)(548)

[Other types of alcoholic beverages - such as brandy - are also allowed]

Cosmonauts are not allowed whole garlic -- the air purifiers are unable to cope with the smell, but the cosmonauts have used garlic as food seasoning. (159)

The Rodnik system enables the crew to use more water and to drink all the coffee and tea that they want. (See 1.10.2.1 Water Supply for Rodnik information.) (189)

1.10.1.1 PACKAGING

The shifting of cargo during flight makes it necessary for the protective packaging and wrapping of food products. (240)

Greater attention is being devoted to the preservation of good quality and taste. Packaging has been improved, and food is being subjected to preliminary processing, using more sophisticated technological procedures.

Food must:

- Have low weight
- Have low volume
- Use minimum consumption of energy

Food is prepared to last for up to 18 months.

Most items are in bite-sized pieces. Most of the bite-sized pieces are made edible by adding water and kneading the food to a pasty consistency.

Some items are coated with a special edible film to prevent the formation of crumbs.

Foods are primarily canned or dehydrated.

For foods such as goulash, which usually has a liquid state, the space cooks make sure it contains more than 10% liquid (in a jellied form).

ORIGINAL PAGE IS
OF POOR QUALITY

Aluminum Tubes:

- Weigh 165 grams each
- Cottage cheese, soup and fruit are packaged in these (the most convenient type of packaging for these foods)
- Food is eaten and drunk directly from these



Ed. I

Canned Foods:

- Sterilized
- Containers weigh 100 grams each
- Cosmonauts become tired of these foods

Dehydrated Foods:

- 10% to 20% of foods are dehydrated
- Restored in flight with water
- Importance:
 - They reduce the weight of rations
 - Increase shelf life
 - Improve the nutrition
 - Increase the stock of food onboard
 - Diversify the assortment

(2)(42)(43)(177)(189)(206)(273)(320)(345)(366)(284)(476)(576)(600)

1.10.1.2 FOOD PROVISIONS

A food heater and hot water make it possible to have a normal hot meal. (345)

Food provisions include:

- Food allowance
- Containers for stowing and storing foods
- Folding table for dining (accommodates 4 people)
- Electric warmer
- Place settings
- Device to recycle water
- Containers for disposal (42)(43)(206)(543)
- Can openers
- Spoons
- Forks (385)
- Device to restore dried products (43)
- Hot and cold water hoses (543)

Two ovens are available to heat food. (170)(543)

For international flights, special ethnic foods are supplied. (476)

The oven is a small recess in the wall heated by electric current to 80°C.

Rubber straps on the table surface allow the cosmonauts to restrain the hot tubes of food so they don't fly off. (365)

SOVIET SPACE STATION ANALOGS, Ed. II

1.10 Food

Rations are developed on the basis of:

- The flight duration
- Complexity of the program
- Anticipated energy use
- Food storage
- Heating and dispensing equipment
- Features of the water supply system
- Features of water reclamation (240)

1.10.1.3 APPELITE

Experience shows that:

- Appetite decreases in space
- Cosmonauts have a tendency to get bored with some foods
- Dehydrated foods taste better (548)
- There is a desire for spicy foods (192)
- Appearance and aroma are important (297)(350)
- Under weightlessness, taste changes occur (See 4.1.1 Weightlessness.) (128)

FATIGUE AND TASTE

The change in the taste perception of cosmonauts in flight against the background of fatigue was subjected to study.

In order to improve the appetite under such conditions, it is necessary to add different spices and condiments to stored food products, provide desirable and diverse foods and snacks. (320)(339)(476)

Cosmonauts' individual tastes are considered.
(240)(308)(345)(385)(396)(548)

"As much as possible we try to take into account the tastes of each cosmonaut in coming up with the food ration." (240)

Crews may select their favorite courses as long as the caloric ration as a whole is not changed. (240)

"...any product, no matter how good it is, quickly becomes boring."
(264)

Nutritionists are studying to see if there are changes in tastes as missions get longer. (177)

1.10.1.4 CREW REQUIREMENTS

There is control over food intake prior to the 24 hours before lift-off. Cosmonauts are prohibited from eating any food not prepared in the flight kitchen. The meals are composed of food that is easily digested and not too large in quantity. The food provided has a low capacity for developing intestinal gas and is composed of nutrients that do not have excessive bulk and lipid content. (548)

Products have been incorporated which promote the normalization of metabolism under conditions of physiological stress. (320)

Cosmonauts consume approximately 3,000 calories per 24-hour period. The actual amount is determined by body weight:

-Per kg of body weight:		Average:
Protein:	1.5 g (1 g = 4 calories)	140 g
Fat:	1.4 g (1 g = 9 calories)	100 g
Carbohydrates:	4.5 g (1 g = 4 calories)	395 g

-The mean daily allowance contains:

Calcium:	.8 g
Phosphorus:	1.7 g
Magnesium:	.4 g
Potassium:	3.0 g
Sodium:	4.5 g
Iron:	- 50.0 mg

(38)(42)(43)(44)(85)(170)(177)(206)(385)

SOVIET SPACE STATION ANALOGS, Ed. II

1. 10 Food

As a result of studies, the following water requirements were determined:

- 17 ml for drink
- 800 ml food ratio
- 300 ml metabolic

This quantity makes it possible to retain human water balance. (385)

Cosmonauts do not want liquids yet they are ordered to drink at definite times. (This is important because the urinary output and elimination of fluids is increased as a result of blood circulation that is different than normal.) (476)

Humans must consume:

- 700 grams (dry weight) of food with 3,000 to 3,300 calories for normal activity
- 800 grams of oxygen (delivered into space in a chemically-bound form)
- 2,500 grams of drinking water
- 2 liters of water for sanitary and hygienic purposes (2)

[It should be noted that, to date, all long-mission cosmonauts have been male. Requirements may vary for females.]

The cosmonauts consume an average of 1.2 to 2.5 liters of water per day. During the last few days of flight they drink more to correct fluid deficiencies that would become more apparent on Earth. (127) (154)(170)(176)(385)

Crews take two vitamin preparations every day to improve their metabolism. (44)(170)

A. Ground-Based Studies**SALYUT 6 DIET**

The diet on the Salyut 6 was well balanced as determined by a study of metabolism of subjects in ordinary conditions, in hermetically sealed chambers, and in a ground-based model study. The test personnel evaluated:

- The condition of proteins, lipids, carbohydrates
- Vitamins
- Water - mineral exchange
- Indices of immunobiological reactivity
- Assimilation of food
- Digestion
- Activity of hormones and enzymes (42)(43)(44)

1.10.1.5 EXPERIMENTAL FOODS

Along with official rations there are experimental ones (for example, sublimated, moistureless products). These experimental rations may be valuable in the future when there is sufficient regeneration of water. In this case the use of natural products will become inadvisable. Products processed by the vacuum drying method retain their properties for a long time, do not require the use of cumbersome devices and can be packed in compact containers. Experimental rations usually consist of soups, meat, potatoes, juices and tea. (2)(456)

1.10.1.6 MISSION HIGHLIGHTS**Salyut 6:**

The role of food changed and evolved. Diets became more varied, tastier, of higher nutritive value and eventually incorporated most of the requests of crew members. Crew members would eat together four times a day. (2)(42)(476)(576)

The results of the Salyut 6 missions (95-, 140-, 175- and 185-day flights) revealed that the nutrition elements were good and helped to maintain work capacity. (42)

140-DAY MISSION

Consumption of water at a sufficient level assisted in the preservation of a volume of erythrocytic massive blood. On this flight the cosmonauts lost less of their circulatory blood than those cosmonauts that had flown earlier. The earlier cosmonauts had not consumed enough water. (87)

The crew was supplied with luxury tins of foods but after a while they complained they did not like them. Instead, they asked for fresh items. (127)

175-DAY MISSION

There was a high calcium content to maintain bone strength. Cosmonauts consumed 70 different meat, dairy and other products. They received fresh fruits and vegetables from the Progress to add to the onions, dill and parsley they cultivated in their onboard vegetable garden. They ate 3,100 calories per day. (170)

185-DAY MISSION

This crew was the first to gain a considerable amount of weight. This was attributed to preventive measures and also appetite stimulators such as onions, garlic and other sharp seasonings, which together resulted in more food being consumed than energy expended. These findings confirm that it is imperative to strictly regulate nutrition in flight. It should be consistent with the body's requirements. (42)

This crew liked fish, mashed potatoes and spices more than anything else. They also liked the Hungarian food that was brought on the Progress 10 for the visiting crew members. (47)

Salyut 7:

For the first time the pantry system was used. The food is now preserved and delivered as separate units. The cosmonaut can select what he prefers to eat on a given day within a stipulated caloric rate. The physicians keep track to see that the ration is balanced

as far as composition and caloric count. At the end of each week the crew has to inspect the supplies and send the data to Earth for medical monitoring so they will know what products in what amounts need to be sent to the crew on the next cargo ship. (Problems: This method makes it difficult to inventory and replenish the food from the Earth.) (6)(75)(189)(502)

211-DAY MISSION

These crew members enjoyed the soups. They also ate buckwheat porridge, sweets, canned goods and bread. (213)

150-DAY MISSION

This crew asked for more vegetables and fruits and said that the meat rations could be decreased. (374)

Aleksandrov: "We drink a lot--fruit juice diluted with water. Evidently this counteracts psychological stresses." (249)

Aleksandrov: "When we were unloading the Cosmos we found a sealed, silvery packet. It turned out that this was eleutherococcus. (See 1.10.1.8 Vitamins and Supplements, C. Eleutherococcus.) We were so pleased. This is an invigorating liquid. Thanks to the doctors who placed this present here." (249)

237-DAY MISSION

These cosmonauts said that the food was gradually approaching what they ate on Earth. Experts believe that food was very important to sustaining this crew's high capacity for work. (599)

On international flights, special foods are sent up. For example, when the Indian cosmonaut flew on the 237-day mission, pineapple and mango juice were added to the diet. (161)(575)

SOVIET SPACE STATION ANALOGS, Ed. II

1. 10 Food

1.10.1.7 MENU

The following groups of food are used:

- 25 meat dishes
- 6 first courses
- 5 dairy products
- 5 bakery products
- 10 pastry items
- 12 fruit and juices
- 3 beverages
- 2 condiments (2)(44)

MENU EXAMPLES

The list of foods and dishes for a one-day menu:

First Breakfast:

- Chicken with prunes - 100 g
- Bread - 45 g
- Candy - 50 g
- Coffee with milk - 150 g

Lunch:

- Cottage cheese with
pureed black currants - 165 g
- Honeycake - 45 g
- Black currant juice
with pulp - 50 g

Dinner:

- Sauerkraut soup - 165 g
- Roast beef with
mashed potatoes - 57.5 g
- Bread - 45 g
- Prunes with nuts - 60 g
- Candied fruit - 50 g
- Coffee with sugar - 24 g

Supper:

- Chicken in
tomato sauce - 165 g
- Bread - 45 g
- Cheese - 100 g
- Tea with sugar - 23 g

(44)

Breakfast:

Pork with sweet pepper (dehydrated)	- 40 g
Russian cheese	- 100 g
Honeycake	- 45 g
Prunes (dehydrated)	- 50 g
Coffee with sugar	- 24 g

Lunch:

Jellied beef tongue	- 100 g
Praline candies	- 50 g
Cherry juice with pulp (dehydrated)	- 40 g

Dinner:

Ham	- 100 g
Borsch with smoked foods	- 165 g
Beef with mashed potatoes (dehydrated)	- 52.5 g
Rye bread	- 45 g
Cookies with cheese	- 25 g
Apple juice with pulp (dehydrated)	- 30 g

Supper:

Cottage cheese with nuts (dehydrated)	- 50 g
Assorted meats	- 100 g
Enriched wheat bread	- 30 g
Plum and cherry dessert (dehydrated)	- 50 g
Tea with sugar	- 23 g (42)

After each expedition the diet is improved, primarily by widening the assortment of products and dishes and replacing foods that are rated poorly. (42)

Menus are prepared so there is no repetition of a particular dish for at least six days.

At times, visiting Soyuz crews and/or Progress do bring up alcoholic beverages. (548)

SOVIET SPACE STATION ANALOGS, Ed. II

1. 10 Food

1.10.1.8 VITAMINS AND SUPPLEMENTS

A. Vitamins:

Vitamin pills are considered necessary because some of the foods, being tinned, do not contain enough vitamins. They are also necessary because of the strenuous activities of the cosmonauts. (85)(177)(320)

Vitamins are given to crew members in the form of a lozenge. (42)(240)

Vitamins:

- C
- B2
- B6
- P
- PP
- E
- Pantothenic Acid
- Decamerit
- Methionine
- Glutamic acid

The vitamin complex is to promote:

- Intensified metabolism
- Syntheses of catecholamines
- Normalize intestinal microflora
- Normalize lipid metabolism

B. Water and Salt Supplements:

Water and salt supplements are added to the diet before landing. This is because it is important to slightly increase the amount of fluid in the bloodstream and in the tissues before returning to Earth. (38)(43)

Women use a non-hormonal drug to regulate menstrual flow. (Soviets consider the use of hormonal preparations "unwise.") (361)

C. Eleutherococcus:

For twenty years the Soviet Union has used the extract of a thorny creeping plant known as Eleutherococcus senticosus. This belongs to the same family as the ginseng root. Soviets have found that the use of this increases stamina and performance and has less side effects than any other known stimulant. (82)(127)

Eleutherococcus is said to play a special role, particularly in the final stages of flight.

The Progress cargo ships keep crew members supplied with the drug. (127)

Salyut 6 crews took Eleutherococcus every morning to increase their long-term stamina. [There appears to be a contradiction in how much the cosmonauts took. One article (S.112) stated they took 4 millilitres everyday, but in an interview in Paris, 1982, a Soviet physician stated that crew members would take 500 milligrams everyday or 1,000 milligrams every other day.] This drug plus exercise and a high calcium diet are three ways in which Soviets are trying to reduce calcium loss that has occurred in the crews. (168)

Ground-Based Study:

ELEUTHEROCOCCUS SENTICOSUS TEST

A test was given to a group of athletes before a 10-mile race. The athletes taking the extract outran others who had taken a placebo by five minutes.

Another test was performed on athletes at the Lesgraft Institute of Physical Culture. It was found once again that this plant increases endurance as well as reflexes and concentration, particularly in longer events.

The only side effect was an occasional and transient rise in blood pressure.

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1. 10 Food

This plant extract has been taken by Soviet deep sea divers, mine and mountain rescuers, climbers, explorers, soldiers and factory workers to resist stress while working hard under inhospitable conditions.

It is prescribed in the USSR for anemia, depression and chronic infections such as tuberculosis. "It is not claimed to be a curative, but restorative, that is to improve the general health, resistance and energy of those who are weak, debilitated and under stress." (82)

D. Tranquilizers and Other Drugs:

A lab experiment with the use of sedative substances (mild tranquilizers) showed:

- An improvement in health during alarming situations
- Increase in attention span
- Reduction in finger tremors (114)

Other drugs used for stimulating efficiency and performance are:

- Phenamine
- Centedrin (ritalin, meridil)
- Reactivan
- Mefaxamide
- Duklidin
- Panklar
- Katovit
- Tosolin

These have been extensively studied and are used a great deal. (288)

1.10.1.9 FOOD AND WORK PRODUCTIVITY

High quality nutrition plays an important part in maintaining a person's health and work capabilities, especially under demanding conditions. Work capacity can have an effect on flight safety. (320)(321)(548)

"The cosmonauts' health and capacity for work depend largely on their diet in flight, the number of meals per day, distribution of calories, and intervals between the meals." (576)

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1.10 Food

1.10.2 FOOD AND WATER STORAGE

The most difficult technical problems are those of supplying food, water and oxygen.

If the products of the vital activity are not recovered, a crew of three in a one-year flight will require the following amounts of these substances:

- Food (allowing for packaging) - 1.5 tons
- Bound oxygen - 3.3 tons
- Water - 5.9 tons

This is almost half the mass of the Salyut 6 orbital station. (2)

In long-term flights there should be a full processing and restoration or reserves of food and water. (S.182, S.187)

A. Food Storage:

It is impossible to store some stocks of food onboard for a very long time (the quality of the products deteriorate and there is a loss of vitamins and other nutrients.) For this reason, the growing of plants onboard is important. Researchers are developing the means for doing this. (See 1.2.8 Plant Facility.) (253)

Dry rations are kept in two cupboards on the right and left sides of the working compartment. (345)

It is necessary that the food maintain its quality under storage conditions at 20-25°C and stay safe throughout the entire mission.

A refrigerator has been added which is in the working compartment of the Salyut 7:

- Capacity: 50 liters
- Temperature: +3°C (75)(189)

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1. 10 Food

B. Water Storage:

The water reserve is preserved on the Salyuts with silver ions.

Method for storage of water:

-Ionic silver - dose of 0.2 mg/1 to provide full retention of the sanitary and hygienic indices of water within the limits of time. (This kept the water hygienic during the Salyut 6 96-day and 140-day expeditions.) (297)(385)(548)

Studies made of the water supply system show that the method of storage of the water with ionic silver in a dose of 0.2 mg/1 provided full retention of sanitary indices of water within the limits of the time period. (385)

1.10.2.1 WATER SUPPLY

The life support system requires regular deliveries of drinking water and supplies for purifying the cabin atmosphere. (Some water is recycled aboard the Salyut.) (537)

The water regeneration system has led to a substantial improvement in the quality of the cosmonaut's diet. (See 1.4.7.2 Water Reclamation.) (600)

The Rodnik water system provides water to the kitchen through a faucet. (See 1.4.7.2 Water Reclamation.) (6)(8)(75)

1.10.3 FOOD CLEANUP

There are facilities for cleaning table accessories, and bags for collecting food leftovers and packaging. (320)

1.10.4 EATING SCHEDULE

The intervals between meals range from three to five hours, which is conducive to digestion.(42)(43)(576)

There should be 3 to 5 hours between meals (for digestion purposes). (43)

There is a 15 to 20 minute interval between exercise and eating, and intervals of 1 to 1-1/2 hours between eating and exercise. The most important work requiring high mental work capacity is scheduled no sooner than 1 to 1-1/2 hours after eating. (42)(43)

According to crew reports there have been no changes in gustatory sensations. There have been no dyspeptic disorders. (42)

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1. 10 Food

1.10.5 FOOD RESEARCH

The Soviets feel that there are many questions on nutrition that need further investigation:

- Data to determine energy requirements under space conditions:
 - Information will be provided by establishing an experimental laboratory in the station
 - Nutrition requirements during different phases of the mission
 - Consideration of the individual cosmonaut metabolic rate at various stages of the mission
 - Modification of catabolic activity due to the space environment and concurrent stress by employing dietary and pharmaceutical supplements
 - Improvements in diets to improve long-term storage and acceptability
 - Further understanding of nutritional requirements both in pre-flight and post-flight adaptation
 - The use of dietary substances for counteracting detrimental space conditions (radiation, weightlessness, demineralization)
- (548)

1.11 CONTAMINATION

A long stay in a closed space leads to a number of problems:

- Ecological
- Sanitary-hygienic
- Microbiological (40)

Bacteria in the air of the space cabin can change under the influence of weightlessness and ionizing radiation. This can lead to changes in the speed of transmitting disease. (114)(259)(385)

Data show that on long-term flights there is a reduction of the immune properties which can lead to the increased possibility of illness. (385)

1.11.1 SOURCES

The sources of contamination are the equipment and the crew members themselves. (206)

Surfaces in the cabin play an important part in the retention and transfer of conditionally pathogenic microorganisms.

The rate at which the body releases chemicals into the environment depends on:

- Motor activity
- Atmosphere
- Diet (259)

1.11.2 CONTAMINANTS

The emission of volatile components of waste products may contaminate the station even in the presence of adequate storage areas. The major volatile mixtures generated by the crew from exhaled air, perspiration, urine and intestinal gases consists of:

- Ammonia
- Methylamine
- Diethylamine
- Formaldehyde:

FORMALDEHYDE CONTAMINATION

During the 140-Day Mission and the 175-Day Mission, there was a sensitivity to bacterial allergens. There was a sensitivity to formaldehyde that was recorded post-flight, although no crew member had exhibited such sensitivity pre-flight. All of these reactions had been seen in previous flights. This points to the need to reduce formaldehyde contamination of the cabin atmosphere. (288)

- Acetone
- Methylethylketone
- Propionic aldehyde
- Carbon dioxide
- Formic
- Propionic
- Valeric
- Isovaleric
- Butyric and lactic acid
- Methyl
- Isopropyl
- Propyl alcohol
- Methane
- Ethane
- Propane
- Hexane
- Trace amounts of other organic compounds (548)

Without the effective removal of these substances there could be an accumulation to toxic levels. This could result in a decrease in productivity. (259)(548)

The main microorganisms are:

- Staphylococci
- Bacteria
- Gram-positive spore bacilli (259)(385)

These are carried on the skin and mucosa of the upper respiratory tract.

Fungus of the Asperagillus genus have been found in single locations.

The microflora in the air and on surfaces are primarily non-pathogenic types of bacteria. (385)

Dandruff in the atmosphere may be inhaled, get into eyes, or stick to instrument scales. (219)(297)

A. Aerosol:

The formation of an aerosol under space flight factors is a lengthy process and its study is possible only during an actual flight of very long duration. However, it is known that aerosols entering into the respiratory tract in weightlessness can be hazardous. (259)(385)

Accumulation of aerosol in the gas atmosphere of manned spacecraft could lead to a considerable worsening of the cosmonauts' living conditions. There is a need to detect the sources of aerosol pollution of cabins.

Humans are one of the sources of aerosol particles in confined habitats. A clothed person emits 100,000 to 30,000,000 particles per minute (depending on physical activity). A study was done to obtain quantitative and qualitative characteristics of aerosol in pressurized habitats:

GROUND BASED
AEROSOL POLLUTION STUDY

Results: The accumulation of aerosol increased with the reduction of volume and with human presence. This can lead to mechanical injury to the upper respiratory tract and allergic disease.

Studies were conducted in two pressurized compartments 24 and 140 m³ in size. Normal microclimate was maintained by means of recycling and conditioning the gas atmosphere. The subjects wore woolen exercise suits, cotton underwear and sport shoes.

In the background studies performed without humans, the concentration of aerosol diminished. In the manned chambers the aerosol concentration fluctuated over a wide range.

There usually were two- to three-fold changes in concentration over a 24-hour period.

The entire cause of these fluctuations could not be determined. The decrease in particle concentration during the periods of daytime naps and at night were related to the decreased activity of subjects. There was an increase in large particles when changing bed linens and an increase in fine particles when preparing food.

The estimated weight concentrations of aerosol increased with the reduction of free volume per person. The levels of bacterial aerosol in manned habitats is directly related to population density and activity of people. Humans are the main source of aerosol in pressurized rooms.

With the reduction of free volume per person, the size of aerosol particles increase. There is a probability that this can lead to mechanical injury to the upper respiratory tract and allergic disease. (12)(259)

1.11.3 CONTAMINATION CONTROL

A. Filters:

The Soviets use filtering media for the removal of waste gases and microparticulates. These include:

- Activated charcoal filters
- High efficiency fiberglass filters
- Catalytic chemical absorbants (548)

B. Cleaning:

"There should be the development of hygienic requirements and engineering devices...(for)...maintenance of optimal sanitary-hygienic conditions with respect to the scope and methods of personal hygiene, waste management, water supply, diets...and...anti-epidemic support to prevent disease." (259)

Cosmonauts sponge daily with moist washcloths.

In the absence of adequate hygienic protocols (See 1.4.4 Personal Hygiene.), the potential for cross-infections are enhanced. (548)

Most of the microorganisms are sensitive to antibiotics. (385)

SALYUT 6

Housekeeping was increased to keep contamination down with the second crew of Salyut 6. Cleaning was done more frequently.

Cleaning of the station using disinfecting equipment resulted in a clearer atmosphere. Bacterial contamination was kept within the limit under 400 microcells per 1 m³ of air and the content of the bacteria on the surface objects amounted to 250 + 100 microcells for 100 cm² of surface. (385)

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1.11 Contamination

Salyut 7: The composition of the atmosphere and dust pollution are analyzed. (6)(8)

The Soviets are experimenting with a variety of techniques for maintaining a purified cabin environment. Techniques under consideration for the removal of carbon dioxide include:

- Molecular sieves
- Synthetic zeolites
- Freezing of carbon dioxide out of the gas mixtures (548)

1.11.4 RESEARCH AND STUDIES

SALYUT 6

On the Salyut 6, the parameters of the barometric pressure were constantly controlled, as well as the gaseous composition of the air medium and the microclimate. Periodically a control test was made of the chemical composition of the air for indications of harmful admixtures and the sanitary state. Samples were sent to Earth with visiting expeditions. (385)

SALYUT 7

On the Salyut 7, chemical, biological and physical factors are tested. The gas composition is measured qualitatively and quantitatively. Past results: A higher content of acetone and acetaldehyde when the cosmonauts worked on various trainers and unloaded the Progress cargo. (392)

It is important and necessary to investigate the mechanism of transmission of microorganisms from one individual to another during long-term space flight. This is because changes in the auto-microflora of cosmonauts and requirements of providing for epidemic-free performance of crews should be determined. (326)

MICROBIAL DISCHARGE

In studies performed on the station (as well as in sealed capsules on Earth), the Soviets observed that there is a marked increase in microbial discharge in the space capsule.

The discharge and concentration becomes ten times higher in a closed environment. The microbial flora of the skin is increased by ten-fold in an airtight environment "under reduced personal hygiene, restricted by a limited energy and water supply, as well as by the weight and dimensions restrictions posed by the space capsule." (548)

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1.11 Contamination

A. Ground-Based Studies

PERSON-TO-PERSON TRANSMISSION

In this laboratory study, samples of microflora were collected:

- From the inside surfaces of the pressure chamber
- Collected four times a day (using the washing off method that is customary in sanitation bacteriology)

Five percent blood agar was used. The cultures were placed in an incubator and kept at a temperature of 37°C for two days. After this, colonies of microorganisms were counted.

Results:

- The concentration of bacterial aerosol depended on the number of people in it
- With the interconditioning systems working and increasing the number of people in the compartment by 2 and 4 times, the concentration of bacterial aerosol increased by 4 and 10 times, which corresponded to 810,000 mic/m³ on the second day of the studies
- With an increase in the number of people in these conditions there may be a drastic increase in concentrations of bacterial aerosol

It has been noted that the degree of bacterial contamination of inside walls and equipment surfaces in sealed rooms is greater when air conditioning equipment is used than when it is not, if all other conditions are equal.

This data can be used for:

- Designing life support systems
- Developing measures to provide sanitary hygienic and epidemic-free conditions for people working in confined, isolated quarters (326)

1.13 VIBROACOUSTICS

"The point...is not the noise itself, which under ground conditions corresponds to permissible levels, but the unique living conditions in a spacecraft, including weightlessness and the continuity and monotony of the acoustic activity." (212)

To improve the operator's working conditions it is important to know the characteristics of the auditory perceptions and sound sources. (114)

Regulating noise parameters depends on:

- The basic tasks and peculiarities of the mission
- The activity of the crew

Physiological and hygienic norms for noise will increase working ability. (390)

Salyut 6: During the life of this station, the internal sound insulation layer was thickened by 50% to enable it to dampen most of the station's ambient noise (the hum of the ventilators, fans, motors and instrument functions). Cosmonauts who worked on the Salyut 6 still considered it noisy. The life support system motors were moved in flight to the side of the working compartment to reduce the noise and many instruments were muffled. (177)

When they slept the cosmonauts said that they were subconsciously listening to background noise to determine if the station was functioning correctly. (177)(212)

A. Improvements:

Salyut 7: The ventilation fans are less noisy and are equipped with dust collectors. (188)(548)

1.13.1 REQUIREMENTS

Work and rest areas should have noise levels that are not the same:

Rest area: should not exceed 40 dB (548)

Noise levels for a station without special compartments for sleep or rest:

Living quarters: 35-40 dB for day
25-30 dB at night (390)(391)

The constant acoustic background should not exceed 60-65 dB for an exposure of up to 60 days.

In compartments where cosmonauts only visit for short periods of time, higher noise levels can be allowed.

Maximum and minimal levels of noise should be standardized.

Special attempts must be made to reduce noise at its source and to choose optimal sound-insulating and sound-absorbing materials for use in the station.

During missions, the continuity of acoustic stimulation becomes important. This necessitates the search for new ways and means of establishing permissible noise levels. (391)

With a 30-day exposure to noises of 60-65 dB:

- The range of its amplitude and frequency should be changed:
 - To prevent the adverse psychoacoustic effect of monotonous noise
- The Soviets have determined that a background noise of 60-65 dB is not detrimental to cosmonauts (548)

When the intensity exceeds 100 dB:

- Individual protection is a must (391)

1.13.2 PROBLEMS

Noise can have an adverse affect on people. (203)

Hearing disorders following prolonged exposure to defective noise develops first in subjects with decreased resistance to noise. (242)

A. Low and Medium Intensity:

Soviet specialists in space medicine have shown that continuous exposure to noise of low and medium intensity in combination with other flight factors may, with time, increase:

- Irritability
- Sleep disorders
- Headaches

These problems occur most often at the end of a long mission, when fatigue increases and when cosmonauts rest and sleep within the same continuous, monotonous noise, even though they would prefer silence. (170)(212)(242)

B. High Intensity:

Data suggests that high intensity noise causes an alteration in the nerve cells that perceive sound and also influences the functional and psychological state of the central nervous system. This can lead to:

- Reduction in the capacity to perceive constantly changing conditions of the external environment and bring about such manifestations as irritability and fatigue
- May bring about premature aging (548)

C. Vibration Experiments:

Salyut 7, 150-Day Mission: This crew produced a crystal-by-crystal drawing through a mold, a technique used on Earth from a moltant mass. During an early test the station's micro-accelerometers noted vibrations by fans and other equipment which affected the results. (175)

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1.13 Vibroacoustics

The cosmonauts also noted that some of the strong vibrations may have been due not only to the fans, but also to the movement of the solar arrays. (528)

An acceleration experiment (See 3.1.3 Experiments.) was done on the Salyut 7 to record problems caused by vibrations. (592)

1.13.3 SOLUTIONS

Several ways of avoiding detrimental background noise:

- Decrease the general level to optimal values
- To reduce monotony: music (See 1.9.1.2 Music.) (212)
- Choose sound-insulating and sound-absorbing materials (391)

A. Monitors:

Cosmonauts say that correct operations can be monitored by sounds that accompany the activity of different systems and assemblies.

This listening usually occurs subconsciously and therefore does not distract the crew from their main activity. (212)

The constant background noise from the operation of instruments intensifies the feelings of discomfort, which may not always be conscious. Therefore, noise is monitored. It is important to consider the:

- Volume of sound
- Pitch
- Tonality (8)(114)

HEARING FATIGUE

The study of hearing is becoming more important as mission length increases. The auditory threshold differences in the lower frequencies between measurements on the ground and onboard the Salyut 6 can be traced back to the disturbing influence of the noise level in the orbital station. The reduction in auditory sensitivity after flight and the failure to restore hearing to a normal state during the period of 24 hours after landing points to some hearing fatigue. (327)

SENSITIVITY THRESHOLD

An experiment was done to see the sensitivity threshold of human hearing in space flight conditions. For no apparent reason this threshold proved to be lower than it was on Earth. (Studies indicate that cosmonauts may merely adapt to noise.) (170)

A. Ground-Based Studies

NOISE INTENSITY

During a series of experiments it was shown that subjects complained for the first time of the affect of noise during periods of sleep and rest when exposed to 24 hours of noise with a total intensity of 74-76 dB.

In experiments lasting 10 days, subjects had headaches and ringing in the ears. The cardiovascular system reacted to standard physical exertion by a slight lowering of vascular tone. There were signs of fatigue.

Result: The continuous and periodic action of high frequency noise with an intensity of 75 dB causes effects which differ both in their character and in the degree of modification of the function of the auditory system. In case of periodic reaction of noise (up to 7 hours per diem) a cumulative effect is observed after only months and years; continuous exposure, however, gives rise to these effects after only 10 days. (391)

CASE OF THE VENTILATORS

During long term presence on the Salyut station the constant noise emanating from the numerous instruments (particularly the ventilators), although insignificant, nevertheless constantly caused irritation and distracted the crew during activities requiring concentration. (114)

The most suitable model for studying the effects of the cumulative effects of noise on hearing are ground tests in an environment closest to the actual conditions of a space station: (242)

THREE-PERSON SIMULATION

A physician, biologist, and technician spent a year on this experiment as volunteers. The basic sources of noise in the hemochamber were the self-contained blocks of the atmosphere purification system, air conditioning equipment and the life support system ventilator.

Noise levels were measured. Hearing was evaluated before and during the experiment. For evaluation of the psychological effect volunteers provided subjective analyses.

Results: During their presence in the hemochamber all volunteers experienced some degree of discomfort. They felt the noise was unpleasant and acted as an irritant, especially during the rest period. Total adaptation to the noise did not occur.

At the end of the experiment all three volunteers noticed a "wadded emptiness," noise and ringing in the ears and head which was the cause of restless sleep and insomnia. They felt a need to converse constantly in order to suppress this silence.

Restoration of initial hearing sensitivity showed an individual character. In two volunteers it occurred on the 7th and 25th days. In the third volunteer restoration of hearing to normal did not occur during the 7-month observation period after completion of the experiment.

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1.13 Vibroacoustics

After the experiment some changes were noted in the vestibular analyzer. They were manifested by:

- Disorders of gait
- Mild dizziness
- Decrease in vestibular-vegetative stability

This study showed that with increased noise, acoustic trauma can occur. (242)

125-130 dB

One study reported that after exposures of 125-130 dB for 20 minutes, subjects suffered from:

- Head pain
- Ear ringing
- Feeling of stuffiness in the ears for 20-40 minutes after exposure

Subjects did not recover for 1-2 hours. (58)

Data indicates that it is possible to assess the affect of noise on a worker only with quantitative consideration of the degree of fatigue that develops under the influence of the work process itself. There should be further studies done. (203)

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1.14 THERMAL CONTROL

1.14.1 TEMPERATURE

Maintaining the proper temperature in the station is important. The station passes from the shadow of Earth to the solar side. (Temperature can go from 150°C in the shadow to +130°C on the sunny side within 90 minutes.) Consequently, in one 1-1/2 hour turn it is necessary to neutralize the effect of this gradient on the living areas twice. Heat isolation and automatic heat regulation are used. (206)(543)

Hot and cold air do not mix well in weightlessness so fans must be employed continuously:

-Blowing speed: 0.1-0.8 m/sec

In the living part of the Salyut:

Temperature is maintained: 15-25°C
Moisture: 20-80%

(543)

Most of the outer surface of the small diameter operations section is covered with the temperature control system's radiator. To maintain the proper temperature, the body of the operations section is covered on the outside with mats of vacuum shield heat insulation, while the large diameter portion of the section is covered with the fiberglass cover for protection from aerodynamic heating during powered flight. On the sides of the station are panels with sensors to study the flux of micrometeorites.

The equipment section is thermostated in flight and has external heat insulation similar to the insulation of the operations section. (537)

The crew can change the temperature (within certain limits). (206)(345)

To set standards for microclimate it was deemed necessary by studies to determine the range of temperature and humidity preferences of cosmonauts:

COMFORTABLE TEMPERATURES

A comparative analysis of temperature sensations of crew members of the Salyut 7 and Salyut 6 and parameters of microclimate revealed that uncomfortable temperature sensations were observed in all people at air temperatures below 19°C and relative humidity over 60%. Good and comfortable temperature was indicated at temperatures between 22-24°C.

The perception of ambient temperature is attributable to some extent to the peripheral circulation of humans in weightlessness, which affects heat transfer processes.

Optimization of the environment involves the combined setting of environmental factors affecting a person's thermal status:

- Air temperature
- Humidity
- Velocity

It can become too hot within the station because of the amount of heat generated. Therefore, the temperature regulator system's typical problem is to eliminate the excess heat. This system also removes moisture from the atmosphere in the crew quarters.

Technological experiments, performance of which is associated with additional heat sources (heating panels), contributes to some of the thermal properties. For example, during performance of several technological experiments and television broadcasts, air temperature was 2-3°C higher than the daily mean. The drop in air temperature to the usual mean daily level was observed 3-4 hours after terminating work with the unit. (392)

There is vacuum-shield insulation made from a metallized film that helps preserve the heat in the station. (70)(206)(345)

1.14.2 HEAT REGULATION SYSTEM

Pipes carrying the liquid heat transfer agent are welded along the inside walls of the station (but behind the panels which the crew sees) for thermal regulation. For the well-being of the crew this is important:

- The station has openings to allow electrical and hydraulic leads to connect equipment on the outside with the interior. Rubber gaskets are used to seal the holes, and correct temperatures must be maintained in order for them to maintain their elasticity and strength.

Heat is generated inside the station (by crew and equipment) and retained by using a multilayer thermos material made from metalized film. Excess heat is radiated into space with a thermal regulation system. When no crew is onboard, an electric heater is used to maintain proper temperatures. (548)

The heat regulation system has two independent fluid contours:

- Cooling
- Heating

Both have internal and external main lines separated by heat exchange-coils with fluid circulating inside. One of these is painted a dark color and the other white.

The sun heats the dark coils and the fluid circulating in them is also heated. The heat is then transmitted to the station. The excess heat is eliminated through the white radiator-cooler.

The heat regulation system also helps with air circulation. (See 1.3.6.2 Air Circulation.) (206)

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1.15 CLOTHING

Individual color preference of crew members is advocated. (79)

Crews participate in designing styles, color, pockets, patches and form for their own uniform. (34)(121)

Clothing should be convenient for work and relaxation and should not restrict movement.

Clothing for single-time use simplifies the problem of washing but with prolonged flights is not practical. Repeated-use clothing is also not ideal because of the lack of cleaning and drying equipment. Most used will probably continue to be replaceable clothing.

Clothing for one-time use is worn during a specified time. After this period, it is placed in the waste disposal system or packed into hermetic bags and stored until the end of the mission. Repeated clothing is worn and then cleaned. (79)

1.15.1 UNDERWEAR

Underwear is changed once per week. (548)

Underwear should be:

- Nonirritating
- Durable for extended wear
- Light
- Not hinder heat exchange by convection, radiation or evaporation of moisture
- Washing should not alter fabric (porous knitted cotton/rayon is good)
- Compatibility with the next layer of clothes (flight suit or pressure suit)
- Have a small number of seams
- Limit wrinkling

Knitted fabric is recommended (cotton/rayon) per investigations. It has:

- High permeability to air (not less than 400-600 l/m²s at a pressure of 5 mm water)
- High permeability to water vapor (with a resistance of about 1 mm of an air layer)
- The hygroscopicity of the fabric is not less than 7% when air has a relative humidity of 60%
- High durability
- Tensile strength is not less than 20 kg for a strip 5 cm wide
- The thickness of a fiber under a load of 10 g is 0.73 mm
- Comfortable when worn under a pressure suit
- Good ventilation

Design:

- Jersey sweater
- Undershorts (with a special valve in the crotch so cosmonauts can use the WMS)
- Seamless socks (cotton) (79)

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1.15 Clothing

1.15.2 OUTERWEAR

June-September Mission, 1985: Cosmonauts had new heat protective coveralls to wear. The cosmonauts said this was particularly helpful since they came to a station that was without any electricity and thus no heat. (See 1.3.13 Maintenance Activities.)

These two crew members did say that their legs and hands got very cold. Fur boots and warm socks were not much help. (The crew said that they warmed themselves by tapping one leg against the other while working.) (654)

The cosmonauts wear regular clothes over their underwear. The outerwear should be:

- Easy to put on and take off
- Not hinder movement
- Provide for using WMS
- Fit well with the underwear
- Have the ability to provide for attachment of physiological instrument sensors
- Have pockets for small personal objects
- Soft, light, elastic, long-wearing, flameproof
- Should not contribute to the build-up of electrostatic charges (Electrostatic charges can lead to pain for the persons wearing the clothes. Clothing made of chlorine and acetate silk and footwear made of polymer materials should be avoided.)
- Maintain its properties after washing and sterilization (if repeated use)
- Not hinder heat exchange by convection, radiation or evaporation of moisture
- Preservation of cosmonauts' thermal balance

Natural fabrics should be used rather than synthetics. Synthetics have:

- Lower hygroscopicity
- Vapor permeability
- Heat resistance
- Poorer hygienic properties

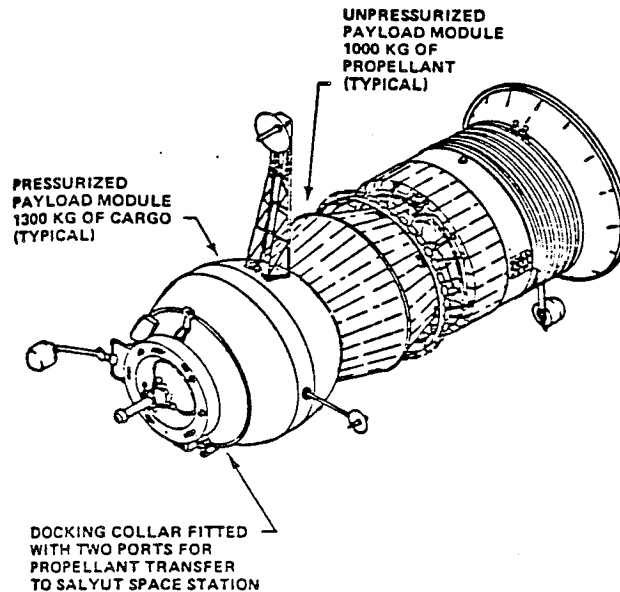
For prolonged flights the lowering of microorganisms on skin will be more significant. (See 1.11 Contamination.) (Use antimicrobial textile materials. Problem: instability during washing.) [The issue of the proper cleaning facilities for clothing has not been resolved.] (79)

SOVIET SPACE STATION ANALOGS, Ed. II

1.16 LOGISTICS

Presently the Progress Cargo Ship and the Soyuz T Transport Ship are used for routine resupply and crew visits and return. The Kosmos series (See 1.16.3) is under evaluation as a logistics vehicle. The Soviets are also developing a space shuttle program. (635)

1.16.1 PROGRESS CARGO SHIP



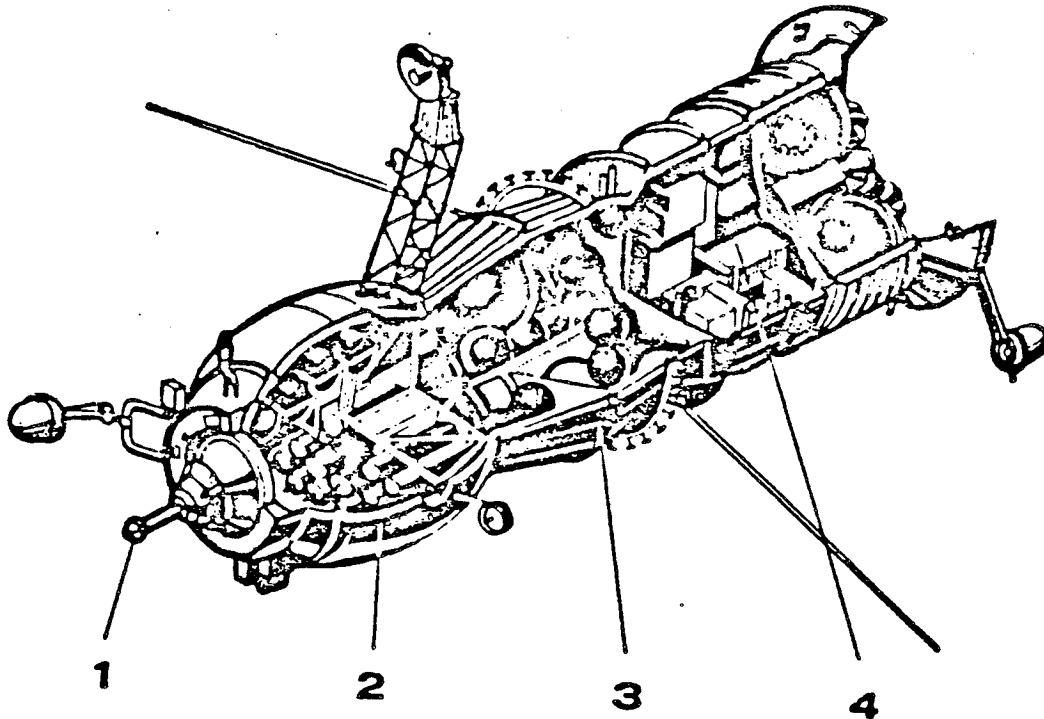
548

The Progress Cargo Ship is sent to the space station once every three to six weeks.

"It is obvious that for flights lasting several months...to a year, it is impossible to make the necessary reserve of materials to the station in one trip. It is necessary to organize continuous material and technical supply of the station and its crew by using special cargo ships." (264)

SOVIET SPACE STATION ANALOGS, Ed. II
1.16 Logistics

The USSR resupplies their station with the Progress, an unmanned and nonreturnable ship. The Progress was initiated on the 96-day mission (docking with the Salyut 6 on January 22, 1978). Its configuration was based on the Soyuz. For economic savings many of the same systems were used. The Soviets credit the Progress ships as a reason for the Salyut 6 operational life being doubled.
(62)(128)(154)(173)(265)(387)(407)(548)(619)



1. DOCKING UNIT
2. CARGO COMPARTMENT
3. REFUELING COMPONENTS COMPARTMENT
4. INSTRUMENT - ASSEMBLY MODULE

Ed. I

1.16.1.1 FREIGHT

Some of the items Progress supplies to the Salyut:

- Oxygen regenerators for ECLSS
- Food (fresh and for pantry)
- Water
- Elements for the life support systems
- Tools
- Scientific equipment
- Parcels from families
- Letters
- Eleutherococin (See 1.10.1.1 Vitamins and Supplements.)
- Unexpected gifts (For example, on the 140-day mission one cosmonaut had his guitar sent to him.)
- Fuel

(34)(62)(100)(126)(127)(128)(154)(167)(174)(243)(265)(320)(341)(350)
(407)(458)(537)(548)(600)(649)

On the Progress 17, launched August, 1983, a small insulated compartment with its own hatch was built into the ship. Fresh fruits and vegetables were placed into it a few hours before the launch.
(147)(548)

Since each cosmonaut consumes approximately 15-30 kg of materials per day (almost 10 tons per year), a two-person crew requires a resupply mission every 3 to 6 weeks. (62)(154)(265)(548)

The type of cargo it carries can be changed to meet the specific requirements of crews. Some ships have transported chiefly items that are subject to depletion:

- Fuel
- Water
- Food
- Air regenerators for the life support system

Other ships have carried cargo consisting mostly of:

- Instruments and equipment (51)

SOVIET SPACE STATION ANALOGS, Ed. II

1.16 Logistics

The amount of cargo delivered is a hundred times greater than that which is returned to Earth. Since the Progress is unmanned and nonreturnable, it decreases the cost of transportation and operation. It also increases the payload capacity because the ship does not require heat protective shields, parachute systems, soft landing engines and launch control systems. (51)(264)(265)(329)(619)

After the crew has emptied the Progress of its cargo they fill it with trash and old equipment and it burns up during re-entry. (548)

A. Unloading

Cargo is carried in a special cargo compartment which has a multitude of shelves where various objects are fastened in place. (458)

Items on the Progress ships are secured so that a half turn of a special bolt lock is enough to release even the bulkiest items. However, items are still rigid enough to stay attached during the rigors of launch. (163)

Unloading takes some skill since items have to be moved around in such a way so as not to upset the stability of the Progress. (548)

The cosmonauts must be very careful while unloading. Some containers are so heavy that with too much force the container could turn into a projectile and damage the station or equipment. (62)

Unloading becomes easier with experience. (572)

As a rule unloading a Progress takes 3-4 full days. During the 237-Day Mission the time was extended slightly. (The cosmonauts unloaded the ship gradually.) (639)

B. Freight Compartment:

- Hermetically sealed
- It contains all the dry cargo which is mounted on a special frame
- The cargo is fastened with rapid release catches and special bolts which release the material with only a quarter turn
- The hatch to the Progress can be opened automatically or manually (548)
- Ordinary air atmosphere (760 mmHg)
- Temperature: +3° - +30° C
- Connected to the refueling component section (537)

SOVIET SPACE STATION ANALOGS, Ed. II

1.16 Logistics

1.16.1.2 REFUELING COMPARTMENT

Refueling Compartment:

- Has four tanks for fuel and oxydizer
- Spherical containers filled with compressed air and nitrogen for life support
- Requisite pneumatic and hydraulic systems
- The total weight of fuel and gases it can carry is 1,000 kg

A. Refueling:

When a Progress docks with Salyut the main pipelines are automatically coupled.

There are two fueling units:

- One for propellant (hydrazine)
- One for the oxydizer

Progress has four tanks, two for each.

These tanks have an accordion-type device in the middle. When the tanks are full the accordion is flat; as they empty, nitrogen is forced into the accordion to force fuel into the engines.

The first task in refueling is to remove the nitrogen from the fuel tanks and pump it back into its storage tank.

This is accomplished by a special compressor that has a 1 kw, 3 phase electric motor powered by the solar panels via an AC inverter. Since the power required for this is considerable the procedure is staggered over six shifts.

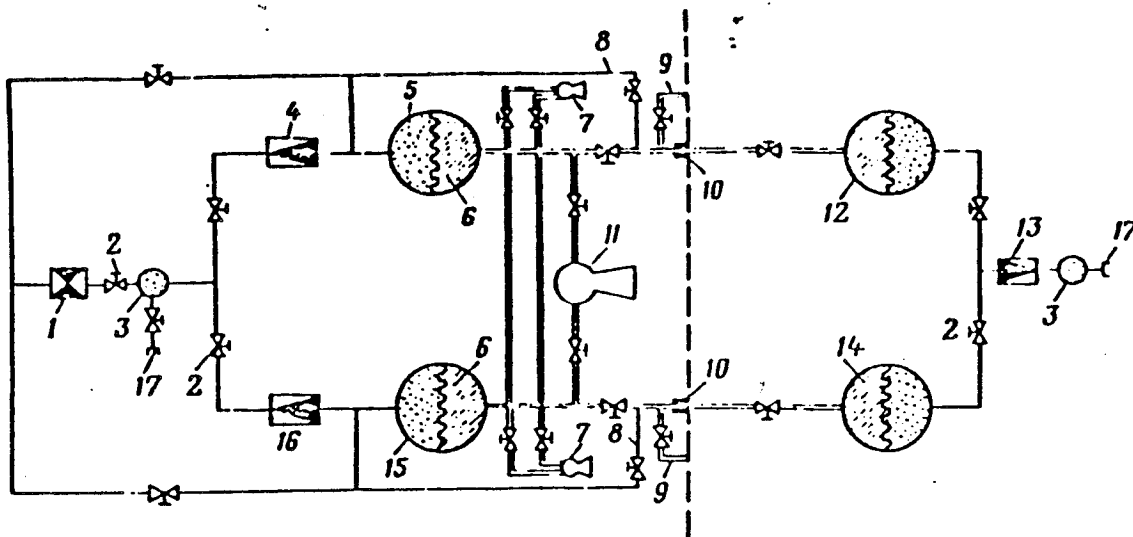
Once the nitrogen is removed from the fuel tanks, pumping of the propellant is done first, followed by the oxydizer.

Compressed nitrogen at 8 atmospheres is used to force the fuel from Progress into Salyut. (548)

After these operations are completed, all the fuel lines are bled and compressed nitrogen is forced through to insure that no excess fuel contaminates the atmosphere near the space station or the surface of the spacecraft. (548)(638)

The transfer of fuel is easier if the cargo ship can connect directly into the propulsion system. In this way the transfer is automatic, with little danger to the cosmonauts. (62)(154)

B. Progress/Salyut Refueling System:



- | | | |
|--|--|---|
| 1. Compressor | 7. Engines for minor movements | 12. Propellant tank (on Progress, 1 of 2) |
| 2. Valves and Vents | 8. Air lines to "blow off" residual fuel from pipe lines | 13. As no. 4 |
| 3. High pressure sphere for forcing of fuels | 9. Lines leading to exterior valves | 14. Oxydizer tank (on Progress, 1 of 4) |
| 4. System for pumping and withdrawal of compressed air into and out of spherical tanks | 10. Hydraulic connectors for docking system pipe interface | 15. Oxydizer tank on Salyut, 1 of 3 |
| 5. Tank for propellant (on Salyut, 1 of 3) | 11. Engines for major movements | 16. As no. 4 |
| 6. Partition | | 17. Tap for control of flow of compressed air |

SOVIET SPACE STATION ANALOGS, Ed. II

1.16 Logistics

- The Salyut has six tanks:
 - Three for fuel
 - Three for oxidant
- When a Progress docks on the aft docking port (fuel lines for in-orbit fueling are only located here) the fuel and oxidant pipes are connected
- Before fueling begins, tank pressure is about 20 atm
- Instead of providing Progress with powerful pumps capable of overcoming this pressure, the nitrogen pressurizing gas is pumped back into the supply bottles before refueling operations begin, flushing out the tanks with helium
- Use is made of a 1 kw, three-phase electric motor powered by the station's solar arrays via an AC inverter
- The propellants stored in the Progress (at a pressure of 2.5 to 3.0 atm) can be transformed to Salyut at pressures of up to 7 atm (537)(548)

If a Soyuz is located at the aft port and a Progress is needed to resupply the station, the crew dons spacesuits, enters the Soyuz, and undocks from the aft. The Soyuz station is then rotated by the ground crew around one of its transfer accesses until the forward end is facing the Soyuz and the crew redocks. (548)

1.16.1.3 MISSION HIGHLIGHTS

[See chart at the end of this section and calendar in Appendix.]

Listed are Progress ships sent to occupied or soon to be occupied stations.

SALYUT 6:

A. 96-Day Mission:

Progress 1 (first Progress delivery)

Docked January 22, 1978; undocked February 6, 1978

Brought to the Salyut:

- Mail and newspapers
- Water
- Food
- New clothing (including underwear)
- New weighted training suits for the crew
- Bed linen
- Equipment for routine work
- Air (to replace air which was lost when the crew opened a hatch either for EVA or for disposing garbage)
- Air purification filters
- Carbon dioxide absorber units
- Safety straps for chairs
- New set of "pickups" for the orientation and movement control system
- Splav electric furnace for materials processing experiments

The crew unloaded 1.3 tons of material. (548)(598)

B. 140-Day Mission:

Progress 2, 3 and 4

Progress 2	Docked July 9, 1978	Undocked August 2, 1978
Progress 3	Docked August 10, 1978	Undocked August 21, 1978
Progress 4	Docked October 6, 1978	Undocked October 24, 1978

SOVIET SPACE STATION ANALOGS, Ed. II

1.16 Logistics

Brought to the Salyut:

- Mail
- Water
- Food (including strawberries and milk)
- Fur boots
- Equipment for biological and medical experiments
- Fuel and oxydizer
- Film for the cameras
- A camera for Earth photography
- Photographic materials
- Guitar
- Globus instrument panel
- Kristall furnace for materials processing experiments
- Cassettes containing materials to be processed in Splav and Kristall
- Regenerators (548)(598)

C. 175-Day Mission:

Progress 5, 6 and 7

Progress 5	Docked March 13, 1979	Undocked April 3, 1979
Progress 6	Docked May 15, 1979;	Undocked June 8, 1979
Progress 7	Docked June 30, 1979	Undocked July 18, 1979

Brought to the Salyut:

- Mail
- Food (including five types of bread, fresh vegetables, apples, onions, and, at the crew's request, honey and fresh dried strawberries)
- Clothes
- New gravity suits
- Sleeping accessories
- A linen dryer
- Bath shampoo
- New tape recorder
- Walkie-talkie for IVA communications
- Film
- Electric bulbs
- A book called The Moscow Area (to remind the crew of the forest, fields and streams back home)
- Six CO₂ detectors (These were to be placed in various areas of the station to alert crew to concentrations of carbon dioxide. They also doubled as smoke detectors.)
- Black-and-white television set for two-way visual communications with Earth (and to allow the crew to watch regular television programs)

- An improved Kristall furnace (since the first one had stopped working)
- A tulip which had almost blossomed (Scientists wanted to find out how it would blossom and also thought it would bring the crew a touch of Spring.)
- Indoor plants
- The Biogravistat plant centrifuge
- New clocks and new command signal devices to properly sequence automatic commands
- New science instrument control panel
- Teletype machine
- Equipment for the life support system
- Vaporizer (Isparitel)
- Resistance experiments
- KRT-10 radio telescope
- Ampules for materials processing equipment (548)(598)

Prior to this mission there were practically no renewable resources stored onboard since during the interval between the 140-Day Mission and this mission the station was on automatic. All of the life support equipment as well as scientific equipment and food items were delivered by the cargo ship. (174)

Progress 8:

- An automated resupply ship sent to the unmanned station. It was still docked to the station when the 185-day crew arrived. Docked March 29, 1980; undocked April 25, 1980. (548)(598)

D. 185-Day Mission

Progress 9, 10 and 11

Progress 9	Docked April 29, 1980	Undocked May 20, 1980
Progress 10	Docked July 1, 1980	Undocked July 18, 1980
Progress 11	Docked September 30, 1980	Undocked December 9, 1980

Brought to the Salyut:

- Mail
- Air
- Polaroid instant camera and film
- New 25 cm color television (to replace the black-and-white model they had been using)
- Cassettes of pop music
- Onion, dill, parsley, cucumbers, radishes, canned fish, new flower seeds for the hydroponic garden

SOVIET SPACE STATION ANALOGS, Ed. II

1.16 Logistics

- Material for the life support system
- New motor for the Biogravistat centrifuge
- New intensifiers for the BST-lm submillimeter telescope
- Device to rectify a problem with a Bulgarian-made Duga instrument which was producing inverse images
- Atmosphere regenerators (smaller than previous models. Reduced the need for carbon dioxide absorbers) (548)

It was reported that 30% of the dry goods brought had been specifically requested by Cosmonauts Popov and Ryumin. (548)(598)

Progress 11 remained docked to the station when the crew left. It also transferred fuel into the station while the station was unoccupied. (548)

SALYUT 7

Improvements:

-The system for pumping liquids automatically from the ship into the station. (Practically eliminates the participation of the station's crew in this operation.) Each Progress usually has some fuel left in its own propulsion system after docking with the station and this fuel can be used to boost the station's orbit. (51)

-Equipment which is delivered to the ship has become more compact and lighter. (The high cost of delivering freight and the small amount of living space on the station has made it necessary to think about a decrease in the size and mass of the equipment and apparatus.) (75)

E. 211-Day Mission

Progress 13, 14 and 15

Progress 13	Docked May 25, 1982	Undocked June 4, 1982
Progress 14	Docked July 12, 1982	Undocked August 11, 1982
Progress 15	Docked September 20, 1982	Undocked October 17, 1982

F. 150-Day Mission:

Progress 16, 17 and 18

Progress 16	Docked November 2, 1982	Undocked December 13, 1982
Progress 17	Docked August 19, 1983	Undocked September 17, 1983
Progress 18	Docked October 22, 1983	Undocked November 13, 1983

Brought to the Salyut:

- Mail
- Fuel
- Book of poetry
- Equipment
- Research materials
- Life support equipment
- Components for the Tavriya unit (175)(487)

Improvements:

- During this mission, for the first time Progress was specially outfitted to transport perishable goods. (Previously the hatches to the cargo bays had to be closed several days prior to launch.) (147)
- Built-in fresh fruit and vegetable compartment (See 1.16.1.1 Freight)

The Kosmos 1443 also delivered items to the Salyut 7 during the 150-day mission.

G. 237-Day Mission:

Progress 19, 20, 21, 22 and 23

Progress 19	Docked February 23, 1984	Undocked March 31, 1984
Progress 20	Docked April 17, 1984	Undocked May 6, 1984
Progress 21	Docked May 10, 1984	Undocked May 26, 1984
Progress 22	Docked May 30, 1984	Undocked July 15, 1984
Progress 23	Docked August 16, 1984	Undocked August 26, 1984

SOVIET SPACE STATION ANALOGS, Ed. II

1.16 Logistics

Brought to the Salyut:

- Mail
- Food
- Drinking water
- Propellant
- Refuel:
 - Fuel
 - Oxydizer
 - Oxygen
 - Water
- Newspapers
- Movie and photo film supplies
- Portable cardiograph
- X-ray telescopes
- Regenerators for the life support system
- New scientific hardware
- New instruments
- Scientific apparatus (590)
- Medical equipment
- A total of 9 tons of supplies (124)

During this mission a Progress ship was separated from the Salyut without firing engines for the first time. The separation of the Progress 22 was accomplished with spring mechanisms. This was done as an experiment to check whether any products of combustion from the burn of the engine settle on surfaces of the solar batteries and thereby reduce their efficiency. It was said that no differences were detected in the output of the solar batteries as a result of the new method as compared with the old one. (31)

The control center recommended that the unloading of the Progress be carried out differently. For the first time, the crew did not work at it for several days continuously as was done earlier, but brought in supplies in stages while also carrying out the scientific research projects. (72)(139)(140)(161)(162)(245)(246)(308)(317)(489)(533)(616)

H. June-September 1985 Mission:

Progress 24 Docked June 23, 1985 Undocked ---

Brought to the Salyut:

- Fuel
- Equipment
- Apparatus
- Material for scientific research
- Life support (506)

SOVIET SPACE STATION ANALOGS, Ed. II
1.16 Logistics

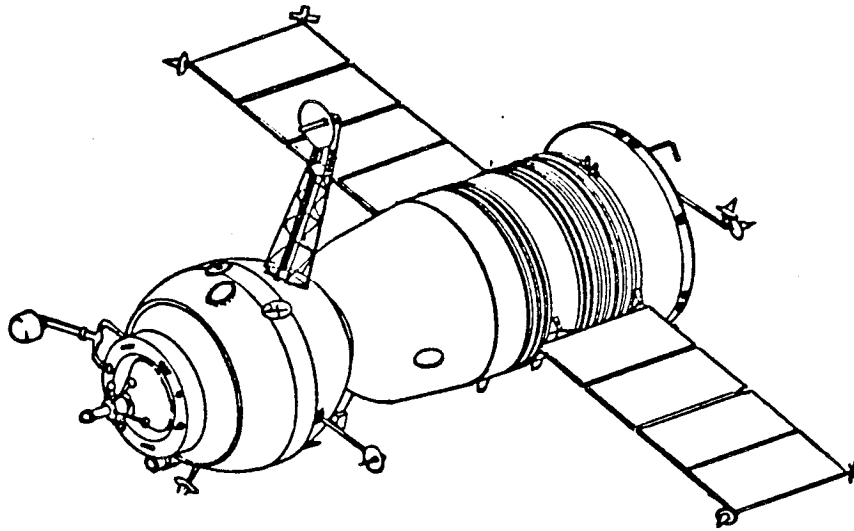
PROGRESS CALENDAR

PROGRESS	DOCKED	UNDOCKED	NO. OF DAYS	MISSION
1	01/22/78	02/06/78	15	96-Day Mission
2	07/09/78	08/02/78	31	140-Day Mission
3	08/10/78	08/21/78	11	
4	10/06/78	10/24/78	18	
5	03/13/79	04/03/79	21	175-Day Mission
6	05/15/79	06/08/79	24	
7	06/30/79	07/18/79	18	
8	03/29/80	04/25/85	27	Sent to unmanned station; still docked when 185-Day Mission began
9	04/29/80	05/20/80	21	185-Day Mission
10	07/01/80	07/18/80	17	
11	09/30/80	12/09/80	70	
12	01/24/81	03/19/81	-	75-Day Mission
13	05/25/82	06/04/82	11	211-Day Mission
14	07/12/82	08/11/82	30	
15	09/20/82	10/17/82	27	
16	11/02/82	12/13/82	41	150-Day Mission
17	08/19/83	09/17/83	29	
18	10/22/83	11/13/83	22	
19	02/23/84	03/31/84	36	237-Day Mission
20	04/17/84	05/06/84	19	
21	05/10/84	05/26/84	16	
22	05/30/84	07/15/84	46	
23	08/16/84	08/26/84	10	
24	06/23/85	----		June-September 1985 Mission

SOVIET SPACE STATION ANALOGS, Ed. II

1.16 Logistics

1.16.2 SOYUZ T - MANNED TRANSPORT SHIP



Pic. 548

This vehicle is used to transport the crew.

The Soyuz T space operations limit is arbitrary, with at least a five-month capability considered normal. (467)

On a normal Soyuz rendezvous, the ship will make four orbital corrections to establish the Soyuz near the Salyut. From about a 12 mile range the rendezvous is completed automatically using ranging data supplied by the Soyuz antenna.

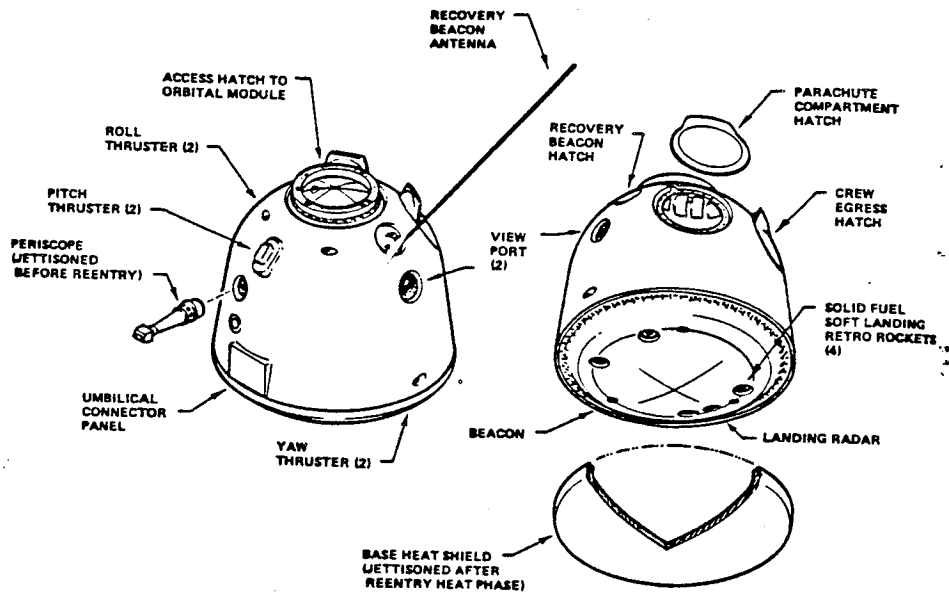
A final approach can be flown manually from about 3,000 feet if ranging data is available. (521)

Once its cargo has been unloaded into the station, the orbital module can act as a container to hold used equipment and trash for subsequent destructive reentry.

The computer onboard has no backup. (537)

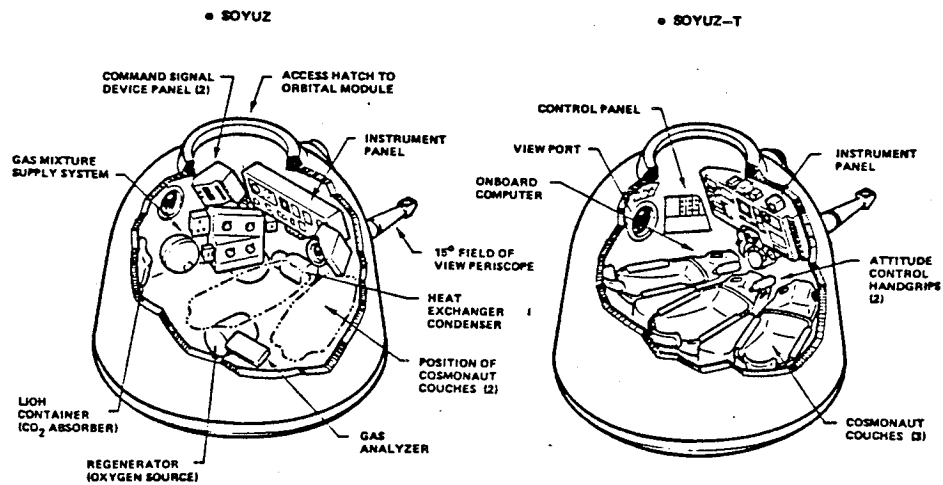
The Soyuz is used at times for privacy. The cosmonaut gets in, closes the hatch, and can spend some time alone. (45)

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Pic. 548

Soyuz Descent Module--Exterior Details. The cosmonaut crew is launched and recovered in the descent module of the Soyuz. After successful reentry, the base heat shield is dropped away to expose a set of soft landing solid retro rockets that are ignited just moments before touchdown.



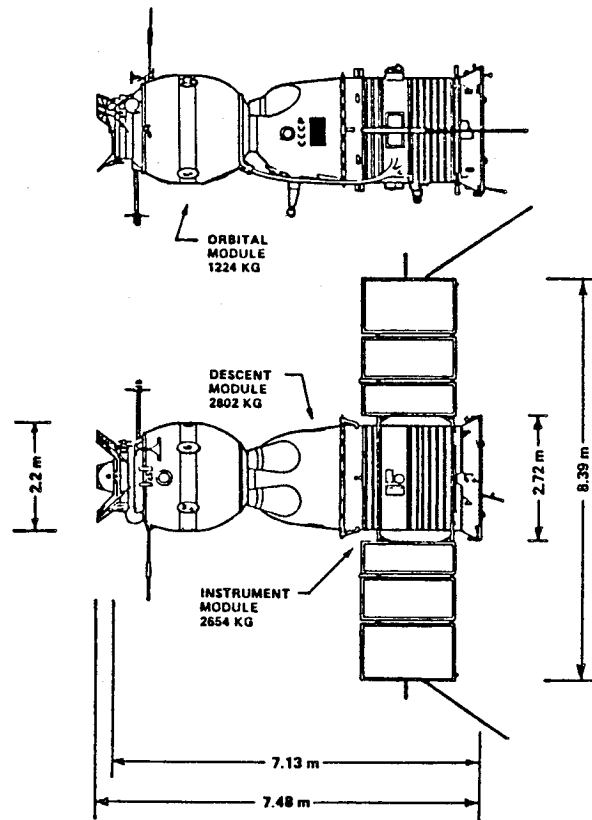
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Pic. 548

Soyuz Descent Module--Internal Details.

The spacecraft is divided into three connected elements that are independent for the power, thermal control and propulsion sections:

- Orbital module: contains the docking mechanism
- Command module: crew and flight instrumentation
- Rear section: motor and solar panels (569)



Pic. 548

A. Improvements:

The Soyuz T has been improved over the Soyuz with:

- An onboard computer system that provides increased spacecraft docking capability with the station and improves the Soyuz reentry capability (216)(598)
- It can hold three cosmonauts (If only two are flying, they can take along an extra 100 kg of payload (373)(527)(598)

SOVIET SPACE STATION ANALOGS, Ed. II

1.16 Logistics

The Soyuz could seat only two cosmonauts, so although the space station is large enough for a crew of more, only the constant two-member crew and at most two visitors could work. Soyuz T can seat three crew members, and, as a result, now crews of up to six have been accommodated onboard the Salyut 7 station. (273)

The Soyuz T rendezvous from above and in front of the Salyut rather than catching up with the station from behind as the former Soyuz would do. (548)

Upgrades:

- Three-person crew (or two plus cargo pod)
- Solar panels reinstalled
- New avionics including GPC with CRT, performing both GNC and SM functions
- Unified propulsion system (OMS and RCS on same tanks)
- New launch/landing pressure suits
- Jettisonable orbital module: can be left attached to Salyut docking port
- More powerful touchdown retro rocket (270)

150-Day Mission: Engineering improvements on the Soyuz T increased the use by crew to a maximum of 180 days. (124)

237-Day Mission: For the first time all data from the video display of the Soyuz T was transmitted not only to FCC but also to the Salyut. Blagov, deputy flight director, said that this made control a mutual process and thereby more reliable. (31)

1.16.2.1 COMPUTER

There is an autonomous onboard computing complex which can fly the mission without human involvement. This computer has a CRT display unit. Analog sequence control devices that were used previously have been removed, while the number of indicator panels have tripled. A periscope is still used so the cosmonauts can orient themselves in space. (548)

1.16.2.2 SAFETY

The rescue system has been designed so that if a malfunction occurs during the launch and initial flight, the launch vehicle main engines are automatically switched off, the spacecraft is separated from the booster and the rescue rocket engines are ignited for a controlled emergency landing. (548)

1.16.2.3 FUEL SYSTEM

The fuel system of the Soyuz T has been designed so that the main engine and all four attitude control thrusters can use the same fuel supply. This means that the attitude thrusters can serve as a backup to the main engine in an emergency. This unified system is also used on the Salyut and Progress. It results in higher thrust and maneuvering capability. The orbital module separates before retrofire instead of after as had been the case with the old Soyuz, thus saving 10% of the fuel since there is less mass to decelerate. The landing engines now have more thrust to provide for a softer landing. (548)

1.16.2.4 MISSION HIGHLIGHTS

Salyut 7, 150-day mission: The cosmonauts flew the Soyuz T-9 from the docking port of the service module to the docking port of the transfer module so that the service module docking port would be ready for the docking of the Progress 17.

Before undocking, the cosmonauts checked the serviceability of the onboard systems. They then passed into the Soyuz T-9 and closed the transfer hatches. Mutual search and rendezvous systems of the two spacecraft were switched on at a preset time. The station made a 180° turn. The Soyuz T-9 was linked up and docked with the transfer module. After checking the airtightness of the joints, the cosmonauts opened the hatches and passed into the compartment of the station.

The 150-Day Mission of the Salyut 7 demonstrated an operational lifetime of the Soyuz T of 150 days. (149)(523)(537)(557)

237-Day Mission: The visiting crew experimented with testing TV links between their Soyuz T and the Salyut. The visiting cosmonauts saw the inside of the Salyut on their screens. (546)

SOVIET SPACE STATION ANALOGS, Ed. II

1.16 Logistics

1.16.2.5 PROBLEMS

A fuel leak from an unclosed valve began a fire at the base of the A-2 rocket:

FIRE ON THE LAUNCH PAD

During the 150-Day Mission, two visiting cosmonauts, who had been trained to undertake space walks to correct a leak of the oxydizer, were set to launch. (The main crew had not been trained for panel EVAs.)

Ninety seconds before the launch, a valve failed to close and a fuel leak from it began a fire at the base of the A-2 rocket.

The crew had to eject from the burning rocket with the Soyuz launch escape system. This launch escape system (LES) should have fired instantly but due to the fire this did not happen.

From their control stations, the controllers responded and commanded the LES to fire. This involved two controllers in separate rooms ordering the ignition simultaneously. During this ten-second operation, the whole rocket was enveloped in flames with an explosion imminent.

The LES ignited and an automatic sequence took over. Within one second of the pyrotechnic separation of Soyuz, between the descent module and the instrument section, the solid rocket cluster on the LES tower ignited to pull Soyuz and its shroud away from the burning booster. The A-2 exploded under the rapidly rising LES, causing considerable damage to the pad and forming a massive fireball.

The LES carried the Soyuz a kilometer high before the cluster burned out five seconds after ignition. The four aerodynamic panels at the base of the shroud opened out like petals to slow down the ascent.

As a set of smaller solid rockets at the top of the LES tower fired, the descent module (DM) separated from the orbital module and fell out of the bottom of the ascending shroud. The DM reserve parachute opened to slow the fall and was rapidly followed by the ejection of the DM heat shield, exposing the small retrorockets at the base. These rockets fired when the Soyuz was close to the ground to slow the landing.

The touchdown was much rougher than normal. Rescue teams found the two cosmonauts shaken, but uninjured. (59)(175)

Engine trouble:

SOYUZ TROUBLE

Salyut 6, 175-Day Mission: During this flight Cosmonauts Ryumin and Lyakhov were to be visited by two other crew members who were coming on the Soyuz. The Soyuz ran into engine trouble and had to be sent back to Earth. Ryumin said that after this occurred they were concerned because the Soyuz that they were to return in had the same engine. They began to worry about engine function. "....two possibilities opened to us at this point in time: let ourselves go...and fall apart. Or, grin and bear it, and don't give it another thought. We chose the second as a means of psychological survival. And to make sure that it works, fall into work leaving ourselves no time for tormenting doubts." (338)

SOVIET SPACE STATION ANALOGS, Ed. II

1.16 Logistics

1.16.3 THE KOSMOS SERIES

Basic Characteristics of Kosmos Series:

Power:	3 kw
Orbital Module	14 metric tons
--Payload Up Capacity	3 metric tons
Descent Module:	6 metric tons
--Return Payload	500 kg

The Kosmos 929 was launched in 1977 and orbited for 201 days. (16)

The Kosmos 1267 was an unmanned module that was launched on April 25, 1981, and docked with the Salyut 6, while it was unmanned, on June 19, 1981. It was deorbited on July 29, 1982. (537)(548)

Prior to docking:

- Performed many orbital maneuvers
- Including separation of a large modular section weighing 600 kg. which re-entered and was recovered (548)

After Salyut 7 was launched, Kosmos 1267 propelled Salyut 6 into destructive re-entry on July 29, 1982. (537)(598)

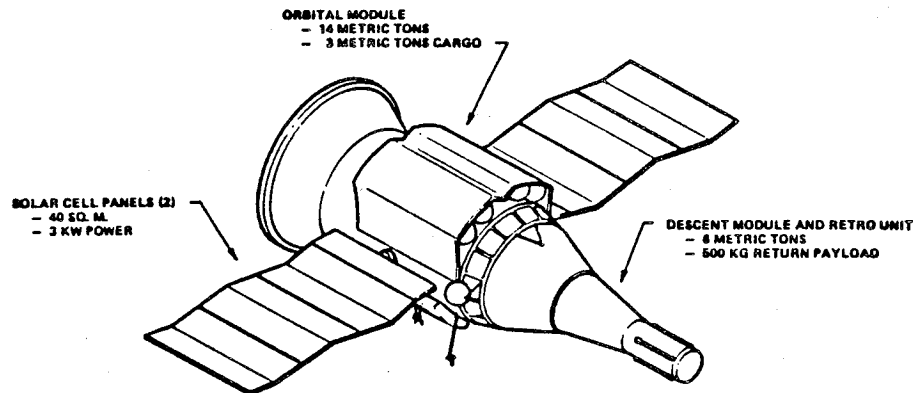
The Kosmos 1443 was launched on March 2, 1983 and docked with the Salyut/Progress on March 10, 1983. It was seen as a prelude to operations involving larger crews.

The Kosmos was undocked and was on independent flight for more than a week. During that time designers conducted additional tests:

- Maneuvers were performed in orbit
- Reserve systems were activated
- Methods for controlling the craft were perfected (107)

Two reports (537)(59) said that the Kosmos had a serious malfunction. [The reports did not indicate what the malfunction was or when it occurred.]

The cosmonauts seemed to enjoy the extra room they were able to use in the Kosmos. They were able to set up a workshop and put a vice in to do metal work. They were also able to store equipment there. They noted that the Kosmos would have been a good place to install a permanent shower. (See 1.4.5 Shower.) (535)



Pic. 548

On September 27, 1985, the Kosmos 1686 (said to be similar in design to the Kosmos 1267 and 1443) was launched. The aim of the launch was said to be:

- Try out the equipment units and the elements of the satellite in different flight regimes (including a joint flight with the Salyut 7) (653)

The Kosmos 1686 docked with the Salyut 7 and Soyuz T complex on October 2, 1985. The mutual search, the closing in, the mooring and docking were carried out automatically and were controlled by FCC and Salyut crew. The Salyut was docked to the station from the direction of its transfer compartment. (643)

The Kosmos 1686 delivered:

- Equipment apparatus and other cargo (643)

SOVIET SPACE STATION ANALOGS, Ed. II

1.16 Logistics

1.16.3.1 CARGO

Most of the materials were packed in containers stacked along the sides of the vehicle. Special trolleys that moved along guides set in the passageway facilitated the loading and unloading. (9)(415)

A. Delivered:

- Two supplementary solar batter panels (See 2.2.12 EVA Missions, 150-day mission.) (380)
- Food
- Water
- Filters
- Spare instruments
- Tools
- Regenerator units
- Medical equipment
- Scientific instruments

-Physical exercise equipment (331)

B. Returned:

- 350 kg of material (a week after Kosmos 1443 separated from the Salyut--August 23, 1983):
 - Results of 45 experiments
 - Pieces of equipment that had malfunctioned aboard the Salyut:
 - Air regenerator
 - Components of the Delta computer (548)

1.16.4 DOCKING

The aft docking port of the Salyut is used for Progress and Kosmos. (548)

Two days after its launch, the Progress docks with Salyut.

The two-day rendezvous results in slower closing speeds, which simplifies docking operations since there is no crew onboard to make final adjustments.

All systems are automated.

A radar rendezvous system is used for docking and the docking unit has warning systems to insure that plumbing and docking latches are connected properly.

The docking assembly has additional automatic hydraulic connectors to insure hermetic coupling of the main hydraulic lines of the Progress with those of the Salyut for the refueling operations.

There are 14 engines for docking and orientation:

- Each have 10 kg thrust

There are 8 precision orientation engines

- Each with 1 kg thrust

All operate on a unified fuel system as does the Salyut space station and Soyuz T. (548)

There are position lights at the tip of the horizontal solar panels to help docking operations by visual control. (422)

1.16 Logistics

There are three lights and two television cameras to help with the docking, which is controlled by the crew, ground controllers, or both:

- One television camera is aligned along the longitudinal axis
- One television camera is perpendicular (548)

The launch and docking of the Soyuz T takes about 24 hours. (154)

Docking is more difficult and uncomfortable when it is made at the moment of passage from light to shadow. This abrupt change in illumination makes it difficult for the eyes to adapt in time and control in docking under conditions becomes difficult. (339)

Docking problems:

FAILURE TO DOCK

Three cosmonauts were launched on April 20, 1983, but their Soyuz T was unable to dock with the Salyut 7/Kosmos station due to what appeared to be problems with the rendezvous regime.

The Soyuz rendezvous radar antenna would not deploy and an optically guided approach to the station had to be aborted in darkness when the cosmonauts were afraid there would be a collision between the Soyuz and Salyut.

Commander on the Soyuz T, Titov, said he was unable to get closer than 525 feet to the Salyut.

Problems began in the second orbit when the crew found that the dish antenna mounted on a large boom had deployed only partially from its launch position. (The radar antenna is a key element in the Soyuz automatic rendezvous and docking system.)

The crew received ground control permission to make several attitude control maneuvers at rates high enough to possibly swing the antenna in position. This failed.

The crew had received permission to attempt a rendezvous using only an optical sight and ground radar inputs for guidance. This had never been done before.

Without ranging data to provide distance and closing rate information, Titov had to tell Ground how large the Salyut appeared compared with the reticle marking on the sight. The ground team then computed what type rendezvous maneuvers to perform.

On orbit 19 Titov saw the Salyut in his alignment sight and reported the data. The ground told him to fire the spacecraft maneuvering engine for 50 seconds. Titov then reported to the ground the Salyut first occupied 60% of reticle section, then 80% of a section of the sight. At this point the Soyuz and Salyut flew out of range of Soviet ground stations for 35 minutes. Due to orbital geometry, however, the crew had to continue the rendezvous optically, some of it at night. Titov said he was able to approach within about 1000 feet of the Salyut and shine a searchlight beam from the Soyuz on the section as the two vehicles entered darkness. He said he could not see the space station clearly and was unsure of his depth perception accuracy for final maneuvers as the distance between the two vehicles closed.

Titov said by the time he reached about 525 feet from the Salyut he believed his closing speed was too great. He fired a braking maneuver and later said: "The speed still seemed too great and a crash was possible. I then switched on the engines to descend away from the Salyut."

The Soyuz is limited in the amount of propellant it can use for maneuvering and attitude control before a point is reached that suspends usage prior to re-entry.
(521)(539)(646)

SOVIET SPACE STATION ANALOGS, Ed. II

1.17 FUTURE DESIGN

The Soviet program is outspending the U.S. space effort by 3 to 4 billion per year and the Soviets are expected to quadruple their current annual 18 billion effort by the year 2000 as they expand manned space station operations. (560)

The Soviet Union modifies and adapts technology that is already in hand. This increases its capabilities in incremental fashion. "By relying on systems flight-proven in earlier space projects, the Soviets may have been able to restrain costs and minimize the time spent in development and construction." (61)

The Soviets are working on:

- More vigorous manned flights
- A permanently operating station with larger crews
- Replaceable modules docking with a space factory or laboratory:
 - Manned spacecraft not used just as laboratories, but probably as small production facilities in space:
 - For manufacturing materials for the electronics industry and medicine (Space research such as materials processing and astronomy have already made advances.)
- Reusable shuttle-like vehicles to ferry people and supplies
 - The Soviet space shuttle's first flight is expected by early 1986. Basic characteristics:
 - Similar in shape to U.S. Shuttle
 - No main engines in the orbiter
 - Main engines located in the external tank to which are attached four oxygen/hydrogen-fueled strap-on boosters:
 - Jet engines to provide more flexible landing capability
 - Engines not reusable. Will be jettisoned with the external tank on each launch
 - Lift-off weight: 4.4 million lbs. with 6.6 million lbs. of lift-off thrust
 - Maximum payload: 66,000 lbs.
 - Unmanned cargo module capable of "piggybacking" on the external tank in place of the orbital, which would provide 220,000 lbs. of payload capability (60)(562)

-Specialized stations or specialized modules:

--Housing several specialized labs on a single station will be difficult and is not necessary. A more attractive possibility is that of docking special purpose modules with the main station (The new "Mir" will accommodate such modules)

These will include more comfortable conditions for crews.
(70)(73)(124)(158)(270)(271)(368)(450)(510)(537)(591)(598)(646)

Replaceable modules will be connected by additional docking ports. The modules may fly detached from the main module. Modules that have been used for scientific research may be separated permanently or temporarily, or may be replaced by new ones which arrive from Earth.
(158)(273)(275)(351)(387)(450)

...it is more advantageous to use relatively small, relatively cheap and...improved stations..." (397)

Long-term orbital stations are seen as an effective instrument for space research. A prolonged mission is a means of achieving bigger results at less cost. (450)

General Vladimir Shatalov, Cosmonaut Corps Commander: "We are close to the constant operation of an orbital station -- to the around-the-clock and year-round work of cosmonauts aboard them, replacement of crews directly aboard the stations, and regular delivery of the necessary material into orbit...[but] it seems that the economic and scientific-technical advantage of large stations for the time being still appears doubtful and the possibilities of our Salyuts are far from exhausted." (275)

Ryumin: "Everything indicates that we will start out for other planets from near-Earth launching platforms, which will become the prototype of the first engineering settlements outside the Earth." (400)

SOVIET SPACE STATION ANALOGS, Ed. II

1.17 Future Design

1.17.1 CREWS

"The construction in the Soviet Union of orbital stations with changeable crews and of the Progress cargo craft marks a step forward on mankind's way toward interplanetary travel." (127)

Stations are being designed for 10-20 cosmonauts with the possibility of crews of 100. This could involve more than one large Soviet station in orbit simultaneously. (As of May, 1986, there are two Soviet stations in orbit: the Salyut and the Mir.) (63)(351)(423)(560)

There would be:

- Crew rotation leading to semi-permanence with three-person crews
- Longer overlaps with a six-person crew and 24-hour operations
- More specialist cosmonauts:
 - Doctors/biologists
 - Material specialists
 - Geologists/oceanographers
 - Astronomers/physicists

(271)(647)

Blagov, Deputy Flight Director, said that in the future consecutive work may take place. This would mean:

- Continuous manned flight, rather than putting the station on automatic mode periodically (See 3.1.1.1 Automatic Mode.)
- Loss of working time would be eliminated:
 - The crew would familiarize themselves with new scientific equipment and features of working with it on the station, and give the replacement crew a briefing [In September, 1985, this occurred, with one main crew member staying aboard the Salyut with two new crew members, while the other main crew member returned to Earth.] (30)(486)(646)

A. Longer Flights:

Researchers are looking into long flights. (359)

1.17.2 SPECIALIZATION AND MODULAR DESIGN

To make the transition to commercial production in space requires stations of modular design, or specialized stations designed to solve specific problems (biomedical or astrophysical, for example). These could prove to be more efficient because: (48)(351)(504)

- Research equipment could be used more effectively: (351)
- Modules could be equipped with specific-purpose instrumentation (504)
- It would alleviate overcrowding (of crew and equipment)
- Crews would no longer have to be limited to broadly trained cosmonauts:
 - Specialists in various areas could be included (537)

[It is expected that dedicated Kosmos-type vehicles will be used with the Mir]

Planned Systems:

- Some of the modules could fly independently and dock only for short periods of time for maintenance or repairs.
- Some would not dock at all but would be visited periodically by cosmonauts from a central base station. (48)
- Each module would have its own engine and be placed in orbit by an individual carrier rocket.(397)

SOVIET SPACE STATION ANALOGS, Ed. II

1.17 Future Design

1.17.3 ORBITAL COMPLEX

The Soviets plan to build a complex of large facilities in orbits ranging from 200 to 4000 kilometers. These would be served by freight and passenger transport spacecraft. (See 1.16 Logistics.) Included in the list of separate installations:

- Research laboratories
- Housing modules
- Powerful energy installations
- A refueling station
- Repair workshops
- Construction sites for producing and installing standardized components

Some of these facilities would operate automatically while others would be permanently manned.

Benefits of this orbital complex:

- Ability for continuous monitoring of the state of atmosphere and crops
- Detecting forest fires
- Producing mineral resource surveys
- Tracking ships and aircraft
- Providing stable television reception and permanent radio and television communications
- Batch production of materials unattainable on Earth
- Serving as a base for other space projects

Assembly could be accomplished by space tugs (See 1.16.3 Kosmos 1443), which would be used to assemble structures weighing many metric tons, the components of which would be launched into orbit stage by stage. (548)

1.17.4 OTHER DEVICES

Other New Systems in Planning:

- Heavy lift expendable boosters
- Closed life support system: (537)
 - Generate water, air and food independent of external supply
- A surgical table (reportedly completed):
 - Compact container which holds:
 - A soft insulated chamber of transparent material (so the operation can be observed)
 - The operating table
 - Sleeves with sterile surgical gloves are built into the chamber
 - Surgical equipment
 - All bandages and instruments are passed through valves
 - Facilities for supplying sterile air
 - Can be adjusted to a patient's height
 - Can be set in different positions (depending on the type of surgery (505)(592)
 - "In the view of the Soviet scientists, the use of...space operating tables on long...expeditions is fully justified, since in space flight not only...[is]...traumatism possible but also cases of various illnesses requiring effective surgical intervention." (505)
- Robotics
- Recycling of various products:

The Salyut 7 has a system for regenerating fresh water from atmospheric water condensation. In the future, there will be new systems to recycle other products. This means crews will no longer have to be supplied from Earth. "Naturally years of intensive work will be needed before a complete ecological cycle is created...but the first successful steps towards that goal have already been taken." (642)

II. TECHNOLOGY

2.1 INFORMATION AND COMMUNICATION SYSTEMS

The command radio link is used to transmit:

- Control commands and settings from the Earth to orbit
- Trajectory measurements
- Two-way telephone communications between Earth and the station
- Television and telemetry information from the station to Earth

This radio link system includes:

- Receivers
- Transmitters
- Antenna feeder device
- A program timer
- Decoder
- Other electronic and automation equipment (537)

Automatic signals should be clear so they can be received without distortion and in the shortest possible time:

- Signals should be sufficiently lit
- Adequate size for scales and indicator arrows
- A sufficiently loud auditory signal (114)

The Soviet Union deployed a system similar to the U.S. Tracking and Relay Satellite (TDRS) system in late 1985 called "Luch". This system will allow reliable, nearly continuous communication with Salyut stations and other spacecraft in low Earth orbit. (61)

2.1.1 COMPUTERS

The onboard computer contained in the "Del'ta" compact digital computer system relieves the crew of many complex operations. (340)(502)

The Del'ta System:

On the Salyut 6 the Del'ta was experimental. On the Salyut 7 it became part of the standard equipment. It is smaller than a typewriter. Its functions:

- Navigational calculations
- Turning the radio equipment on and off during communication sessions and recording the sessions
- Producing reference information
- During astrophysical experiments, it controls the station so instruments are aimed at appropriate space objects:
 - Uses minimal fuel
 - Uses minimal time
- Can position the station horizontally or vertically

(6)(8)(54)(236)(525)(548)(592)

Computers, as with any automation, can malfunction. During the 211-Day Mission, there was a computer problem that involved a Soyuz T visiting crew, during the final docking phase. The crew was able to switch to manual procedures to dock successfully. (See 3.1.1.1 Automation.) (215)

The 150-Day Mission crew had a malfunctioning memory board on the Del'ta. (See 1.3.13 Maintenance Activities, 211-Day Mission.) (235)

A. Displays:

Signaling devices and controls should be:

- Functional (related functions together)
- Significant (most important devices located in the "best" area.

For example, in the center of the panel.

SOVIET SPACE STATION ANALOGS, Ed. II
2.1 Information and Communication Systems

- In optimal position (determined by characteristics required in the use of the instrument)
- Arranged according to usage sequence (of operations performed) and usage frequency (most frequently used in center; infrequently used around periphery)

Numerals, divisions, markings, pointers and other detail should be heavily contrasted from the general surface.

There should be good illumination and no glare.

There should be no disorderly bunching of data displays, levers, handles or knobs. (219)

B. Future Design:

In the future, the Soviets hope that computers will take over the job of controlling all the systems of the station to save the crew a great deal of time. By special command, a cosmonaut will simply ask about the performance of something (for example, the heat regulation system), and Del'ta will flash a reply on its display. (592)

COMPUTER AS ARTIFICIAL BRAIN

The use of voice requests to be used within the computer system is being considered. Cons: It is difficult for humans to be governed and to trust a machine. Pros: Voice requests by a computer are convenient and more expedient.

The speech contact system can be designed so that the computer will react differently to the operator's emotional condition. The emotions would be determined by speech signs.

There will be an automatic verification of the speaker and an evaluation of the human emotional state. (263)(375)

SOVIET SPACE STATION ANALOGS, Ed. II
2.1 Information and Communication Systems

Computers will also be used to solve problems of automatic medical controls and will handle the programmed collation of scientific and diagnostic information.

Storing of information will be done in onboard memory systems.

If a doctor is present onboard (as was the case in the 237-day mission), the computer will be used as an aide by performing in the role of a diagnostic machine. (385)

C. Salyut 6:

Much of the processing of information was done using the onboard and ground-based computers. Calculations were performed in a matter of minutes. On the EVM computer more than 3500 telemetric sensors were set up which could transmit with a frequency of one per minute to a hundred times a second. The entire volume received at FCC in one communication session with the station could exceed 10^9 binary units.

Information Received:

One third concerned the operation of visually important systems:

- Heat regulation
- Maintenance of the gas composition of the atmosphere
- Electrical power supply
- Engine assemblies
- Systems of control

One third was concerned with the scientific and technical experiments.

One third was concerned with the operation of the onboard systems and structure of the station. (198)

2.1.2 TELEVISION SYSTEMS

The television system is used to transmit color and monochrome images from the onboard television cameras to Earth and to the onboard television screen. The system includes:

- External stationary television cameras (3-monochrome images)
- The reporting television camera (1-color)
- The reserve reporting camera (2-monochrome)
- Video monitors
- The antenna feeder devices
- Special lamps
- Automation and electronic equipment (537)

[On the Salyut 7, the cameras are probably located in a manner similar to the Salyut 6]:

On Salyut 6:

Two external cameras:

- Located just above the two docking ports to aid in docking maneuvers. (This is especially important during the automatic docking of a resupply craft at the aft port.) (154)

The cosmonauts' work outside the station during EVA was monitored with the aid of a television camera which was mounted on a magnetic ball joint installed near the EVA hatch. (424)

Inside the working compartment there were two television cameras:

- One manual
- One permanently attached

The manual one could be used to make television reports from any section of the station. (70)

Daily inspections of the Salyut 6 exterior were made with these cameras. (154)

SOVIET SPACE STATION ANALOGS, Ed. II
2.1 Information and Communication Systems

The Salyut-7, 211-day flight: Some cosmonauts complained that there were too many television sessions and it interrupted their work. (45)

Niva: An onboard television complex that was developed in order to record the results of experiments:

- Images are recorded on videotape and then transmitted to Earth via a television channel
- Also can be used as a means of psychological support
- Includes a set of video films sent from Earth. Films are constantly renewed

2.1.2.1 TWO-WAY TELEVISION

- Enable cosmonauts to link up directly with computer systems (91)(174)
- Used for training sessions (91)(174)
- Used for psychological support(421)
- Cosmonauts can see and talk to their families: (170)(338)

Salyut 6, 185-Day Mission: During this flight, the FCC arranged for a television broadcast from Ryumin's apartment to celebrate his birthday. The broadcast featured a party that included a birthday cake and friends and family singing, "Happy Birthday." (164)

Salyut 7, 211-Day Mission: One of the cosmonauts had a daughter who celebrated her eighth birthday while they were on the Salyut 7. The crew made a cake from packets of bread and used felt-tipped pens for candles, simulating the tongues of flame with foil. They hung colored balloons around the station. They projected all this to her by two-way television. (213)

SOVIET SPACE STATION ANALOGS, Ed. II
2.1 Information and Communication Systems

A. Problems and Solutions:

Two-way television was not easy to accomplish because interference with reception from various apparatus onboard had to be overcome. A directional aerial was devised which automatically locks onto the station and sends the television signals in the right direction. Ground control can now transmit sketches, maps, graphs, photographs and visual instructions for repair work to the crew. (422)

B. Improvements:

During the 237-Day Mission:

- TV information was transmitted from the Soyuz T spaceship to the Salyut 7 for the first time
- Materials of echo-location studies of the heart were transmitted via TV channels from the orbiting complex (201)(526)
- Crew used the Earth-orbit TV link to receive two-way TV of the checks and instructions from FCC (161)

SOVIET SPACE STATION ANALOGS, Ed. II
2.1 Information and Communication Systems

2.1.3 IVA COMMUNICATION

Portable miniature radio sets are used in different areas so that the crew can communicate with each other without turning on the intercommunication system, which is located only at the control station. (6)(8)(502)

To provide loudspeaker communications within the sealed station sections, there are loudspeakers, microphones and amplifiers at the control posts and working locations. (537)

A. Salyut 6:

A walkie-talkie system for internal communication was used. (170)

SOVIET SPACE STATION ANALOGS, Ed. II
2.1 Information and Communication Systems

2.1.4 AIR-TO-GROUND COMMUNICATION

The Salyut cannot communicate via line-of-sight circuits directly with Earth stations during every one of its 15 or 16 daily orbits. On those orbits when communication is not possible the cosmonauts sleep and telemetry communicated via shortwave circuits is sometimes used to monitor basic onboard systems. (537)

The crew can communicate with Earth stations on Soviet territory for only 25 minutes out of every 90. (61)(537)

Prior to the Salyut 7 the Soviets renovated and expanded the facilities of the FCC. They added a third control room for controlling the flight. (167)

One room in the FCC has been dedicated to psychological support. Special radio programs, music and messages are prepared in this room for broadcast to crews. (See 2.1.2.1 Two-Way Television and 3.3.2.1 Family and Friends.) (217)

Each evening the latest news is transmitted to the crew.(213)(456)

Russian experiments have shown that as mission length increases, the depth and duration of external communications also increased. (58)

2.1.4.1 CREW AND GROUND

Lebedev, 211-Day Mission: "The hardest thing during a flight is keeping good relations going with the Ground and among the crew." (45)

Lyakhov, 150-Day Mission: "If the mood is good on Earth, then it is good here, too. And this means that the work goes smoothly." (104)

SOVIET SPACE STATION ANALOGS, Ed. II
2.1 Information and Communication Systems

The chief operators are usually cosmonauts training for subsequent flights. (252)

There should be:

- Psychological compatibility among the crew and the ground (87)(263)(339)(410):
 - The FCC capcom's good mood is vital because it is passed on to the crew. (170)
- Cooperation and friendliness (339)(410)

When there are visiting crews from foreign countries, and experiments are being conducted, scientists from both countries are at FCC for communication. (260)

A. Problems and Solutions:

As the mission lengthens, the cosmonauts begin to show signs of hostility. They sometimes:

- Hold back on communication to the ground, deliberately hiding information
- Become irritated at questions they deem unnecessary (34)

The communication channel should be utilized to resolve two basic problems of medical support:

- Optimal organization of communications
- Use of the interrelationships between crew members, ground-based controllers and operators as a tool for regulating the psychological status of the cosmonauts

Correct operator/crew contact dictates the psychological climate in the space cabin. For instance, inaccurate actions by operators may cause anxiety, waste of time due to additional questions, and change in the time schedule of different operations. It is the responsibility of psychologists to help regulate the psychic status of cosmonauts.

SOVIET SPACE STATION ANALOGS, Ed. II
2.1 Information and Communication Systems

Communication operators should have some knowledge of psychology and know how to use it in practice. They should:

- Observe the etiquette of voice communications
- Evenly distribute questions between the crew members
- Avoid statements with negative implications
- Allow crew members the longest time in voice communications (91)

2.1.5 TELETYPE

The teletype and printer make it possible to receive information from FCC without interrupting the cosmonauts' work. (70)(537)

ORIGINAL PAGE IS
OF POOR QUALITY

SOVIET SPACE STATION ANALOGS, Ed. II

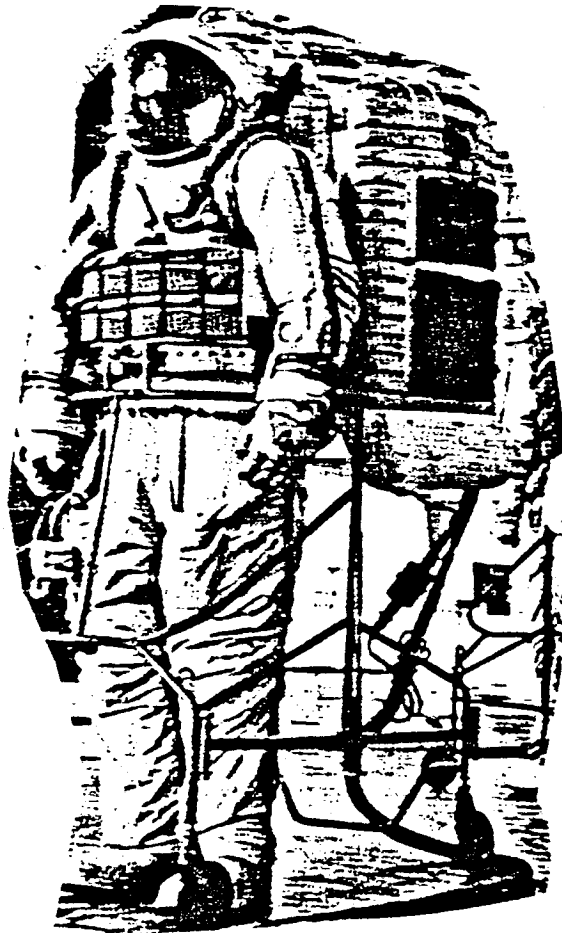
2.2 EVA

2.2.1
SPACESUIT



A. Spacesuit Design:

The Soviet spacesuit has evolved gradually. New suits with greater capability were sent up to the Salyut 7 during the June-September mission of Dzhaniybekov and Savinykh. The new suits are modified versions of the EVA suits Salyut crews used from 1982-1985. The improvements made were based on the EVAs of Salyut crews. (427)(648)



The EVA suit:

- Weight: 154 lbs
- Semi-rigid
- Operating pressure:
 - Variable
 - Upper pressure of 7.73 psi (400 mm quicksilver)
 - Generally operated at 5.88 or 4.00 psi

- Sizing: Adjustable (one size fits all)
- Metal upper torso
- Cloth arms and legs:
 - Convolute joints
 - Sealed metal joints with ball bearings
 - Soft hinges
 - Sizing adjustment devices
- Custom gloves:
 - Small attached mirror on cuffs
- Entry:
 - Rear hatch with zipper
 - Unassisted entry taking 2-3 minutes
- Single gas system
- Liquid-cooled undergarment
- Metal helmet with plastic visor
- Control panel on chest:
 - The controls have been located more conveniently on the new suits
- Reusable
- Ambient pressure backpack
- Maintained on-orbit (648)

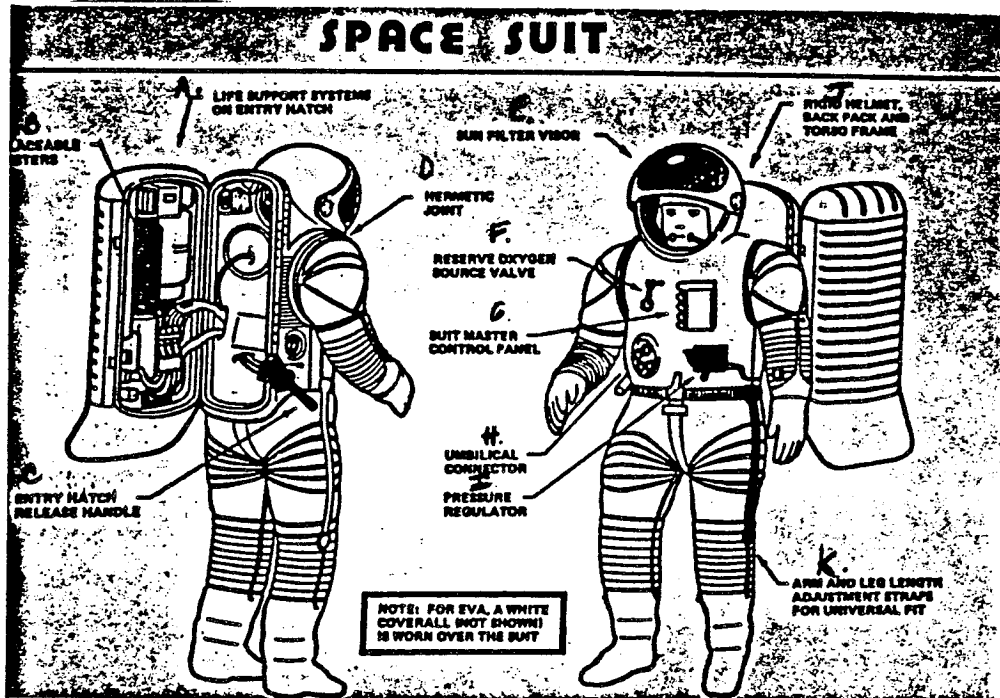
The entry hatch is closed by a cam-fitted handle locked in a closed position by a special locking device: (348)

-The cosmonaut pulls a ring on the front of the suit to pull the backpack closed, and pushes down a handle on the right side near the waist to effect the seal. The pressure seal is made by means of a bladder/pin system in the backpack. When the back-pack is closed, a range of pins are inserted into the rim that holds the bladder. The bladder inflates when the suit is pressurized, completing the seal.



Entry Hatch

The backpack (PLSS) is an ambient pressure system. Valves and connecting systems are not secured to vacuum.

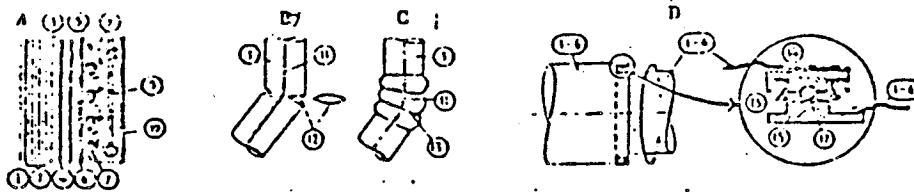


Pic. 548

- A. Life support systems on entry hatch
- B. Replaceable cannisters
- C. Entry hatch release handle
- D. Hermetic joint
- E. Sun filter visor
- F. Reserve oxygen resource valve
- G. Suit master control panel
- H. Umbilical connector
- I. Pressure regulator
- J. Rigid helmet, backpack and torso frame
- K. Arm and leg length: adjustment straps for universal fit

SOVIET SPACE STATION ANALOGS, Ed. II
2.2 EVA

The soft arms and legs, which facilitate mobility, have been improved on the new suit. (648)



Pic. 540

Structural Components of Suits

- A: Variants in structure of soft shell
- B,C: Joints of soft parts of suit
- D: Pressure bearing

- 1) Outer protective fabric
- 2) Packet of layers of screening and vacuum insulation
- 3) Pressure shell of suit
- 4) Main airtight shell
- 5) Backup airtight shell
- 6) Lining
- 7) Ventilation - system tubes
- 8) Ventilation gap
- 9) Water-cooled garment
- 10) Next-to-body undergarment
- 11) Pressure fastener (strip, cord, cable)
- 12) Transverse fold
- 13) Transverse cord
- 14) Outer race of bearing
- 15) Inner race
- 16) Airtight valve
- 17) Ball bearings

The protective metal helmet has been improved on the new suits:

- There are two lights on this helmet which are convenient to switch on
- Even on the dark side of the orbit the lights permit illumination of the control panels or the work place in front of the cosmonaut(s)

There is a recycling system for absorbing carbon dioxide.

There is a harness with medical monitoring equipment:

- Sends EKG, pulse and respiratory rate information to the ground

The suit:

- Can operate autonomously or via an electrical line to station
- Backpack for reserves of:
 - Oxygen
 - Water
 - Exhaust fans
 - Pumps
 - Full access to backpack (S.389)
- There is a tether with a snap hook that the cosmonaut attaches to securing points on the surface of the station
- Curves correspond to the joints of the body with soft hermetic hinges

The mirrors on the cuffs can be used for rearview viewing.

Pressure bearings are used in the region of the shoulder and wrist.
(518)

Suits are kept on orbit without return to Earth for maintenance or repair for about 10 EVAs (or a total of 50 hours of EVA with a length of about 5 hours per EVA).

Suits are left in the airlock, connected to a ventilation system, when not in use. This prolongs the service life of the life support system.

SOVIET SPACE STATION ANALOGS, Ed. II
2.2 EVA

Prior to EVA, the crew replaces:

- Water filters
- The oxygen cannister
- Lithium for CO₂ scrubbing

After EVA the suit is:

- Wiped out
- Blown dry
- Connected to the ventilation system

Heat rejection is controlled by a sublimator system, which is monitored and controlled by means of a telemetry link by the ground. (33)

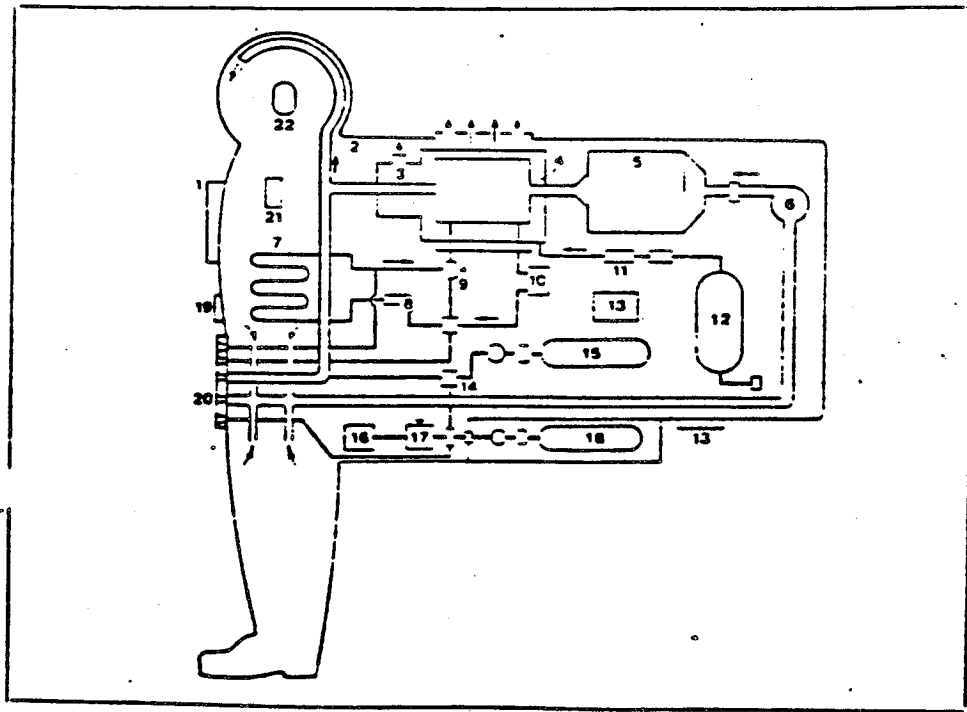


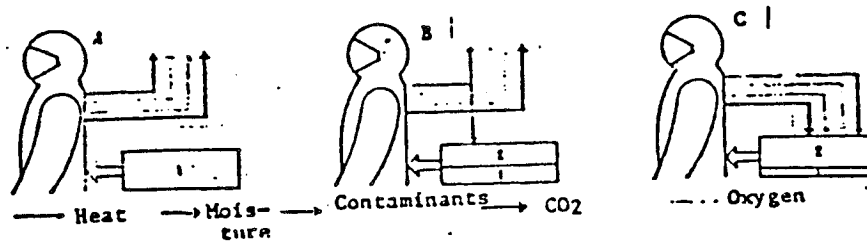
Fig. 306

- | | |
|---------------------------------------|--|
| 1) Central panel | 13) Automatic control equipment |
| 2) Cavity | 14) Emergency oxygen valve |
| 3) Moisture absorber | 15) Cylinder of reserve oxygen |
| 4) Heat exchanger | 16) Oxygen regulator |
| 5) Carbon dioxide remover and filter | 17) Suit-pressure regulator |
| 6) Fan | 18) Main oxygen cylinder |
| 7) Water-cooled clothing | 19) Safety valve |
| 8) Pump | 20) Connection with spacecraft life support system |
| 9) Water temperature regulator | 21) Medical equipment |
| 10) Closed-loop water cooling circuit | 22) Radios |
| 11) Water flow regulator | |
| 12) Open-loop water cooling circuit | |

(1)(22)(33)(96)(129)(152)(154)(163)(236)(271)(306)(348)(349)(410)(465)
(476)(548)(646)(648)

B. Life Support System:

- Ambient pressure system located in the backpack
- Self-contained
- Consists of a number of integrated systems:
 - Oxygen supply system that includes reserve oxygen storage, supply devices and equipment for control and maintaining suit pressure
 - Ventilation system and environmental gas composition control system includes carbon dioxide and contaminant removal units and gas circulation control equipment
 - Thermal control system (See 2.2.4.2 Thermal Control System.) provides removal and dissipation into space of the heat produced by human and instruments. It also provides for the removal of heat transferred into the suit from outside
 - Electrical system, equipment control and monitoring systems
 - Radio communication system (348)



Schematic of Functioning of Standard Open-Type PLSS
 (Water Cooling not Shown):

- | | |
|------------------------------|-----------------------|
| A: With venting into vacuum | 1. Oxygen-supply unit |
| B: With partial regeneration | 2. Regeneration units |
| C: With full regeneration | |

The spacesuit has no umbilical lines. Supplies of oxygen and water, blowers, pumps and other equipment are accommodated in the cover of the rear "hatch."

The life support system of the suit is connected to panels on the station before and after EVA, which means suits can be worn for a longer period of time. (311)

C. Thermal Control System:

The thermal control system maintains the cosmonaut's body temperature within given limits and a normal moisture content in the gaseous medium. Gas or water is used as the heat carrier which, when heated by part of the cosmonaut's body heat, keep him from overheating. Forced ventilation causes the gas to circulate through the spacesuit. (25)

With the water system, the cosmonaut wears a garment that has a network of plastic tubes through which the water circulates. There are several layers. In carrying off part of the heat generated by the cosmonaut, the heat carrier is warmed and then cooled in heat exchangers that radiate into space, after which it is used again to cool the cosmonaut's body. The temperature can be maintained manually on a physiological basis or automatically from the ships temperature regulation system. Materials and colors which reflect strong solar radiation are used. (25)(152)(311)(348)(349)(465)(585)

-Has three layers of protection against extreme temperatures:

--Outer layer:

---A protective vacuum insulator

---Load bearing

---Not hermetically sealed (476)

--Inside:

---Special flying suit that regulates the temperature

---Made of rubber

---Hermetically sealed (465)

D. Safety:

On the station exterior walls the number of restraint devices has been increased:

-Cleats

-Hooks (22)

There is a safety line with a snap hook which the cosmonaut can use to secure himself to handrails on the surface of the station. (311)

SOVIET SPACE STATION ANALOGS, Ed. II
2.2 EVA

E. Operating Pressure Pre-Breathe:

- 30 minute pre-breathe
- The new suit has an upper pressure of 7.73 psi (400 mm of quicksilver):
 - The Salyut 7 psi (14.7) is not lowered to accommodate prebreathing for EVA (33)(36)

On the Salyut 6/7 Suit I, the high absolute pressure was 300 mm of quicksilver. (349)

The cosmonaut can manually vary the pressure from a control on the front of the suit. This capability is limited to 5.88 or 4.00 psi. (33)

Short-term emergency operation is allowed down to 3.8 psi to provide enhanced finger dexterity and mobility. (274)(349)

F. Complaints:

-Overcooling:

- Overcooling appears to be related to the differences between microclimate of the spacesuit and station (the temperature and air humidity of the station being quite low), as well as dampness of underwear when working in the spacesuit. Changing to dry underwear and warm clothing, raising ambient temperature and eating hot food leads to normal heat sensation. (1)

-Overheating:

- The overcooling and overheating occurs because of the sharp contrasts in temperature. On the light side, temperature can be +136° and on the shadow side, -140°. (456)

-Spacesuit not elastic enough: (45)(121)(413)(577)

- Too much energy has to be expended for each movement (Cosmonauts lose about 6.6 lbs in body weight after several hours in EVA) (413)(646)
- Difficult in using some tools (particularly the URI) (See 1.3.8 Tools.)

-Vision limited (413)

-Tying knots:

- "...It's like trying to thread a needle in boxing gloves." (589)

One cosmonaut complained that the folder, which is attached to the wall, vibrated all the time and the pencil would slide out. (96)

2.2.1.1 FUTURE SPACESUIT GOALS

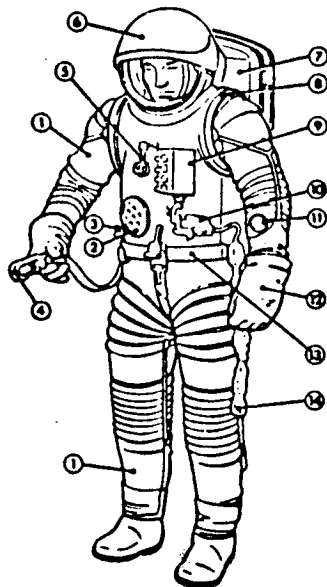
- Comfort
- Reliability
- Regenerative closed life support system
- Facilitation for movement
- Facilitation for orientation
- Restraint systems
- Mobility devices
- Special tools and instruments
- Freedom of movement
- Option to perform multiple operations
- A wide field of view
- Strong
- Light
- Easy to put on
- Adjustable

For greater reliability, all systems and units should be duplicated.
(20)(21)(152)(311)

2.2.1.2 SPACESUIT EVALUATION

- Easy to put on and take off
- Good arm mobility
- Good tactile sensitivity while manipulating small objects while wearing pressure gloves (163)(311)(349)
- Serviceability and higher reliability due to:
 - The absence of external pneuhydraulic pressure lines integrating the path and the spacesuit
 - The controls location on the rigid torso in places of easy access)
- Safe pressurization (a mechanical joint provides pressure sealing)
- Compactness in operating state (overall dimensions are less than those of corresponding pressurized soft spacesuit with a pack) (348)(349)
- Adequate visor assembly density
- Suit universality (easy individual fit - it can be worn by cosmonauts with different anthropometric data)
- Suit design allows for cosmonauts' "growing" during weightless flight (22)(349)

Salyut-6 Semi-Rigid Suit



- ① Soft arms and lower torso assembly
- ② Gas-water connector
- ③ Entrance hatch door handle
- ④ Safety tether hook
- ⑤ Emergency oxygen supply lever
- ⑥ Sun visor
- ⑦ Hard (metal) torso
- ⑧ Shoulder bearing
- ⑨ Pressure control and monitoring panel
- ⑩ Suit-pressure mode selector
- ⑪ Suit pressure gage
- ⑫ Glove
- ⑬ Load bearing ring (bottom of hard torso) provide
 - Attach points to donning station
 - Safety tether attachment
 - Lower torso axial restraint attachment
- ⑭ Electrical connector

2.2.2 EVA LENGTH

There has been an increase in the maximum time during which the EVA suits can support the cosmonaut:

-5 hours on the Salyut 7, as compared to 3.5 on the Salyut 6
(75)(96)(175)(548)

There has been an increase in the operating time of the heat regulation system. During the Salyut 6 Missions, the heat regulation system had to be repaired.
(25)(311)

The total time dedicated to an EVA activity, including all pre- and post-activities, is about 8-9 hours. (33)

2.2.3 EVA MOBILITY

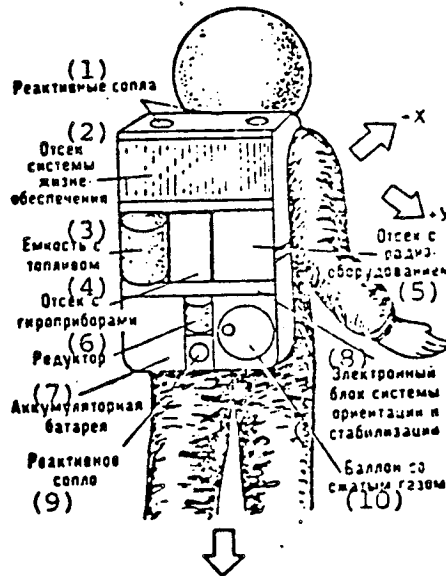
During EVA it is necessary to use goal-oriented locomotion which can only be learned to a limited extent on Earth. This involves stable use of a tether cable, optical-motor coordination, and vestibulo-vegetative stability. It is important to find the optimum impulse in relation to the body center of mass. If these special aspects are not observed, there may be uncontrolled rotary motion, accompanied by a loss of orientation, which can result in a dangerous situation. (119)

2.2.4 FUTURE EVA MOVEMENT PACK (MMU)

Extravehicular Movement Packs are being developed. These will be important when large structures are assembled in space.

The Movement Pack will include a number of systems:

- Reaction motors
- Orientation and stabilization
- Life support
- Thermal regulation (25)



Ed. I

Extravehicular Movement Pack for a Cosmonaut

Key:

1. Propelling nozzles
2. Life support system compartment
3. Fuel tank
4. Compartment with gyroinstruments
5. Radio equipment compartment
6. Regulator
7. Storage battery
8. Electronics unit for orientation and stabilization system
9. Propelling nozzle
10. Tank with compressed gas

"...Designing these units is a problem of engineering psychology and must take into account a whole set of psychological and physiological parameters in the 'cosmonaut/MMU' system." (95)

A. EVA Movement Pack Requirements:

- Cosmonaut's trunk must be seen as the principle body because:
 - Its small mobility
 - More than 50% load of the body mass is concentrated in the trunk

- The limbs and the devices they support (such as instruments) should be seen as mobile bodies
- Different work postures are necessary
- To provide rotary motion around the center of mass or for counteracting perturbations, a device such as a gyroscope may be used:
 - The simplest device of this kind is a jet device in the cosmonaut's hands. The typical device produces a total impulse of about 18 kgf (using compressed gas as the working fluid: nitrogen oxygen). The engine switch and the thrust vector direction choice is performed by the cosmonaut. (95)

2.2.4.1 SAFETY

Oxygen can be supplied from the reserves stored onboard the spacecraft. This would be done with an umbilical line placed in a halyard. This would also carry the electrical leads for a telemetric measurement or radio communication system. Oxygen can also be supplied by an independent system. In this case, tanks similar to those used by scuba divers with oxygen stored in a compressed form is fed to the spacesuit through a reduction valve that reduces the oxygen's pressure. Carbon dioxide and impurities are eliminated with the help of absorbers that contain lithium oxide and activated charcoal. (25)

2.2.4.2 REACTION MOTOR SYSTEM

The pack would be equipped with reactive microengines. For progressive movement at least six engines would be needed. So that a cosmonaut might revolve around a center of mass, a reactive motion system consisting of 12 to 16 motors is required. This system would provide a high degree of reliability because of redundancy.

2.2 EVA

The motors would operate on compressed gas, emitted from a nozzle. This gas could be replenished either by replacing the tanks or refilling them from supplies onboard the ship.

Greater velocity could be obtained with motors using hydrogen peroxide or two component fuels. However, the temperature of gases coming out of the nozzle would be too high, which would make additional demands on the spacesuit thermal shielding system. (25)

2.2.4.3 ORIENTATION AND STABILIZATION SYSTEM

This system would need an instrument that measures the angular deflexion of the cosmonaut and the pack from the rate of deflection. A one-access gyroscope would be suitable for this purpose.

Control knobs would be used for manual orientation: One for controlling progressive motion; one for rotation around the center of mass. Both knobs would be located on the elbow rests. By moving the knob through a certain angle, the cosmonaut would send a signal to the control system and maneuver in space because of the production of linear or angular velocity.

The EVA Pack's operating time would be dependent on the fuel supply. Therefore, it is important that fuel use be minimal during the maneuvering process. This could be achieved by decreasing the frequency of motor use. (25)

2.2.4.4 PROBLEMS WITH THE MMU

Problems:

- Need for precise consistency of the thrust vector
- When the cosmonaut's hands are busy with stabilization and motor control, they lose efficiency in carrying out the space operations:
 - Further, during maneuvering the cosmonaut has one or both hands occupied, which restricts the performance of any other type of orientation. Some specialists propose to introduce a voice control system. (25)

- The absence of automatic stabilization increases the cosmonaut psychological and physical stresses: (95)
- While working outside, the cosmonauts perform different motions with their arms and legs. These movements cause a disturbing effect on the stabilization system and disrupt the cosmonaut's spacial orientation. These movements result in the constant displacement of the system's center of mass.
- The shifts in the center of mass are even more significant if the cosmonaut is carrying tools in his hands. (25)

2.2.5 FEATURES OF EVA

- Severe physical stress:
 - At the airlock stage the average hourly energy expenditure for most cosmonauts:
 - 170-230 W, reaching the maximum of 270 W in one person when preparing for EVA:

EVA EXAMPLE

At this stage the most labor-consuming operations are the final ones, when changing from onboard life support systems to the life support systems of the spacesuit. This is when energy expenditure of all cosmonauts in this sample increased to 280-420 W.

The physiological parameters were consistent with the work performed and changed over the following ranges during the airlock period:

- Pulse rate: 60-130/minute
- Respiratory rate: 10-30/minute (1)

-Emotional stress

-Changes in visual perception: (21)(119)

EVA VISUAL PERCEPTION

It is difficult to estimate distances in outer space. Past experience shows that a target can be estimated correctly only within 120 m. There is almost no reflecting matter in space so there can be difficulty in perception and the recognition of the shapes of objects. Because it is very bright (almost unrefracted light as well as the sharp formation of shadows), three dimensional objects can be perceived as flat surfaces. (119)

"Psychologists have discovered that switching over from spacial perception on the Earth to that in open space is...a difficult task, as the only source of information on one's position in outer space is the [eyes]." (21)

2.2.6 BIO-MEDICAL MONITORING DURING EVA

During EVA, cosmonauts wear a bio-medical belt. The sensors transmit real time data to Earth on:

- EKG
- Pulse rate
- Respiration
- Temperature conditions (1)(306)(311)

2.2.7 CAUSES OF EMOTIONAL STRESS DURING EVA

- The unaccustomed environment of outer space
- The high risk
- The feelings of responsibility
- A shortage of the information necessary for the accomplishment of a task
- A discrepancy between the ideas developed during training and simulation and the actual event (119)
- Spacesuits (338)

There is also the possibility:

- Of being hit by a meteorite
- Spacesuit depressurizing
- Operator's spacesuit could cease to function
- Spacesuit could malfunction (although there are backup systems)
(456)

If the same kind of work is done several times the cosmonauts:

- Have less emotional and physical tension
- Can do the work within a shorter period of time (349)

2.2.8 SUPERCOOLING

On completion of EVA and upon return to the station (when the environmental temperature is 19-20° C) the crews have reported body supercooling. This is explained by a microclimate change when leaving the suit (where temperature and humidity are elevated) as well as by the emotional stress of the EVA. (25)

2.2.9 EVA TRAINING AND SELECTION

Selection criteria for EVA include:

- Good physical training
- Good vestibular stability
- Psychological stability
- Visual and motor coordination (21)

Training for EVA:

- Using a space pressure suit
- Capability of working in emergency situations:
 - Sharp drops in pressure
 - Seal failure (13)

Cosmonauts are given special training to acquire skill in working with spacesuit systems and to refine operations related to EVA. Used are thermal pressure chambers (altitude chambers), a hydroweightless stand and flying laboratories. (See 3.4.1.4 Training Equipment and Facilities.)

During training, all the cosmonauts are subjected to 4-6 ascents in the pressure chamber, with prebreathing for 25-30 minutes at a pressure of 550 mmHg, followed by 2-4 hours of work with an average energy expenditure of 240-350 W. The absolute pressure in the spacesuit ranges from 270-300 mmHg with a change to an absolute pressure of 198-210 mmHg for 15 minutes. (1)

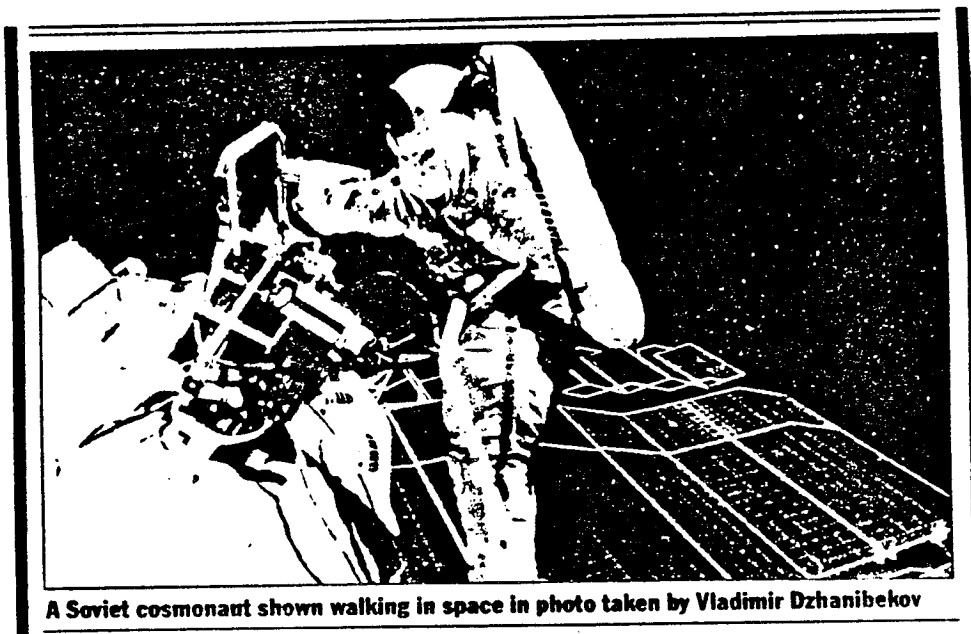
EVA training should include:

- Skills in locomotion (to keep uncontrolled rotary motions and angular positions of the body under control)
 - Simulator training to:
 - Develop the ability to orient the body in outer space with the help of a tether and to stabilize it
 - Learn to apport the expenditures of force while pushing away from the exit hatch and the use of traction force on the cable
 - Learn specific goal-oriented locomotion
 - Avoid uncontrolled body positions and uncontrolled motions
- (119)

2.2.10 EVA Instructions:

During EVA, a cellophane folder carrying the instructions is placed in the airlock.

2.2.11 EVA EXPERIENCE AND MISSIONS



Parade, 7/27/86

Pg. 14

A. Salyut 6 Missions:

[Note: Underlined cosmonaut performed the EVA.]

96-Day Mission:

Date: December 19, 1977
Cosmonauts: Grechko and Romanenko
Duration: 20 minutes (First Soviet EVA in almost 9 years)
Notes: --Inspected the docking unit
--Checked the station exterior
--Assessed the condition of joints, sensors, and attached flasks containing biopolymers for an experiment
--Carried a mobile color television camera (so FCC could see what was happening) (548)

ALMOST LOST IN SPACE

Grechko was to perform the EVA while Romanenko remained in the airlock to monitor the medical readings on Grechko and the performance of his spacesuit. Grechko corrected the malfunction and was preparing to return to the airlock when he saw Romanenko's helmet sticking out of the hatch. This cosmonaut was not scheduled to leave the airlock. Romanenko drifted further and further out of the hatch, but his safety line was not attached. Grechko leaned out as Romanenko floated by him and managed to grab the line and save Romanenko's life. Had Romanenko been a few more yards away he would have floated free until his air ran out and he suffocated.

Romanenko and Grechko did not tell Ground about Romanenko almost floating away from the ship. In fact, they did not talk about it for months, even after their return to Earth. Grechko: "I hope that the flight directors will not be offended, but we concealed the fact that it wasn't just me who went out into open space as was called for in the program, but also Commander Yuriy Romanenko. It was very difficult, naturally, for him to restrain himself. It turned out that he had forgotten to fasten his safety line, and I had to grab hold of his line and hold on to him." (276)

140-Day Mission:

Date: July 29, 1978
Cosmonauts: Ivanchenkov and Kovalyonok
Duration: 2 hours, 5 minutes
Notes: --Replaced part of the scientific equipment installed on the exterior to see what happens to materials when they are exposed to micrometeors and the space environment (348, 548)
--Part of the EVA took place while the station was in the Earth's shadow. The crew used portable lights to illuminate their work
--Installed a device for studying cosmic radiation (348) (548)

* * *

175-Day Mission

Date: August 15, 1979
Cosmonauts: Ryumin and Lyakhov
Duration: 1 hour, 23 minutes
Notes: --Dislodged the KRT-10 antenna to clear the docking port

- Brought in samples
- Salyut passed out of Ground radio range. The crew had to wait to resume communication
- Worked in daylight for 30 minutes. Remaining time spent in the dark
- Ryumin's spacesuit got entangled on his re-entry and he had some difficulty disengaging it.
(288)(548)(552)(555)

ANTENNA FREED

During the last months in space the cosmonauts assembled a radio telescope which blocked the rear .

The end antenna was to be cast off to allow other spacecraft to use the rear docking assembly. However, the mesh became entangled on the outside of the station. This presented serious problems for survival of the Salyut.

Ryumin: "[It was] either quit the...station...or make an attempt to save it through extravehicular activity. There was serious thought about the first possibility."

The ground and the cosmonauts worried that this EVA would be too much for the cosmonauts because the crew had been in space for so long (6 months) and were tired.

"The extravehicular spacesuits had been...in space for more than two years and, naturally, evoked some doubt as to their reliability...we had been in space for six months and EVA work demanded great physical strength...we had already prepared psychologically for an ending to the work...we had not practiced this on

ground." Ryumin noted that no one knew how the semi-rigid antenna would behave in space. It could entangle the cosmonaut. "We were given permission to skip our exercises which was amusing in the circumstances. Yet, thinking of the heavy job ahead of me I was grateful I had not cheated on it; I was, indeed, in good shape." The night before the EVA Ryumin took a sleeping pill. The cosmonauts knew that there was some chance that they would not return from the walk in space.

The cosmonauts had to wait for sunrise before beginning the EVA. "...I was not...eager to step out into the void. It was scary." Mission rules forbade them to work outside during periods of orbital nighttime. The job was complicated because the sun was shining directly into Ryumin's eyes. He managed to dislodge the antenna. (See 1.3.13 Maintenance Activities.)
(154)(163)(338)(341)(503)

185-Day Mission:

No EVAs performed.

B. Salyut 7:

211-Day Mission:

Date: July 30, 1982
Cosmonauts: Lebedev and Berezovoy
Duration: 2 hours, 33 minutes
Notes: --Brought experimental materials and instruments into the Salyut
--Installed new experimental materials and instruments
--Used cutting tools
--Made interface connections
(30)(208)(349)(429)(548)

* * *

150-Day Mission:

Date: November 1, 1983
Cosmonauts: Aleksandrov and Lyakhov (First time two cosmonauts both fully outside the station simultaneously on purpose)
Duration: 2 hours, 49 minutes
Notes: --Installed solar arrays:
--Retrieved solar panels from storage
--Assembled and attached them to existing battery (272)(646)

PREPARING FOR SECOND EVA

November 2 was spent preparing for the second EVA on November 3. The cosmonauts had to dry out their suits with a fan, replace elements in the life support system, and check to see that everything they were to take out was in working order. Their daily regimen was disrupted because they had to go to bed after lunch and get up at midnight. (139)

Date: November 3, 1983
Cosmonauts: Aleksandrov and Lyakhov
Duration: 2 hours, 55 minutes
Notes: --Installed solar arrays

SOLAR ARRAYS

On the main panel of the solar array the cosmonauts installed a hinged arm with a winch mounted on it, a cable, and mounting assemblies for suspending the supplemental panels. Each panel was placed in a container with handles for transporting. (Kosmos 1443, See 1.16.3 Kosmos.) had ferried up two small solar panels that were to be added to Salyut's arrays to increase the power available for scientific research.) (S.286, S.391)

Aleksandrov secured himself at the place where the panel would be installed. Lyakhov came out of the hatch and joined Aleksandrov and secured the container and tools, including special pulls with a movable base, and cutters.

Aleksandrov opened the securing points and the special exterior handrail. Taking the container and using two fixing pins, the cosmonauts mounted it on the face of the station's main solar array, manually connected the sockets of the power supply system, and fastened the end of the main panel cable to the holding pin of the supplemental one.

Lyakhov then went to the safe zone (using the handrails) and secured himself to the securing anchor. Slowly turning the crank of the winch (like a flagstaff) Aleksandrov expanded the supplemental panels along the web of the main solar array. The fixing pins of the supplemental panels went into the latch opening at the top end of the array. Installation was complete. The cosmonauts then mounted a screen on the supplemental panel to protect it from the glare of the sun (which can hinder orienting the station's solar array). They then put the arrays into working position.

(59)(139)(175)(238)(349)(380)(430)(448)(465)(482)(487)
(536)(548)

* * *

237-Day Mission:

A total of seven EVAs, totalling 26 hours and 25 minutes, were conducted.

Kizim and Solovyev established a new space record with six spacewalks, totalling 22 hours and 50 minutes.

Savitskaya became the first woman to walk in space.

Date: April 23, 1984
Cosmonauts: Kizim and Solovyev
Duration: 4 hours, 15 minutes
Notes: --Assembled and attached a ring ladder to the exterior of the craft
--Installed receptacles for 42 different tools next to the ladder

SOVIET SPACE STATION ANALOGS, Ed. II

2.2 EVA

Date: April 26, 1984
Cosmonauts: Kizim and Solovyev
Duration: 5 hours
Notes: --Shut off reserve conduit to engine unit and installed valve

APRIL 23 AND 26, 1984

During these EVAs, the cosmonauts started repair on an oxidizer fuel line which had sprung a leak during the first mission of the Salyut 7.

On the first EVA (April 23), Kizim and Solovyev had to drive anchor pins into the plastic exterior of the station's equipment compartment for the installation of the ladder used in the repair work, and secure the box containing tools (made expressly for the repair effort.)

On the second EVA (April 26), they had to cut a window in the plastic to gain access to a control filler of an oxidizer line. They used a piercing tool to make a hole so they could insert a special knife, which they used to cut out a section large enough to work on the filler. The filler had a plug fastened with a nut which was covered with an epoxy putty. The removal of this nut presented considerable difficulty.

After spending two hours on it, they succeeded in removing it with a reducer wrench. With the filler open, the cosmonauts replaced a valve in the line. Then, on a command from Atkov inside the station, the line was pressurized with nitrogen from tanks on the Progress 20 cargo ship. (141)

* * *

Date: April 29, 1984
Cosmonauts: Kizim and Solovyev
Duration: 2 hours, 45 minutes
Notes: --Repaired disconnected reserve line
--Installed heat resistant coating (584)

APRIL 29

Both filler tubes were connected with a metal bypass line. On commands from Earth, nitrogen coming from the Progress filled the line. Telemetry showed that the line was tight, meaning that the pipeline installed could be used in the system of the combined engine assembly.

After the task, the cosmonauts placed a heat-insulating screen over the holes that they had cut out to get to the plug during the last EVA. (These holes were above the filler tubes. This was necessary to maintain normal temperature conditions in the equipment compartment.)
(229)(618)

* * *

Date: May 5, 1984
Cosmonauts: Kizim and Solovyev
Duration: 2 hours, 45 minutes
Notes: --Assembled second conduit
--Removed heat resistant coating (See 3.1.3 Experiments.)
(584)

The timing of the above four EVAs were carefully coordinated with the orbital path of the Salyut station relative to the Sun and to the tracking sights on the Earth's surface.

SOVIET SPACE STATION ANALOGS, Ed. II
2.2 EVA

All four walks began on the orbit which crossed the equator between 23° and 29° East longitude. (274)

* * *

Date: May 18, 1984
Cosmonauts: Kizim and Solovyev
Duration: 3 hours, 5 minutes
Notes: --Raised capacity of power supply system
--Two additional gallium arsenide solar panels were installed, increasing the power of the station by approximately 1200 watts. (This was part of a bigger plan to increase the power capacity of the Salyut 7.):
---Each array made of this material provides a maximum charge current of 20 amperes, which is 6 amperes more than that of a silicon battery.

MAY 18

Kizim and Solovyev installed two panels at one time. (This is in contrast with Lyakhov and Aleksandrov, 150-day mission, who installed one extra panel during two EVAs.)

Panels were folded like an accordion prior to installation. They were installed with the aid of a cable on a winch, as had been done before. (See 1.3.8 Tools.)

The cable was attached to the top part of the panel and the panel was opened by turning the winch. The extra panels increased the area of the station's solar arrays by more than 9 square meters. (232)

During EVA, Solovyev reported that a handle of their winch had broken. After the operation was completed, cosmonauts disposed of the panels' containers by throwing them into space. (Care had to be taken to cast the containers into a different orbit to prevent the station from meeting up with them in the future.) (245)

* * *

Date: July 25, 1984
Cosmonauts: Savitskaya and Dzhanibekov (visiting crew members)
Duration: 3 hours, 35 minutes
Notes: --Tested portable electron beam gun (URI) that will be used for assembling and erecting additional structures in space. (See 1.3.15 Construction, 1.3.8 Tools.)
Performed:
--Cutting
--Soldering
--Welding
--Spraying

VISITING CREW EVA

The visiting crew of Savitskaya and Dzhanibekov used the URI. (See 1.3.8 Tools.) This was attached to the collapsible handrail. Savitskaya transferred to the working platform and attached herself to a special anchor to carry out operations with the URI:

"The first thing I had to do was carry out a cutting operation on a titanium sample 0.5 mm thick...Welding was carried out on samples 1 mm thick. The next operation was the soldering and finally the spraying of a thin layer of silver on an anodized aluminum plate. There were several samples set out onboard for cutting and welding and soldering. Some of them were done with titanium and others with stainless steel. The thickness of the samples also varied. The completion of the last operation in the work with the URI apparatus coincided with the entry of the orbital complex into the shadow part of the orbit. This allowed [Dzhanibekov] and myself to rest a little during the approximate 30-31 minutes; tolook carefully at the Earth not from the station's portholes but open space.

"When we had entered the bright part of the orbit [Dzhanibekov] and I changed places, and he carried out the remainder of the work with the samples that were left...We can already say...at least as far as the outward appearance goes, the welded joints obtained in space are in no way inferior to good industrial samples on Earth." (456)

* * *

SOVIET SPACE STATION ANALOGS, Ed. II
2.2 EVA

Date: August 8, 1984
Cosmonauts: Kizim and Solovyev
Duration: 3 hours, 35 minutes
Notes:

- Shut off pipe and fuel line:
 - The two cosmonauts shut off a pipe in the fuel line with a pneumatic press (which is said to be able to exert a force of five tons) (See 1.3.8 Tools.) Compressed air from the pneumatic gun flattened the fuel line which then remained sealed for the rest of the flight.
- Dismantled fragment of solar panel:
 - Cosmonauts cut and removed part of the solar panel. This fragment was returned to Earth to be examined so as to determine the effects of space on battery elements. (284)

(46)(72)(108)(124)(141)(144)(207)(229)(232)(245)(274)(309)(349)(413)(438)
(442)(451)(456)(463)(470)(529)(531)(539)(545)(558)(568)(578)(582)(589)
(594)(609)(611)(617)(618)(631)(646)

* * *

Date: August 2, 1985
Cosmonauts: Dzhanibekov and Savinykh
Duration: 5 hours
Notes:

- Installed additional panels to the third solar array
- Installed an experimental model of the solar array for researching the effects of space conditions on it
- Installed an apparatus at the airlock exit hatch that will be used to gather meteorite material (427)(641)

(See Appendix for EVA Calendar)

2.2.12 EVA ENJOYMENT/FEAR

Berezevoy, 211-Day Mission: "Immediately after the airlock was opened the impression was that of being on the street on a bright sunny day with the ground covered in pure white snow. The kind of light feeling that you have when you go out of doors in clear, dry weather...I was surprised by the space wind or, more accurately, the unique draft that occurs immediately after the airlock is opened." (96)

Lyakhov, 150-Day Mission: "On our first space walk [November 1] the emotion was less than during the second one [November 3] because we had to get down to work. Everything had to be done on schedule in good time and we had to make sure we didn't forget anything and that it all went smoothly. On the second walk we had time to reflect; to take a look at Earth particularly when we were in a shadow and there was no work that we could do. We exchanged our impressions. We looked at the stars, looked at the moon rising and setting, and at the continents. That was all very interesting for us. We compared that with lying on the beach or on the grass and looking up at the sky from Earth." (481)

Some cosmonauts noted that they enjoyed being in outer space. Cosmonaut Kovalyonok said, "We would like to take our time. It is the first time for 45 days that we have gone out into the street for a walk!" (600)

Some cosmonauts report an experience of "spacephobia." This was reported by Cosmonaut Ryumin upon exiting the hatch and looking down at the Earth moving below him: (21)

"To be honest: I didn't care for it. I was scared. Below us was Earth and we felt our moving through space."

"To get out of the hatch I had to face outward into the void. And while this doesn't matter in a state of weightlessness, I was not happy about it." (338)

2.4 MISCELLANEOUS EQUIPMENT

Pens:

- Specially made for space
- Have proved efficient in whatever position they are used (509)

Knives:

- "The most essential instruments aboard are knives. Each of us has them secured with a long cord to the pocket, and we need them every minute: to prepare food, do repair work; everything starts with opening a package or cutting strings." (Lebedev, Salyut 7) (213)

Film:

- It has been found that storing film onboard for a long time is impossible. Radiation exposes the film. For this reason, exposed film must be delivered to Earth as quickly as possible and the stock regularly renewed. (411)(548)

Watches:

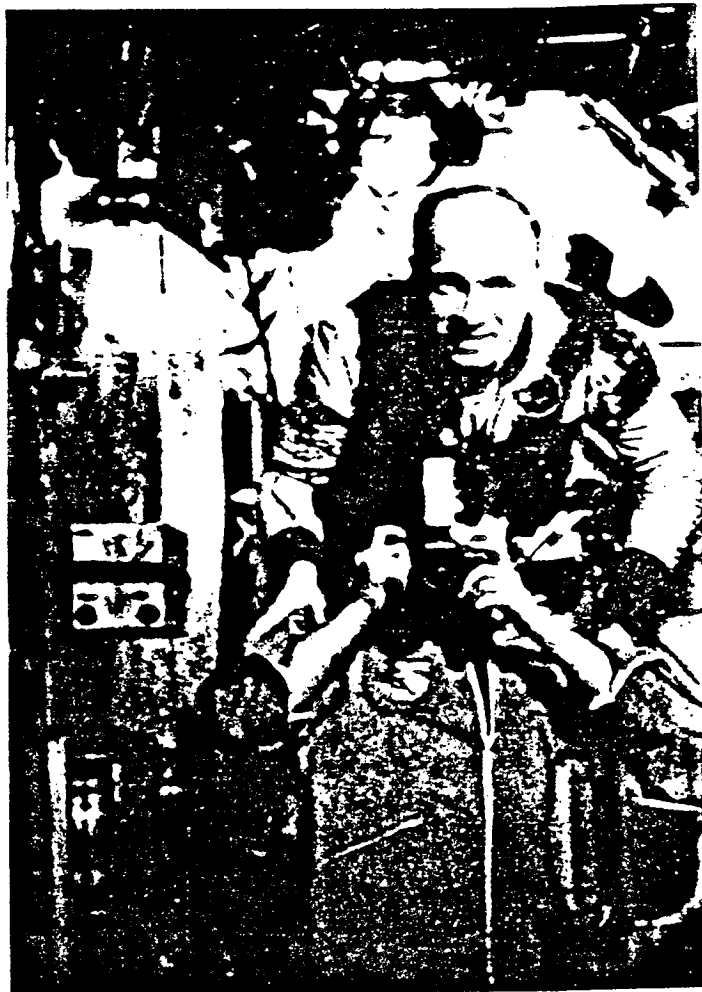
- Soviet specialists noted that watches made from mechanical parts failed to keep proper time in orbit. Watches with electronic components kept time better. Specialists are puzzled over this since most of the Salyut equipment is mechanical. (169)

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SOVIET SPACE STATION ANALOGS, Ed. II
2.4 Miscellaneous Equipment

Hand-held Camera:

- Pentacon 6-M, 70 mm color film ORWO NC 19, ground resolution approximately 100 m. (17)



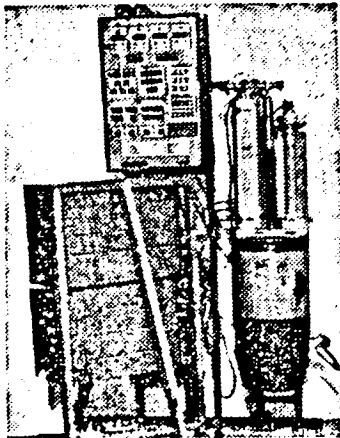
Holographic Camera:

- Weighs 5 kg
- Allows full volume measurements of the subject
- Sensitive to vibration (166)
- Uses helium-neon laser optical system and registering systems (548)

NIVA:

- Television apparatus
- Records a panorama of the Earth on a videotape recorder and transmits it to FCC via a TV channel
- Real-time scale (182)(548)

Korund:



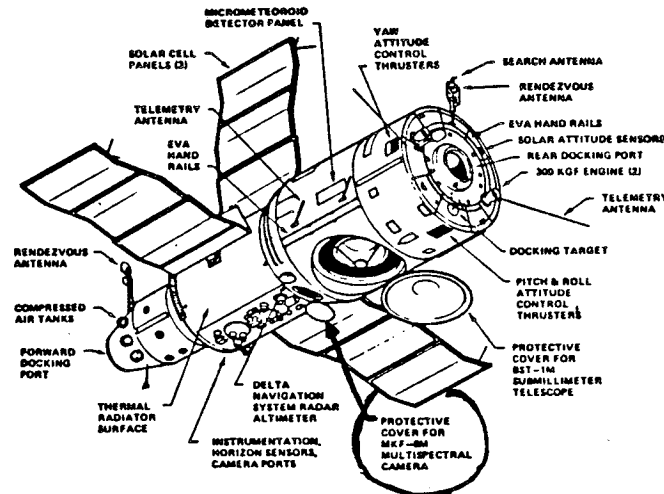
- Grows monocrystals automatically
- Combines the technique of the Splay and the Kristall (which are not used any more)
- Heat field can be varied from room temperature to 1270AOD with the heating up rate from 1/10 of a degree to 10AOD per minute
- Twelve units can be put into the drum simultaneously
- Has a microcomputer so any program can be selected within the framework of the technological process (208)(347)
- Can be used during a manned or unmanned mission (587)

Splay-1:

- Weighs 23 kg
- Mounted in an airlock:
 - So heat it generates will dissipate into space
- Three heating areas:
 - Hot area: up to 1100AOD C
 - Cold area: 600-700AOD C
 - Gradient area: capable of linear temperature change from the maximum to the minimum
- Requires 300 watts of power to operate
- Molybdenum reflectors inside the furnace are used to focus the heat on the samples (23)(73)(548)

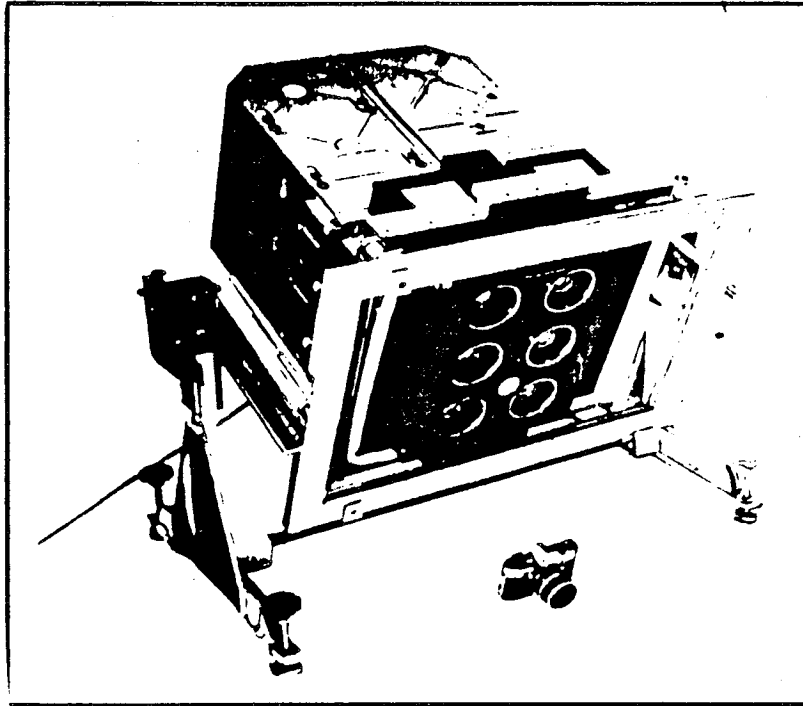
MKF-6M Multispectral Camera:

- Multi-zonal
- Weighs 170 kg
- Used for interpreting space photographs
- Six spectral bands:
 - 0.46-0.50 microns
 - 0.52-0.56 microns
 - 0.58-0.62 microns
 - 0.64-0.68 microns
 - 0.70-0.74 microns
 - 0.78-0.86 microns (284)(548)
- Can be used with just one hand (if necessary)
- Film cassettes:
 - Each cassette weighs 13 kg
 - Each cassette has 1200 frames of film
 - Easy to change
- Alarm on control panel to tell if film breaks
- Provides stereo images because of 60% overlap on adjacent areas (548)
- Each image covers 220x165 km (96)(284)(525)(546)(547)(582)



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The MKF-6M Camera



Pic. 525

KATE-140 Camera:

- Wide-angle stereographic topographical camera
- Surveying apparatus
- Makes contour maps
- Band observed on the Earth's surface is 450 km x 450 in a single frame
- One photographic frame encompasses 200,000 km²(284)
- 85° field of view
- Provides single and strip photographs
- Has two film cassettes:
 - Each has 600 frames
- Can be operated by crew or FCC (46)(284)(548)(582)(592)
- Information obtained makes it possible to:
 - Precisely define the coordinates of any points on the Earth's surface
 - Map broad territories
 - Conduct a study of the terrain and geological structure
 - Trace erosion of soil
 - See condition of pastures, forests, etc. (592)

Spectrometric Equipment

Portable (hand-held) Photographic and Optical (binoculars) Equipment
(6)(73)(75)(180)(403)(512)(548)(628)

The Piramig and the PCN:

- Both cameras were developed and manufactured in France and are used to conduct atmospheric research) (317)(512)(568)

Pyramig Camera:

- Used for astrophysical and geophysical observations
(6)(260)(317)(548)(568)
- Requires a certain station orientation (308)
- Has an electronic image intensifier
- Each fiber acts as a photomultiplier:
 - Electrons are propagated along the tube and amplified as they are reflected from its walls
 - Amplifier has several million fibers gathered into a cylindrical bundle
 - A photocathode and screen are mounted on the end of each cylinder
- Microchannel image intensifier:
 - Intensifying co-efficient of 1000
 - Resolution: 0.05-0.10 mm
- Photocathode: spectral range 1000 to 250 nanometers
- Film is pressed against the screen for recording
- Diameter of useful field: 40 mm
- Lenses:
 - Focal distance and intensity of 58 mm/1.2 and 180 mm/2.8
- Keyboard-type composer:
 - Can set up exposure time
 - A note is made on each frame of the date, time, and exposure time (260)
- Photos taken on the shadow side of the Earth
- Has to be switched off before the station comes into light (208)

SOVIET SPACE STATION ANALOGS, Ed. II
2.4 Miscellaneous Equipment

PCN Camera:

- Used for astrophysical and geophysical research
(260)(317)(512)(568)
- Photos taken with the station on the shadow side of the Earth
- Used for nighttime studies of weak light sources:
- Must be switched off before the station comes into light
(208)(548)

Yelena Gamma Telescope:

- Used for astrophysical experiments (238)
- Measures gamma ray emissions
- Weights: 20 kg
- Dimensions: 300 x 300 x 500 mm
- Area of input window: 50 sq. cm.
- Angle of view: 30°
- Operated in the 30-500 MeV range
- Requires 100 watts
- Can operate continuously for 20 hours (522)(548)
- Individual units can be switched quickly from one measurement mode to another (96)

Mariya:

- Used for studying the distribution in space of high energy particles in Earth's radiation belts and near space
- Predecessor was the Yelena gamma telescope
- Measurements are available in a few minutes, while with the Yelena results could be evaluated only after the flight
- The Mariya instrument counts the number of electrons and positrons in the part of the station where it is set up and measures their energies:
 - These particles are produced by the bombardment of the station's environment by other particles from space (490)

MK 5-M Spectrometer:

- Set up in tandem with a camera
- Records a picture of the area in which the lens is pointed
- Rotates on its own axes
- Can make surveys of objects at different sighting angles
(146)(537)(582)

Pion:

- Studies features of weightlessness (See 4.1.1 Weightlessness.)
- Makes a study of the processes of heat and mass exchange in a liquid media
- Three main parts:
 - Shadow instrument with light and movie camera
 - Electronic control unit
 - Working port with changeable trays (98)
- Processes are recorded on motion picture film and videotaped using a holographic device (548)

The RS-17 and the GSPS complement one another: (317)

RS-17:

- X-ray telescope
- Used for siren experiment (See 3.1.3 Experiments, 237-day mission.) (317)
- Records radiation from 2,000-800,000 electron volts
- Makes it possible to observe black holes and x-ray pulsers (420)

GSPS:

- Gas scintillation proportional spectrometer
- Used for siren experiment (See 3.1.3 Experiments, 237-day mission.)
- Has a high revolving power (317)

Spektr-15 Spectrograph:

- Weight: 10.5 kg
- For spectroscopic survey of the Earth's surface and atmosphere
- Records light in 15 spectral bands:
 - Used to see whether crops are ripe or not, for example (548)
- In one second it can take 100 spectra and transmit the information by telemetry channels to Earth (96)(330)(582)

Tsvet:

- Facilitates the identification of colors of the Earth's surface
- Resembles a camera with levers
- Cosmonaut finds a color identical to the one s/he sees on the Earth (74)(138)(146)(247)

SOVIET SPACE STATION ANALOGS, Ed. II
2.4 Miscellaneous Equipment

Color Atlases:

- Designed especially for space
- Contain 1000 numbered specimens of shades of color
- Are used along with visual observations (333)

BST-1m Submillimeter Telescope:

- Used for atmospheric observations
- Records data in the infrared, ultraviolet and submillimeter ranges
- Weights: 650 kg (largest instrument on the station)
- Has cryogenicaloy-cooled receivers:
 - Have to be calibrated each time it is used
- 1.5 meter diameter mirror
- Optical sight: 12X magnification
- Receivers are cooled by liquid helium (at -269 °C) (548)

Duga Electrophotometer:

- For atmospheric studies
- Has two modules:
 - The optical mechanical module has the optical telescope, dispersing system and image converter
 - Data recording module has a digital tape recorder
- Measures the intensity of optical emissions in the upper atmosphere at 6,300, 5,577, 4,278 and 6,563 angstroms
- Instrument is attached to one of the station's windows with a flange (548)

KRT-10 Radio Telescope:

- For intensive astrophysical activities
- This telescope was brought up into space in separate pieces:
 - The antenna itself
 - The focal container with the irradiators (four horns in the 12 cm band and a spiral irradiator in the 72 cm band) with three expendable supports
 - Device for attaching the antenna
- Weights: 200 kg (half of which is the antenna)
- When directed toward Earth it has a 7 km resolution in the 12 cm band (548)

RT-4M Telescope:

- Used for conducting astrophysical observations in the x-ray range (96)

Spectrum 15:

- This instrument can be used to establish which light rays are being reflected from the surface being investigated and which ones are "noise" generated by water vapors and aerosols that have accumulated in the atmosphere (138)

Elektrotopograf:

- For studying the dynamics of construction material by:
 - Radiation
 - Micrometeors
 - Drops of temperature
- Records microdefects
- Non-destructive operation
- High efficiency
- High information yield: (374)
 - Registers on film even the smallest flaws (pores, cracks) less than one-tenth of a micron (412)

Kaskad:

- This is a space auto-pilot
- 'Put on to Kaskad' means having oriented the station in relation to Earth or the stars (579)

Tavriya:

- For the electrophoretic separation of different biological specimens at zero gravity
- Multi-chambered:
 - One of the chambers purifies a biologically active anti-infectious substance obtained by gene engineering
 - The second chamber extracts a super-pure specimen from the antigen of a flu virus (with a view to producing high-efficiency vaccines and sera)
- The Tavriya incorporates some new systems and equipment which are essentially a prototype of future semi-automatic installations for space biotechnology (74)(133)(456)(546)(568)

SOVIET SPACE STATION ANALOGS, Ed. II
2.4 Miscellaneous Equipment

SKIF:

- An optical mechanical spectrometer
- Portable and hand-held
- Used for finding and monitoring bioproductive areas of the oceans
- Allows primary analysis of spectra to be made onboard
- Can be aimed at any object without turning the station
- Spectrometry and photography of an object and the recording of routine information and speech accompaniment can be accomplished simultaneously:
 - Has a built-in motion picture camera and digital magnetic recorder which enable the instrument to perform these automatically (178)
- Immediately develops the film and analyzes the pictures:
 - This allows the cosmonaut to conduct an experiment and analyze them on the spot. The cosmonaut can then determine the next stage of research. (656)

Isparitel-M:

[This was the precursor to the URI. See 1.3.8 Tools.]

- Electron-beam gun
- Weights: 34 kg
- Substances are vaporized and subsequently deposited in the form of coatings:
 - Silver
 - Gold
 - Copper
 - Copper-silver alloy
 - Non-metallic materials (such as plastics)
 - Other metals and alloys
- Coatings can be applied on:
 - Glass
 - Metal
 - Tape made of polymer film (293)

The gun shoots a beam of electrons at a refractory crucible filled with silver, copper, gold or a copper-silver alloy. The metal begins to vaporize and the vapors settle on a metal or glass plate, forming a mirror-like coating.

SOVIET SPACE STATION ANALOGS, Ed. II
2.4 Miscellaneous Equipment

The Isparitel-M can deposit coatings as thick as tenths of a millimeter. It is completely automated and can perform 8 different kinds of work. (227)(280)(292)(293)

-It has two units:

--First unit: This is the operating unit. It includes several replaceable elements and consists of a set of crucibles

--Second unit: An information and measuring complex, which makes it possible to monitor the process of vaporization of an alloy when it is applied to a surface. This unit is also used to program the necessary operating parameters automatically.

(161)(162)(191)(228)(233)(277)(280)(291)(332)(454)(511)(657)

Torsion Instrument:

-Designed to study the strengths of different materials in conditions of open space (See 3.1.3 Experiments.)

-Instrument used inside the docking module (161)(533)(568)

Infrared Radiometer:

-Measures the temperature of various parts of the Salyut

-Resembles a large pistol

-Can take temperature readings instantly at varying ranges

-It is aimed at a device and a trigger is pressed. The temperature is then shown in digits on a display screen at the butt end

-The device is accurate to one-tenth of a degree (445)

EFU-Robot Installation:

-Used during electrophoresis experiments (654)

SOVIET SPACE STATION ANALOGS, Ed. II

2.4 Miscellaneous Equipment

A. Medical:

Aelita:

- Enables a detailed investigation of the heart, blood vessels and brain
- Can take electrocardiograms and write data to the onboard computer
- When hooked up with the Chibis, the Aelita makes it possible to study venous pressure
- Records individual indexes of the body's condition
- Does a qualitative analysis (See 3.1.2.1 Mission Length.) (96)

Massmeter Scale:

- Monitors weight changes:
 - Cosmonaut half-lies on a platform that is mounted on spring-loaded braces. The cosmonaut presses the body to the platform, using handles and footrests, and makes his body as rigid as possible
 - When started, the system commences an oscillating motion. (The frequency of the oscillation depends on body weight. The figure showing the arbitrary units for the periods of oscillation for the "platform-person" system are shown on an indicator. The measurements are taken 4-5 times. The indexes are then averaged and weight is determined using a special table. (96)(365)

Electrophoretic Chamber:

- Developed for the purpose of fractionating DNA
- Chamber is a cylinder 90 cm long. Placed along an entire length of the cylinder are 230 needles capable of drawing off fractions separated by an electric field. (278)

Special sensors (piezoaccelerometers):

- These detect the echo of the heartbeat by reacting to the pulsing of the blood vessels and adjacent blood tissues (626)

Ultrasound Cardiograph Instrument:

- Provides hard copy readouts (140)(162)(234)(308)
- Transmits pictures of the heart to the screen of a television receiver on Ground
- Weights: 2.5 kg (131)(161)
- Portable

Glucometer:

-Used to determine cosmonauts' carbohydrate metabolism
(161)(162)(489)

2.4.1 EQUIPMENT DESIGN

One of the biggest problems in designing equipment for space is that designers only have a vague idea of what the products will experience in space. Therefore, Soviet designers are especially cautious and try to make up for lack of knowledge of the conditions that will be encountered in outer space by ensuring the high dependability of instruments. General requirements:

- Reliability
- Compactness
- High efficiency
- Minimum of power consumption (337)

2.5 SAFETY

"...greater crew safety is a matter of highest priority." (29)

Making spaceflights safe is the main task of space biology and medicine. Measures include:

- Selecting and training the crew according to medical criteria
- Sanitary-hygienic monitoring of the living environment inside the Salyut
- Medical monitoring of cosmonauts' health
- Preventive measures to stabilize the health of the crew and preserve their working capacity (143)

The minimum time required for emergency evacuation: 15 minutes.
This is the time needed to enter the Soyuz and pull away from Salyut.

Preferred time needed for emergency evacuation: 90 minutes (It would be possible in 90 minutes to carry out all the necessary operations for emergency deactivation of the station and to move to the Soyuz.
(274)(473)

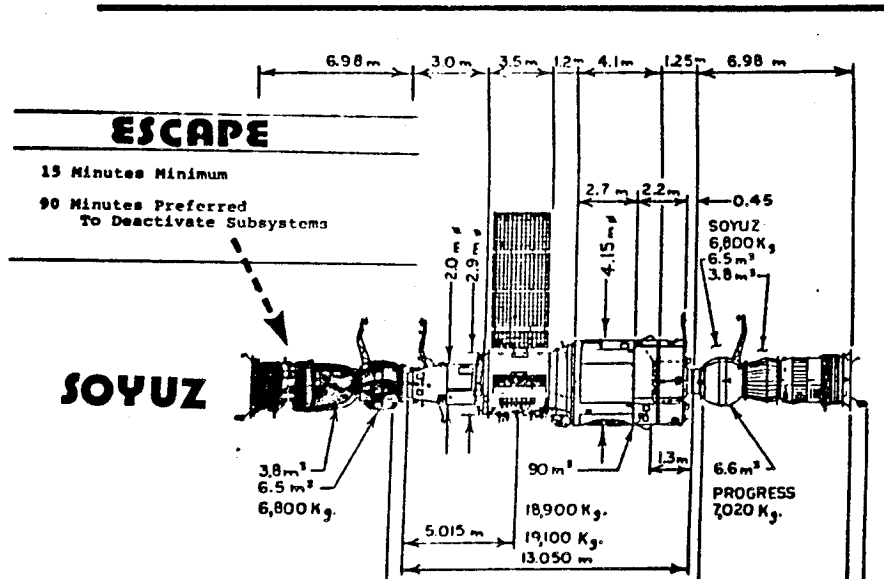
EVA Risks:

- Possibility of being hit by a meteorite
- Spacesuit could become depressurized
- Spacesuit could cease to function (568)

The cosmonauts are protected by the hermetically sealed cabins and the EVA spacesuits. (See 2.2.1 Spacesuit.) (206)

2.5.1 SAFE HAVEN

SALYUT 6



If an emergency situation occurred, cosmonauts would abandon the station and enter the Soyuz transport ship. (378)

The cosmonauts can spend several days in the Soyuz. If landing immediately is necessary, they can:

- Splash the Soyuz down in the ocean
- Touch down in one of the reserve landing areas in the USA, France or other countries (473)

The Soyuz descent module can separate from its work module. The descent module serves as an emergency vehicle in the event of a power failure. The module contains a variety of emergency equipment for either land or water ditching:

- Food
- Water
- Clothing
- Other survival gear (548)

SOVIET SPACE STATION ANALOGS, Ed. II
2.5 Safety

The Soyuz T also contains medical and electronic equipment to broadcast the crew's location to rescue personnel. Survival equipment such as fishing gear, knives and other equipment are aboard. (548)

SAFE HAVEN SOUGHT

On the 150-day mission, there was a problem with the main propulsion system. This resulted in a leak of oxydizer into space. During the incident, Cosmonauts Lyakhov and Aleksandrov were ordered to seal themselves in the Soyuz T in case of an emergency return. (The leak turned out not to be disastrous, but it did affect the scientific work. The leak was eventually repaired during the 237-Day mission.) (See 2.2.10 EVA Missions.) (59)(175)

Dr. Victor Legostaev, who is responsible for the GNC systems in the USSR Spaceflight Program, thinks it is risky not to have an immediate return capability in case of an emergency. He thinks an emergency return is important and that an attached, self-sufficient module should be on a space station. (120)

2.5.3 SAFETY AND MAINTENANCE

To increase crew safety:

- A compartment pressurization monitoring system was installed
- Special fire extinguishers were added
- A fire detection system was created (76)

Anytime one is dealing with something technical/mechanical, there can be problems. (385)

It is important to maintain the systems which are related to the life support of the crew. (351)

2.5 Safety

2.5.4 SAFETY AND CREW SKILLS

A. Training:

Safety is ensured by pre-flight professional and psychological training. Not only should the spacecraft be reliable but the crew members should be trained and have the ability to counter unfavorable factors, especially in emergency situations. (See 3.4.1 Ground Training.) (29)

B. Simulating:

"However complicated the emergency situation we simulate, it cannot cause the stress of a real life situation when a man realizes that his mistakes might cost him his health and probably life. Therefore, we believe it necessary, in spite of organizational difficulties, to resort in the course of cosmonaut training to real life emotiogenic situations which cause a reaction to a real-life stress factor." (See 3.4.1 Ground Training.) (29)

C. Automation:

It is necessary to determine which actions should be automatic actions and to which ones such automatization would be harmful. "...stereotyping of certain actions is one of the causes of flight incidence." (237)

D. Information Inputs:

Cosmonauts are faced in their work with two psychophysiological difficulties:

- An insufficient amount of information and its excess
- Sudden changes from one level of information to the other

These difficulties can generate:

- Fatigue
- Inaction
- Boredom
- Emotional stress

With a long-term action of one or another factor, people with an unstable nervous system might experience neurotic conditions, which may have dangerous consequences if an emergency situation were to arise. (114)

The reason for the development of a neurotic state during the work of operators on fully-automated control systems is that a difficult state arises in the central nervous system. Usually any reflex is completed by an action. Here the reflex takes place at the sensory level--visual observations are not accompanied by a physical motion and are thus an unfinished reflex. [What is seen is not consistent with other sensory input.] (237)

E. Sense of Danger:

The sense of danger should not disappear. It includes psychological, (including emotional) mechanisms which activate human activity and sharpen human thinking in case of an emergency. (346)

The emotional reaction of awaiting an emergency presents special requirements to the nervous system. Not all people withstand this in the same way. This should be taken into consideration during selection. (114)

F. Compatibility:

"An emergency situation should not catch the crew unawares. Here everyone should be on the alert and the team should act as a single unit. Obviously this confidence in one another comes with time. Only long periods of working together make it possible to know one another's capabilities." (219)

2.5 Safety

2.5.6 SAFETY SIGNALING DEVICES

The atmospheric regenerators have pressure sensors to warn the crew of unplanned drops in pressure. (See 1.14.1 Temperature.) (548)

A. Future:

Animals can be used as biological signaling devices for dangerous situations aboard the spaceship. This will require the creation of appropriate onboard computer systems, and the development of diagnostic algorithms. (385)

2.5.7 RADIATION

Protecting cosmonauts against radiation is among the most crucial in space biology, since the very possibility of implementing long-range interplanetary flights depends on such protection. (385)

The dose of ionizing radiation received by cosmonauts to date has not exceeded 5 REM (roentgen biological equivalent) per cosmonaut per entire mission. (88)(603)

A. Sources:

- Galactic cosmic radiation from deep space
- Earth's radiation belt:
 - These two act constantly (115)
- Solar flares:
 - Problematic (88)(115)

Solar flares have been deemed not dangerous to the crew, although they produce an increase in the power of the radiation dose on the station for a short period. (115)(385)

140-DAY MISSION

The strongest flare was noted on September 23, 1978. The density of the flux of protons as a maximum: 2.2×10^9 /cm² x2x STER. The flux for the entire flare: 2×10^9 /cm². (385)

B. Problems:

Radiation can lead to:

- Poor memory capacity
- Irritability
- Impatience
- Stress
- Sleeplessness
- Lack of concentration (219)(476)

2.5 Safety

Under the influence of irradiation there is an impairment of transparency of the glass in ports and optical instruments. Optical instruments transparency loss can be substantially decreased with the addition of cerium oxide to the glass, as well as by using quartz glass with a low content of impurities. (118)

C. Possible Solutions:

An electrical protection device might be used against the effects of ionizing space radiation. It has been patented in the Soviet Union and tested in the flight of the Viosputnik "Kosmos 496." It consists of the creation and maintenance of a strong electrical field around the spaceship, using as the insulating mediums a vacuum which surrounds the spaceflight apparatus. As a result the flow of charged space particles is deflected and does not get into the cabin. This electrical protection can also protect:

- Photographic materials
- Radio apparatus
- Numerous other equipment which is subjected to the action of ionizing rays against the action of space rays

Research directed at finding new chemical radiation protectors show that the following compounds might be promising:

- Adenosine triphosphoric acid (ATP) type and radiation protective formulas based on them

Data from Bulgarian scientists indicate that the removal of the ATP from the indicated radiation protective formula leads to a reliable reduction in its prophylactic effect. (114)

2.5.7.1 MONITORING

Radiation is continuously monitored on the station. Precision dosimetry is important. (40)(88)(115)(288)(385)

If interplanetary flights are taken, then the situation will change. Galactic cosmic radiation may then acquire biological importance. (88)

"PILLE" (Radiation Dosimeter)

This device is used to measure the radiation within the Salyut.
Characteristics of the Pille:

- Does not take up much room
- Weighs less than a kilogram
- Requires a power supply of 3 to 4 watts
- Simple operation:

Little detectors shaped like a pencil with an end that is similar to a key are located on the body and at various locations within the ship. These are inserted into a receptacle on the Pille. A light comes on, indicating that the instrument is ready for measurement. The detector is then turned, using the key-shaped handle, and another light comes on indicating measurement is in progress. In one minute the face of the Pille will display red numbers (with a high of 7 millimeters) indicating the radiation dose detected since the last readout. Each readout will re-zero the instrument. For power conservation the numbers will go out in 5 seconds. Pressing another button will cause the numbers to be displayed again. The data is preserved within the Pille until the next readout.

-Problem:

The evaluation of the data is not simple. The individual sensitivity of each detector must be taken into consideration, together with the fact that prior to flight the dosimeter has also recorded the natural background radiation on Earth.
(3)(88)(288)(289)(476)(603)

SALYUT 6
RADIATION MEASUREMENT

Cosmic radiation was measured inside the station. Measurements were performed with thermoluminescent dosimeters, photographic film and solid state plastic detectors supplied for the experiment. The dose gradient inside the manned modules of the station amounted to 70% for long intervals of time. During the experimental period the dose rate inside the station was 15-30 mrad per day.

Radiation detectors were contained in a hard cassette pack. The packs were mounted at sites that were shielded to different degrees against cosmic radiation by the hardware and equipment.

SOVIET SPACE STATION ANALOGS, Ed. II
2.5 Safety

Analysis showed that the difference in the mean daily dose values was due to the position of the packs as well as the duration of exposure onboard the station. The mean daily dose differed by 40-60% due to variations in the flight altitude.

The results obtained in the same positions during the exposure in March-June were a factor of 1.4-1.5 higher than for the period of May-August, 1979. The decrease of the mean flux values of densely ionizing particles, which occurred mainly during the period June-August, may be due to modulation effects resulting from the increase in solar activity during this period. It is noted that the mean daily dose values in this period were higher than during the former because of the greater altitude of the orbit.

In future experiments the topography of the dose field studies inside the station should be extended to obtain a more complete picture. (3)

2.5.8 METEORITES

"The possibility of an encounter with meteorites is by no means small."
(74)

"...the assurance of safety during an encounter with micrometeorites is one of the factors exerting an influence on computation of the thickness of the pressurized envelope of the station and its external shields." (74)

About one micrometeorite strikes each square centimeter of the station surface once a month. (374)

The small micrometeorites bombard the covering of the Salyut often. It has been calculated that in 100 revolutions, the Salyut encounters up to 200 particles. (96)

At times there are meteorite showers. The Salyut can become covered with small craters. (473)

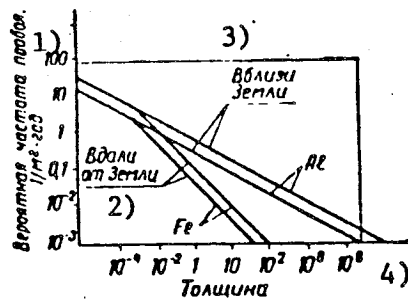
HIT

Meteorites often hit the windows. One crater with a diameter of 3 mm was discovered on the docking unit of the station. Another micrometeorite made a 4 mm diameter crater in a window. (See 1.1.1 Windows.)
(74)(124)(473)(548)

The chances of a meteorite striking the station and disrupting its mission are one in a million. Should an emergency occur, there are procedures for abandoning the craft. The minimum time is 15 minutes, but 90 minutes -- the time it takes to orbit the Earth once -- is considered standard time. After leaving the station the cosmonauts could spend several days in the Soyuz in safety. (See 2.5.1 Safe Haven.) (457)

2.5 Safety

The probability of penetration of a meteoroid with a mass of several tens of grams (which can considerably damage constructions such as a space antenna) is small. However, a through penetration of the wall of a pressurized compartment will cause leakage of the atmosphere and result in serious damage. (118)



Pic. 118

Dependence of probability of penetration of aluminum and iron walls of space vehicles by micrometeoroids on wall thickness

- Key: (1) Probable frequency penetration, 1/mA²D per year
 (2) Distance from Earth
 (3) Near Earth
 (4) Thickness

The effects of meteoroids is dependent on their velocity and mass. The collision of particles with mass of 10A-7D g with a space vehicle leads only to erosion of the surface of the vehicle. Computations show that the total loss of matter as a result of such erosion near the Earth does not exceed several fractions of a micrometer per year. This cannot exert a significant effect on the strength of the space structure. (118)

Due to erosion there will be a change in the characteristics of:

- Windows
- Lenses
- Heat protective coverings
- Reflecting surfaces

Accordingly, for maintaining the prolonged functioning of the heat protecting coverings and reflecting surfaces, it is necessary to renew them periodically. (118)

SALYUT 6

An average of one or two meteorites hit the Salyut 6 every orbit. They were small in size, but their high velocities made it impossible to avoid collision. (193)

The number of micrometeorite impacts on the station were measured using detectors attached to the outside of the station and retrieved during EVAs.

One crew retrieved one of the detectors and found over 200 impacts, many more than expected. Another crew found a 1.5 mm scratch in one of the portholes as well. (Not all the impacts may have been from micrometeorites, since there is a considerable amount of space debris in orbit from previous spacecraft launches.) (548)

2.5 Safety

2.5.8.1 PROTECTION

Meteoroids with a mass of more than 10-7g can cause depressurization of the thin-walled space structures. The method for protection is the use of double-walled structures. The outer thin wall serves for the fragmentation of meteoroids into fine fragments. The inner wall is for pressurization. The gap between the walls is determined from the condition of an adequately broad scatter of fragments. Such a system makes it possible to reduce the mass of pressurized structures by almost an order of magnitude. (118)

There is a micrometeorite sensor. The pitting indents on its multilayered coating gives information to the Ground. (96)

Designers have provided special screens to protect the Salyut. These screens are formed by the heat regulation system's radiating element, special plastic casing, and panels of the heat regulation components. They are put outside the airlock and the shell of the instrument compartment. (Even though micrometeorites are small, designers do not rule out the possibility of difficulties because of the great velocities.) (72)(96)

If the coverings are damaged, the air in the Salyut will take a day to escape through a perforation the size of a pinhead. If the hole is the size of a pencil, it will take 1-1/2 hours. Pressure suits would then need to be donned and the cosmonauts would need to escape to the Soyuz or attempts would have to be made to seal the hole with a special plaster. (96)

Windows have double panels, each 14 mm thick, with a layer of gas in between. (145)(193)(473)

2.5.9 HYGIENE ASSESSMENT

The living environment needs to be assessed for hygiene. The assessment should include:

- Temperature and gas pressure control
- Partial oxygen and carbon dioxide pressures
- Qualitative and quantitative composition of organic impurities secreted by humans and structural materials
- Sanitation-microbiological monitoring of the living environment
- Skin and oral and nasal microflora (See also 1.11 Contamination.) (603)

2.5.10 SPACE DEBRIS

"...There is a considerable amount of space debris in orbit from previous spacecraft launches." (548)

2.5.11 MISSION HIGHLIGHTS

150-DAY MISSION

A fuel leak left the space station with less than half its normal navigating propellant. The Salyut was also flying mostly in a free drift mode because 16 of the 32 attitude control thrusters were not usable.

The cosmonauts had to don space suits and enter the Soyuz. (See 2.5 Safe Haven.) The fuel that leaked was nitrogen tetroxide. It is toxic enough to have killed the cosmonauts if it had penetrated the cabin of the station. (59)(268)

III. ORGANIZATION SYSTEMS

3.1 PROGRAM STRUCTURE

3.1.1 AUTONOMY

The work-rest cycle in prolonged flights should allow crew members more freedom in planning their work. Wide participation of the cosmonauts in the planning of work to be done the next day (or longer time intervals) is beneficial to their psychic adaptation. (91)

"...The crew is in no condition to determine who, how and when, will contact them." (258)

Crew members do help draw up the work and rest regime. (214)

Soviet specialists stress that the time has not yet arrived when cosmonauts can be allowed complete autonomy in the decision making process of any mission milestone. (163)

"To be alone without constant nitpicking from the Earth was sometimes necessary." (346)

Having humans onboard ensures a greater degree of reliability in operating equipment. Humans can revise experimental programs, or can even change and select research objects. (261)(336)

Ryumin: "...In the rigid schedule of the flight there is some time that is free from the mandatory program...People have a chance to formulate their own experiments in orbit." (194)

Yeliseyev (Flight Director): "...a rigid approach is impossible...and unnecessary. In my opinion, both practically and psychologically it is expedient to give the cosmonaut considerable independence in solving a number of operative questions...A constant reminding and watching over all situations could cause irritation and develop a feeling of lack of trust." (386)

Berezevoy, 211-Day Mission: "On Earth you often do not see the final result of your own labor: this dependence is covered, hidden. In this case everything depends on your conscience. But in space both your work and your conscience are on view for all, and you cannot hide behind others." (96)

3.1.1.1 AUTOMATION

Atkov, 237-day mission: "Until we have robots capable of replacing people in every respect, the cosmonaut will cope faster and better with an assigned task." (See 3.1.1.1.3 Automation and Robotics.) (408)

Humans are important in space because their presence is essential for many types of research in space. "In the future, orbiting stations will become comfortable space complexes consisting of various scientific research, production, living and medical zones. What will their inhabitants be occupied with? Scientific work monitoring numerous automatic devices and adjusting and repairing them if need be. The control of spacecraft from Earth already is becoming difficult to manage...therefore, the time is not far off when the flight control center will be located....in space." (222)

Benefits of people over machines:

- Eyes: (94)(546)
 - People can detect small changes better than automated equipment: (94)
 - Relying on the cosmonauts' visual observations has made it possible to identify vertical formations in the ocean and link this with fishery problems (94)
 - Better for repairing systems (See 2.2.10 EVA Missions, for examples.) (74)(94)
 - Irreplaceable when it is necessary to analyze rapidly changing situations
 - To make unordinary decisions
 - To change conditions for the implementation of instruments
 - To regulate equipment
 - To intervene routinely in transpiring processes
- (74)(83)(219)(351)(354)(389)(483)
- Can correct mistakes (389)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

Design should be such that human effort can be devoted only to operations which cannot be performed automatically. There are some situations a machine cannot anticipate. (357)(624)

The spacecraft should be designed as a tool of cosmonaut work. (237)

It is difficult and inefficient to automate all the processes aboard. While systems and equipment are in operation there are frequent situations which are impossible to provide for in the instructions and program. The crew's creativity is necessary for handling them. (351)

Soviet designers rely heavily on automotive control with cosmonauts as backups. Crew members have, in many instances, assumed broader duties to make up for failures in automation. (See 1.16.2 Soyuz T for Soyuz T approach problem.) (61)(537)(646)

The Kosmos has an independent control system that was designed to solve unforeseen situations automatically. (See 1.1 General Layout and Design, D. Kosmos.)

Benefits of Automated Machines:

- Ability to record scientific events with greater detail (546)
- Can do tedious tasks: (158)(351)(396)
- Crew can then spend more time repairing malfunctions

Problem of rational allocation of functions between crew and automatic devices:

- Question of to whom preference should be given
- Question of constructing various control modes which insure the most effective performance of a given operation (94)

3.1.1.1.1 AUTOMATION AND WORK SCHEDULE

Humans are the critical link in the human-machine system. In planning the work regime of the cosmonauts, periods of intense and relatively light work should be altered. At the same time it must be kept in mind that delegating all the activity to automation leads to cosmonaut inattention and a reduction in work.

Automation alone does not solve all the problems of increasing labor effectiveness. Full automation is not always rational, since in this case the reduction of work and operator inattention is a possibility. "...for the automation of one process or another, it is insufficient to ascertain that this process may be automated; it is still necessary to prove that it needs to be automated, to clarify the facts that the measures taken, while improving the system, will not reduce its overall effectiveness due to the complication of technical elements, cost increases, and reduction reliability." (114)

The Soviets want to eventually relieve the cosmonauts of the data collection process and have this done automatically so the crew can spend time repairing malfunctions. (158)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

3.1.1.1.2 AUTOMATIC MODE

A. Reasons for Automatic Mode:

Reasons for unmanned intervals between missions:

- Need to process and analyze materials from scientific studies and the telemetry data brought back
- Notes made during the mission must be examined
- Recommendations must be drawn up for the next expedition
- Amendments made to the scientific research program
- Amendments made to the scientific research methods
- Suggestions from crews on improving the methods for conducting experiments and operations (experiments that are ineffective are excluded and replaced)
- Need to order and build additional apparatus
- Prepare ground and onboard documentation for the next stage
- Carry out additional crew training and training for control personnel (30)

B. Preparing for Automatic Mode:

Prior to leaving the station, a crew prepares the station for automatic mode. Preparations take about three days:

- Engine is refueled:
 - A detailed inventory of the stowage is:
 - Left at the station
 - Transmitted to FCC
- Worn out parts on ventilators and air regenerators are replaced
- Filters are renewed
- Equipment is turned off:
 - Air regeneration system
 - Water supply system
 - Scientific equipment
 - Communications system
 - Lighting system
 - Delta system (30)

- Moveable equipment is secured in its place behind the compartment panels
- Television camera is aimed at the entry airlock (32)
- Samples of air and microflora are taken to Earth for analysis (559)

C. During Automatic Mode:

During automatic mode:

- There are telemetry sessions two or three times a day in which data from the station is transmitted to FCC. (The normal functioning of the station's equipment requires that certain conditions be maintained onboard.):
 - Composition of air
 - Air pressure
 - Humidity
 - Temperature: (582)
 - There are temperature sensors at various points throughout the station. On the strength of the readings of these sensors the FCC decides whether to raise or lower the temperature inside the station. (582)
- Power consumption is much lower than when the station is manned. Because of this, once a week solar batteries are disconnected from the storage batteries by FCC. This extends their service life. (10)(582)
- Ground facilities are used at least once a week to check and correct the orbital parameters of the station by radio (30)(582)
- Research is done automatically:
 - For example, there is remote sensing of farmland and forests for economic needs
- The lights inside the station are out. Only a beacon light shines on the station's front end (582)

D. Reactivating the Station:

- Load tape recorders and stationary photo cameras and make sure they are in working order
- Repair anything that needs to be repaired
- Unload the Progress and/or any other module that has supplies (For example, the Kosmos which, during one mission, also brought supplies.) (574)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

Sometimes instruments have to be put back into working order:
(132)(161)

237-DAY MISSION

When the crew first came to the Salyut, they had to convert the systems from automatic to manned mode and reactivate the life support, power control and heat control systems. The temperature was stabilized at 20°C and pressure was measured at 756 mm on the mercury column on February 10. (See 1.14 Thermal Control, 1.4.7 ECLSS.)(162)

By February 14, the crew reported that 80% of the station had been reactivated. Several minor repairs to plumbing, the hot water supply system and other systems had been made.

Atkov had to replace some parts in the medical monitoring device. (161)(162)

June-September 1985 Mission: When Dzhanibekov and Savinykh arrived at the Salyut 7, they found:

- The electricity system was not functioning:
- Water had frozen
- Instrumental panels were covered with a crust of ice

It took about a week and a half to eliminate the defects and restore electricity and life support systems. A Progress was "urgently set up" to deliver the required instruments, fuel, water and food supplies. (See 1.16.1 Progress.) (641)(654)

During its flight in automatic mode the Salyut 7 had stopped responding to commands from Ground Control. This was due to a defective block of the Salyut's radio system created by the loss of electrical power. (641)

The two cosmonauts also:

- Performed maintenance work on onboard systems and plants
- Checked the state of panels, electricity supply lines, instruments and equipment
- Charged the chemical current sources of the station's power supply system
- Checked the functioning of the orientation system and the system of control over the movement of the orbital complex in various flight regimes
- Examined viewports and replaced a number of units that were past their service life
- Analyzed the gas composition of the atmosphere (610)

E. Future:

It has been calculated that the reliability of an automatic control system designed for flight around the Moon and return to Earth is 22%. With the participation of humans it increases to 70%. If humans are present, there is the possibility of correcting various faults in the different systems and thus reliability increases to 93% or more. (219)

3.1.1.1.3 AUTOMATION AND ROBOTICS

It is necessary to have reliable high speed computers with large memory capacities. Computer technology and the installation of microrobots will make it possible to automate a whole series of processes of the station. However, Soviets do not want complete automation of all processes. Excessive automation can lead to a lessening of equipment reliability. (76)

Although the Soviets still believe that cosmonauts cope and work faster than a robot would, robots are still being considered for the future. (See 1.17.4 Other Devices.) (505)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

3.1.2 SCHEDULING

The best regime of life is the habitual Earth rhythm of work and rest, with an extended rest period (up to 9 hours of sleep at night). (114)(264)

Experience has shown that even when adaptation to weightlessness is completed, work still takes longer than it would on Earth. (342)

An example of Salyut scheduling:

Arise	8:00
Test of the station	8:00 - 8:20
Morning toilet	8:20 - 9:00
Breakfast	9:00 - 9:40
Work	9:40 - 12:00
Physical exercise	12:00 - 13:00
Free time	13:00 - 13:20
Work	13:20 - 14:20
Dinner	14:20 - 15:00
Free time	15:00 - 16:00
Work	16:00 - 17:30
Tea	17:30 - 18:00
Work	18:00 - 19:00
Physical exercise	19:00 - 20:00
Supper	20:00 - 20:30
Free time	20:30 - 23:00
Sleep	23:00 - 8:00

Average expenditure of time:

Sleep	9 hours
Physical exercise	2 hours and 30 minutes
Meals	2 hours and 20 minutes
Free time	2 hours to 2 hours and 30 minutes
Communication and daily operations	3 hours
Experiments and basic operations	5 hours

(63)(85)(177)(385)

A. Recent Changes:

During the 150-Day Mission, the scheduling personnel at FCC made a time and motion study of the cosmonauts' operations. These specialists noted the savings or overexpenditures of time as compared with the time allotted in accordance with instructions. (74)(151)(231)

Based on this study, changes were made for the following 237-day mission:

- Work day was increased to 8.5 hours:
 - 1/2 hour for preparing instruments and equipment
 - 6 hours for conducting experiments and observations
 - 1 hour for looking over plans for the following day's work and preparing equipment (151)(582)
 - The rest of the day:
 - Sleep: 9 hours
 - Exercise: 2 hours
 - Meals, conversation with FCC, leisure: 5-1/2 hours (151)
- Same type and series of work scheduled for several days in succession: (105)(132)(151)
 - This was done for the purpose of conserving time. In earlier missions cosmonauts shifted from one type of work to another several times in the course of the day. (151)(582)
 - Cosmonauts now do "blocks" of work for 4-6 weeks and then shift to another focus. They can also repeat experiments many times to gain more insight into the results, or to change the experiment slightly.
 - Kizim: "This principle makes it possible to go deeply into the essence of an experiment, to analyze the results gained and make the necessary corrections." (582)

B. Importance of Proper Scheduling:

-Prevents emotional, psychological and physical problems (460):

EMOTIONAL STABILITY

Numerous experiments conducted in small enclosures or under conditions of social isolation have shown that any deviation from customary life rhythms and biological rhythm cause a reduction in emotional stability, inadequate physical reactions, and a reduction in work quality. The strict adherence to a daily schedule leads to good health and to the retention of work capacity. (114)

-Prevents accidents:

--Monotony may lead to a reduction in operative awareness, and may lead to emergency situations. (114)

-Improves productivity:

PHYSIOLOGICAL STABILITY

Studies have found that schedule changes can cause physiological and psychological disturbances. These disturbances can lead to a decrease in the reliability and efficiency of work. The severity of these changes are determined by the types of schedules used and the correlation between the degree of shift and the segmentation of sleep-wake cycles. (223)(226)

ONBOARD STUDY

During the Salyut 6 and Salyut 7 missions there was an analysis of work-rest cycles. Studied were:

-Distribution of work-rest cycle within the:

--Day

--Week

--Month

--Entire flight

-The relation of the work-rest cycle with other components of the time schedule:

--The effect of various factors involved in health and work capacity

The study showed that specific work-rest cycles should be rigorously adhered to for maintaining good health and high work capacity. Proper planning and making needed changes in the schedule must be made with regard to:

- Psychophysical variations
- Biorhythmological variations (See 3.1.2.11 Biorhythms.)

One ground-based study that was done to analyze the influence of changing from the usual sleep-wake schedule to a shifted one:

GROUND-BASED SHIFTING SLEEP-WAKE CYCLE STUDY

The use of schedules that differ from customary ones by shifts in sleep-wake cycles of more than three hours can lead to a worsening of sleep even on the first day of the new schedule.

However, a one day shift does not have an influence on the reliability and efficiency of work. Phase shifts that are close to inversion (9 and 11 hours) may be associated with the impairment of Circadian dynamics of HR and some EEG features, as well as poorer performance of some intellectual operation.

The study involved 35 men, 25 to 42 years of age, divided into six unequal groups. The study was done in an isolated room with normal microclimate parameters and artificial light of 150-200 lux. A strict schedule with identical structures was used for each group: experimental, psychological and physiological tests, physical exercises, transmission of reports, self-observation, self-service. Reactions were analyzed immediately after changing to the new schedule.

The parameters used: falling-asleep time, duration of sleep, motor activity, superficial slow wave EEG stages, deep slow wave EEG stages, and a paradoxical phase.

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

Results: A shift to a new sleep-wake schedule caused deviations in dynamics of the tested functions on the very first day. The chief deviation was in sleep. Good sleep was observed in only three subjects who adhered to the ordinary daily schedule.

The difficulties in sleep noted were:

- Increase in falling asleep time
- Intermittent sleep
- High motor activity during sleep
- Waking up frequently

An analysis shows that there is a change in sleep immediately after changing to an unusual schedule, which is related to the duration of the prior waking period and the direction of the shift of sleep-wake cycle.

When there is a shift to the right on the time scale and the waking period is extended, the sleep disorders are primarily in the second half of the sleep period (and this coincides with the waking period of the usual schedule).

When the schedules involve the shift of sleep periods to the left and shorter waking periods, the first half of the sleep period is affected (the process of falling asleep). As the phase shift nears inversion, the sleep disorders become more marked.

This study does not rule out individual differences but the poor results are more likely indicative of the sleep-wake cycles.

Mental productivity may remain on a high level on the first day after altering the living schedule, when the stress reaction is only starting to develop. Productivity can improve with moderate stress; from this point of view some stress is useful.

Arithmetic operations are the most vulnerable on the first day after changing the living cycle. (223)(226)

Scheduling should take into account:

- Professional activities of the crew:
 - Basic work:
 - Operations making up the main content of the program (scientific experiments, dynamic operations, repairs, etc.)
 - Sporadic work:
 - Daily operations such as checking station systems, engaging in communications, self service
- Personal hygiene time
- Preparation and intake of food time
- Physical exercise time
- Time for other necessities

For this reason, the evaluation of the appropriateness of professional activities should be made with consideration of three main parameters:

- Total work time
- Work time's distribution over the entire waking period
- Proportion and relation to other elements on the schedule

Use of the shifted, split, or migrating schedules is associated with nervousness and the faster development of fatigue.

The subjective evaluations of crew members has shown that a change in sleep-wake schedule leads to deviations in the emotional state, physiological state, and work capacity of all crew members. (224)

C. Scheduling Changes:

When there is a visiting crew onboard, the scheduling may change. (260)

No matter how precise planning is, there must be room for scheduling changes. (78)(386)

D. Crews:

Each successive crew resumes working where their predecessors left off. This makes it possible for them to introduce correctives into the program, depending on the results obtained, and to expand it by means of new instruments. (347)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

The crew normally has three or four operations that are scheduled per day. These include loading cameras and operating them, checking a backup communication system, checking a gas analyzer, or perhaps installing a metal ring in a hatchway. At other times the crews will be asked to perform more than the three or four operations. (150)

At times crew members will ask FCC for more work because they will do tasks more quickly than was initially thought. (162)

237-Day Mission: Although Blagov, Deputy Flight Director, stated that a three-person crew is better than a two-person crew (See 4.3 Group Management Skills, Blagov quote.), he said that there was a problem arranging for the efficient operation of the larger crew. "Their activities had to be planned so as to keep them busy and out of each other's way." (632)

Blagov also noticed that the relationship between the 237-day crew members was made easier because one of the crew was a doctor and not an engineer. The doctor had his own research program to do. (632)

Kizim, 237-Day Mission: "We arranged duties onboard in such a way that certain experiments and research went on in parallel. With a crew of three it is possible to do this; one just has to do it rationally. This enhances the crew's output and hence also the efficiency of our work in space." (582)

3.1.2.1 MISSION LENGTH

Referring to the American Space Shuttle and the fact that he thinks Shuttle flights of 7-30 days are not much use for research, Yeliseyev said: "Our cosmonauts say that during their first month in orbit, they are only learning to 'see' and to work productively because many things escape their notice at first." (387)

Experience has shown that during the course of a flight cosmonauts develop better proficiency in performing research. They also improve their handling of equipment. (587)

As flights get longer, more stringent requirements will be placed on the level of professional training and maximum effectiveness while in space. (603)

Ryumin: "I need a flight of sufficient duration so that in addition to the basic program I could accomplish experiments that I sense needed to be done but which had not been stipulated officially. In short flights, the entire program was time dependent. There was positively no time for creativity. Barely had time to turn around and it was time to descend." (339)

Some cosmonauts indicate that they are in favor of still longer expeditions in orbit because longer flights stimulate working ability and make research more effective. (127)

"...now cosmonauts returning to Earth after six months in space are in much better physical shape than they were after the first flights, which were no longer than a few days at most." (Yeliseyev in discussing mission length after the 185-day Salyut 6 flight) (387)

211-Day Mission: "The fundamental result of this flight is obvious: increasing the duration of a manned sojourn in space did not lead to manifestation of any qualitatively new functional shifts in the cosmonaut's body (compared with flights of shorter duration)." (603)

"...we must take the next step -- to move on to the creation of permanently operating orbital scientific complexes with replaceable crews." (417)

The length of the flight is not as critical in readaptation as is conformity to the exercise routine and other prophylactic measures that are prescribed. (See 3.1.2.6 Exercise Time, 1.4.6 Exercise Equipment, 5.1.2 Post Flight.) (33)(89)

"...if the stipulated volume of prophylactic measures is carried out properly and the rest regimes are observed, extended flights can be borne as easily as those of shorter duration." (See 3.1.2.2 Work Day Length, 3.1.2.6 Exercise Time and 5.1.2 Postflight.) (287)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

However, according to an engineer at the Ford Aerospace and Communications Corporation, there have been many complaints from long-term inhabitants of the Salyut station.

Crews have complained that they are eager to go the first time, but they would be hesitant to make a second stay of great length. (625)

Berezevoy, 211-Day Mission: "...the longer you stay in orbit the more you value normal life on Earth." (96)

3.1.2.1.1 MEDICAL REQUIREMENTS

The Soviets have what they call a medical strategy for prolonged flight. This covers:

- Cosmonaut selection
- Training
- Optimization of the spacecraft environment
- Daily monitoring of the health of crews
- Providing medical support
- Preventive and restorative procedures (642)

The longer the space flights are, the more new requirements for medical backup support are needed. Control and surveillance of space crew health must be more intensive. There should be complex diagnostic units and automated analysis in space. [For example, the Soviets have reportedly designed an operating table for the station.] (119)

"...flights ranging in duration from a year to several years are possible in principle, but require the presence in the crew of medical personnel, and on the ship of special equipment for diagnostic and medical-prophylactic assistance. It is also necessary to utilize an extensive complex of measures that facilitate the readaptation of the body to terrestrial conditions after the completion of such flights."
(287)

211-Day Mission: The 8-day stay of Savitskaya showed that there are no significant differences between the reactions of males and females.
(603)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

3.1.2.1.2 ECONOMIC ADVANTAGES

Economic advantages of long missions:

- Requires fewer spacecraft and everything that is related to launching and maintenance (264)
- Long-term observations. In the past this has led to:
 - Directing fishing ships to regions where there are many fish.
On the Salyut 7 the cosmonauts regularly spot and report productive regions of the oceans. They have saved Soviet fishing fleets much money. This indicates that in the years ahead there can be an increase in the economic effectiveness of such investigations. (125)(269)(351)
 - Development of water resources
 - Prevention of soil erosion (347)(647)
- Reduces the number of transport ships needed to deliver replacement crews to a station (351)
- Produces experience necessary for future interplanetary travel (587)

3.1.2.1.3 SUPPLIES

A long mission requires means for expanding the program of research and experiments and delivering reserves of fuel, products and substances that provide life support. It is also necessary to return to Earth the samples of various materials obtained in experiments. For this, the Progress has been used. (15)

The ability of the Salyut 6 to remain in space for so long and to handle such a large number of expeditions was because there was an ability to replenish materials that were consumed onboard. (345)

"It is obvious that for flights lasting several months to...a year, it is impossible to take the necessary reserve of materials to the station in one trip. It is necessary to organize continuous material and technical supply of the station and its crew by using special cargo ships." (See 1.16.1 Progress Cargo Ship.) (264)

3.1.2.1.4 MISSION LENGTH AND DESIGN

Both the mechanical and human aspects of mission length should be considered in the design phase:

Salyut 6:

- In order to prolong the working life of the Salyut 6 station, the engine system and fuel supply system were redesigned:
- Both the main engine and the altitude control engine used the same fuel and oxidizer from the same tanks
- The designers also switched from turbine-driven engines to a simpler and more effective pressure-fed system (177)

Salyut 7:

During the 150-Day Mission, the cosmonauts' work program was changed. The change was made during the month of October.

According to a Soviet spokesman, this was to help the crew overcome the depression which had made them irritable and lonely. By allowing new and different work it was hoped that this could be avoided. They had been working 10-12 hours per day. (175)

3.1.2.1.5 DIFFICULTIES

"...whether we like it or not, the time comes when efficiency in orbit decreases." (587)

Salyut experience has shown that toward the end of the third or the beginning of the fourth month, cosmonauts begin to feel the monotony and seclusion of space. (144)(213)(386)

Some cosmonauts have indicated that the only real problem with a long flight is the ability of FCC to keep the cosmonauts active and interested. (171)

According to Gretchko, the relatively mild effects of six month space flights should not be underestimated. "Even after half a year of space travel, walking and standing gets difficult. You sleep badly and even eating is unpleasant to start with." (See 5.1.2.2 Mission Highlights. Gretchko was on the 96-Day Mission and did not perform all the required exercises.) (360)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

"...many things that do not attract the cosmonaut's attention on a short flight begin to perturb a crew during long ones." (264)

Sources of concern in long flights:

- Vibration
- Noises
- Monotony

These irritations may appear to be petty but they can lead to frustration, which can result in a decrease in work productivity. (See 4.1 Productivity and Morale.) (264)

There is an additional difficulty that may occur: the stress of giving up a life-long habit or being without a usual pleasure. For example, Ryumin noted just before take-off: "I light my last cigarette. I have been smoking for 28 years but no more--for the next 1/2 year." Three months into the mission he noted that he craved a cigarette. (338)

Cosmonaut Dzhaniybekov maintained that life is difficult even on a short flight. [Dzhaniybekov has visited the Salyut four times as a visiting crew member. He returned from a 3-month mission in September, 1985.] "...A short flight...requires the mobilization of all one's strength and capabilities, because the pace of work on a short expedition is very intensive." (456)

3.1.2.1.6 CREW ROTATION

In September, 1985, the first in-flight crew rotation took place. Dzhaniybekov returned to Earth with visiting crew member Gretchko, while his fellow crew member (Savinkyh) stayed onboard with two new crew members. (656)

Rotating crews are seen by the Soviets as very productive.(642) They see it as a way to enhance the efficiency of space station use. (645)

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3.1 Program Structure

3.1.2.2 WORK DAY LENGTH

A properly planned work day with adequate rest breaks:

- Retains productivity (385)
- Restores energy (114)
- Maintains normal biorhythms (See 3.1.2.11 Biorhythms.) (219)

Planning a work/rest regime should emphasize:

- High level of motivation of cosmonauts
- Report by the crew of the results of experiments made
- Participation of crews in planning flight programs (advance discussions for perspective work)
- Measuring for psychological maintenance
- The positive relationship of each cosmonaut to the routine based on tying the periods of sleep to Moscow nocturnal time
- Understanding by the flight director of the significance of medical recommendations in the correction of work and rest routines (385)

Results of investigations have shown that efficiency can change during work not only in the biorhythmological aspect (See 3.1.2.11 Biorhythms.), but under the influence of the work itself. Four main stages are distinguished:

- Breaking-in (30 minutes to 1 hour)
- High stable efficiency (60 minutes to 2 hours)
- Compensated stable efficiency (2 hours to 4 hours)
- Lower efficiency (4 hours to 6 hours) (224)

Some cosmonauts say that a diversified work program is the most important thing for a stable working climate. (400)

Ryumin: "...work is the best cure for anxiety and depression." (400)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

A. Salyut Work Day:

The crews maintain a normal 24-hour day (based on Moscow time) because of problems that occurred in earlier Salyut flights when the day deviated from this.

(154)

Before the Salyut 6, cosmonauts lived on orbital time, or sliding days, which had a negative effect on their well being. The first Salyut 6 expedition showed that even the introduction of a set daily cycle was inadequate. It was necessary to have a five-day work week with two days of rest instead of one, and sleeping and physical exercise periods had to be lengthened. (76)

Crews generally work weekdays and have the weekends to rest. (176)

Crews do deviate from schedules at times. (The 140-day crew, for example, ate three times every 24 hours rather than four times and did not always perform their physical exercise.) (385)

The crews will sometimes work 14 or 16 hours a day to finish experiments. (96)

Cosmonauts should not be overloaded with work during adaptation. (346)

The adaptation to new living conditions depends primarily on optimal regimes of work activity. (114)(264)

Work Time:

- Work time spent observing the Earth: 33.3%
- Technological experiments: 33.3%
- Astronomical observations: 16.6%
- Biological and medical experiments and checkups: 16.7% (87)(127)

Every day the crew has to:

- Undertake obligatory control of onboard systems of the station, the Soyuz, and Progress
- Hold conversations with FCC
- Receive numerous messages
- Undertake maintenance work (579)

Productivity evidence:

- Completing the standard program completely
- A number of cases of fulfillment of the planned volume of work ahead of time
- Initiated conduct of different additional work, observation of experiments (385)

Decrease in work capabilities occurs in different degrees. Reasons:

- Accumulation of fatigue due to the long duration of the expedition
- Heavy workload at certain stages in the flight
- Reactions to weightlessness
- Monotonous activities
- Disturbances in sleep:
 - Due to the necessity to conduct different types of work in different time periods (for example: docking and EVA) (385)

3.1 Program Structure

3.1.2.2.1 DAILY REST BREAKS

Kovalenok, 75-Day Mission, said that one of the most unpleasant aspects of the flight is when you want to rest and know that for about 12 more hours it will be impossible. (98)

The regime of work and rest must restore work capacity and should prevent fatigue:

- At the first signs of fatigue, short rest breaks are recommended, which may be passive or active (specially selected physical exercises, reading, music)
- The first three to five minutes of rest are the most important in restoring work capacity

The advantage of short breaks is that during a short rest a work posture is maintained and so is the attention on work. Long breaks may lead to a reduction in the amount and quality of work performed. Maintaining interest in work depends on a goal-oriented utilization of free time.

The more information that is given and has to be processed, the more fatigue:

REST BREAKS AND ATTENTION

Rest breaks are important for maintaining work attention. With prolonged work at a control panel, attention is turned off for a small fraction of a second at first. Then, as more time passes, protective inhibition intensifies, and attention turn-off increases. There are temporary blackouts in the function of this attention. Arising signals are not reaching the operator's consciousness. As protective inhibition intensifies, the percent of omitted signals increases despite the growing stimulation of the operator and his willful effort. That is why taking a rest break is important. (114)

Often during the last week of the flight the feeling of tiredness does not disappear even after a night's rest. (114)

Monotony causes fatigue, decreased mental performance and irritability. Work-rest cycles should include mandatory rest breaks: (219)

GROUND-BASED
REST BREAK STUDY AND WORK CAPACITY

A study was done with people working at control panels in a television studio using physiological functions as an indicator.

Results: There was a positive adaptation to work for the first 3 to 4 hours, after which a reduction in work capacity began to set in. This reduction could be countered by rest breaks. (114)

According to one study (See 1.13 Vibroacoustics.) needless noise should be avoided during rest periods, as it can be irritating. (242)(390)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

3.1.2.2.2 REST DAYS

During the Salyut 6 missions, Radio Moscow reported that resting in orbit had not been solved. Even two days of rest a week was not sufficient to restore strength. Reasons:

- Crew working in unusual conditions
- It was impossible for the crew to completely disengage themselves from their work program
- "Complex of measures which would make it possible to restore one's strength effectively whilest in orbit is, as yet, not perfect." (127)

Rest days involve some activity. For example, the cosmonauts still do their exercises and do housekeeping. (366)(478)(572)

3.1.2.4 LEISURE TIME



Crew members enjoy reading.

- Two-way television (which provides "meetings" with family, friends, scientists, artists, athletes)
- Video cassettes (of films, concerts and cartoons. This is assembled with consideration for the preferences of the crew):

Aleksandrov: "In the evening we watched a few videocassettes. We have the history of the movies, hang gliding, bits of 'kinopanorama,' and variety and musical comedy. Still, there are not enough tapes."
(249)

- Hobbies (such as playing chess with Ground or fellow crew members. The space chess board has grooves in it.) (45)(366)
- Reading (Problem: only a limited number of books can be taken onboard)

3.1 Program Structure

- Self-education
- Listening to music (very important):

Listening to stereo music is enjoyed. Ivanchenkov:
"...[We prefer] an outside acoustic system rather than earphones so we can somehow distract ourselves from the continuous production noise of the station's onboard systems." (366)

Cosmonauts usually make more frequent requests for the transmission of rhythmic music starting with the second month of missions.

(34)(38)(85)(97)(114)(154)(174)(206)(219)(256)(264)(350)(366)
(417)(456)(649)

Leisure activities which do not require a lot of space and equipment should be strongly considered:

- Hobbies
- A musical ensemble or drama group
- Concerts transmitted to Earth by television (114)

Cosmonauts report that they enjoy the meetings with their families the most. (See 3.3.2.1 Family and Friends.) (417)(206)

A. Organization of Leisure Time:

Leisure events are planned, giving thought to:

- Individual interest
- Psychological climate in the Salyut
- The flight stage (58)

Observers note that hobbies and favorite activities tend to change during missions. (127)

The importance of a proper organization of recreation during rest time has been demonstrated by Soviet experiments on long-term isolation.

Leisure activities should be structured with consideration for cosmonauts' needs, tastes, and habits.

Surprise selections of leisure activities are organized for each crew.
(39)(114)

Experiments show that under conditions of prolonged isolation, subjects occupied themselves during periods when no work was scheduled: they sang, recited poetry, read, painted, and engaged in creative writing and crafts. Researchers took this into consideration when preparing recommendations for organizing the work and rest schedule for the cosmonauts. (256)

Psychological support (See 4.1.3.1 Psychological Support.) aimed at social activation of crews during long flights has been successful. However, it is still unclear whether it is better to facilitate or inhibit normal ground-based ties. The question is whether space flight should be a duplicate of or something different from that on Earth. The question has been raised because of the following observations:

- Refusals of crew members to enjoy the types of rest and recreation that were recommended
- Occasional use of the onboard leisure facilities that were clearly preferred to the more diverse possibilities proposed by the Earth
- Sudden change of interest and desires previously reported to the specialists (91)

"...it is necessary to investigate the forms of leisure time on the effect of 'socializing.' This is especially important for times of musical form. It might be opening up a way to treat correctly the phenomena of unstable preferences...coming from a cosmonaut..." (257)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

3.1.2.4.1 LEISURE TIME AND WORK PERFORMANCE

Leisure time contributes to the working efficiency of the crew. It stimulates their mental state and fitness. (256)

To restore work capacity there need to be leisure activities and also the ability to switch from one activity to another. (219)

SALYUT 6
RELAXING SHOWS

A leisure experiment was conducted in which the cosmonauts, during their off-duty hours, watched specially recorded shows with cultural scenes designed to relax the viewer. Results showed that the crew improved their work performance as a result of these shows. (34)

Experience has shown that telecommunications are effective in maintaining the crew's emotional and work tone. Ryumin stated: "Such encounters help us in our work; they help keep us up to date on the affairs of the Earth, and, to some extent, compensate for the shortage of the usual socialization on Earth." (256)

3.1.2.6 EXERCISE TIME

A. Importance of Exercise:

- Maintains overall muscle mass and strength
- Protects against circulatory system decline
- Protects against the appearance of changes in:
 - Protein metabolism
 - Gas exchange
 - Tolerance to acceleration (18)(152)(548)(552)

Intensive exercise stimulates production of somatrophic hormone, which intensifies synthetic processes in organs and tissues. (44)

Cosmonauts who do not exercise regularly have a more difficult and longer readaptation to 1 g. (See 5.1.2 Postflight.) (18)(170)(601)

No work should be allowed to interfere with space physical training exercises: (600)(601)

NO POSTPONEMENT OF EXERCISE

During one flight the crew members were unloading the cargo ship. It was taking longer than usual and they wanted to postpone their exercises on the bicycle veloergometer. They insisted that it would not take them long and that they could do their exercises at another time. The FCC refused to let them, telling them that they must observe their physical exercise without deviation. (601)

EARTH SIMULATION

The space training devices were tested on bedridden patients. The patients wore the Penguin suits and were suspended in a horizontal position by thin ropes. They were then brought up to a vertical treadmill. They walked along the wall. The patients who received this training returned to normal life after long immobilization much easier than subjects who had remained motionless in bed. (601)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

Beregovoy, 211-Day Mission: "...If crew members follow the prescribed regime conscientiously, their return to the world of gravity will be easier." (26)

Ivanchenkov, 140-Day Mission: "There is no other way to do it, you have to keep in shape." (385)

B. Types of Exercise:

The cosmonauts are allowed some free choice in the type of exercises they do. (170)(601)

The methods of prophylactics and control are becoming more individualized. (24)(33)(87)(90)(119)(170)(388)(633)

Cosmonauts are making more use of sport apparatus. An hour a day is spent on the veloergometer, and an hour and a half on the running track (running at about 8 or 9 kilometers per hour). (20)(87)

C. Time Spent in Exercise:

The cosmonauts spend between 2 and 2-1/2 hours per day: (82)(169)(525)

-Salyut 6:

--Twice a day: morning and evening:

---About 1 hour 10 minutes - 1-1/2 hour each (136)(385)

-Salyut 7:

--Cosmonauts now exercise for one 2-hour period per day.

[The Soviets are still studying exercise time and equipment to determine the most optimal time and techniques.]

There are 15 to 20 minute intervals between exercise and eating, and intervals of 1 to 1-1/2 hours between eating and exercise. (42)

Training is based on a cyclic principle of proportional loads:

-Three days training followed by a day of rest (20)(136)(561)

The physical training program is started depending on each individual's period of adaptation to weightlessness. (150)(385)

Exercises are increased during the last few days of flight. (127)
Cosmonauts also drink more liquid. They drink saline water (3gm of sodium chloride to 400 ml of water) prior to donning their antigravity suits. (548)

D. Problems:

If there are too many people onboard, vigorous exercising can shake the station and disrupt experiments. (368)

A possible solution: "Welding methods...used in...experiments (See 3.1.3 Experiments, 237-Day Mission.) open up the possibility for solving this problem...[by assembling] large gymnasium complexes..." (368)

E. Feelings About Exercises:

Ryumin, 175- and 185-day missions: "I hate our exercises. Loved it on Earth. But here, each time I have to force myself. Boring and monotonous, and heavy work. But you realize you need it to keep in shape so you grin and bear it." (338)

"...it's not easy to fasten yourself each day into a gymnastic apparatus or a veloergometer." (400)

Aleksandrov, 150-Day Mission: "After my first physical exercises there emerged a heaviness in my head and my overall condition was not pleasant at all. I was very thirsty." (249)

Studies conducted in limited space indicate that with the lack of volume, people also experience a lack of desire to exercise. (281)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

Berezovoy, 211-Day Mission: "At present the only way to overcome [the effects of] weightlessness (See 4.1.1 Weightlessness.) is by physical exercise. How joyful the morning warm-up was on Earth! But here the sweat really runs...and it turns out that exercise on the bicycle ergometer or treadmill is not a pleasant form of rest, but exhausting labor on which a great deal of working time must be spent." (96)

3.1.2.6.1 EXERCISE AND WORK PERFORMANCE

The physical training cosmonauts perform keep them in good health and gives them the ability to continue efficient work. (47)(163)

3.1.2.6.2 EXERCISE/CREW HIGHLIGHTS

90-Day Mission: This crew did not exercise religiously. Their readaptation was poor.

140-Day Mission: The two cosmonauts stressed several times that the monotony of the physical exercises exhausted them. Solution: FCC sent up several new music cassettes with specially designed musical accompaniment for physical training. Kovalyonok said that the music was excellent and that playing it while he exercised made the time go faster. (See 1.9.1.2 Music.) (127)

175-Day Mission: After two weeks in space these crew members expanded their exercise routine to 2 - 2-1/2 hours per day at a level of 150% more than the earlier crews. They exercised in the morning and evening. They walked for 4-1/2 km and jogged a further 4 km on the treadmill as well as exercising on the veloergometer. They worked on the onboard chest expander for 30 minutes per day. (170)(388)(548)

185-Day Mission: Everyday on the veloergometer they traveled 10 to 12 kilometers while also covering about 5 kilometers on the running track. The result: for the first time after an extended flight, Ground did not detect any decrease in the strength of the calf muscles. (See 5.1.2 Post Flight for results of missions.) (4)

237-Day Mission: This crew was the first to include a medical doctor, Cosmonaut Atkov. He was able to directly supervise the exercises. (284)(608) Experiments were also performed. (See 3.1.3 Experiments, 237-day mission, Sport experiment.) (608) Due to this new system of physical exercises and the cosmonauts' high degree of fitness [no indication as to what these new exercises were] FCC raised the working day to 8.5 hours. (162) These new exercises were more intensive and strenuous than those performed on earlier flights, but took less time to do. [This seems to point to the single 2-hour time period for exercise, as opposed to the multiple sessions that were performed prior to this mission. A single exercise period would allow less time expenditure for preparation and body cleaning after exercise.] (284)(300)

At one point (in March) the crew was working so hard they stopped doing their exercises for two consecutive days. (161)(162)(579)

At another point, there were six cosmonauts onboard (3 main crew members and 3 visiting crew members). One cosmonaut (visiting Cosmonaut Volk) was said to have been unable to do his physical exercises because he would have disturbed other members. [No indication as to why he would have disturbed other people or how.] (284) Another source indicated that he performed no physical exercises during his stay because he was taking tablets which reduce the unpleasant sensations that are usually experienced by cosmonauts during the first days of flight. He was being monitored by Atkov. [This was an experiment.] (133)

3.1.2.7 SLEEP

A. Facilities:

Beds are heat-insulated sleeping bags with bed-sheet inserts. (174)(366)

Air vents on all sides of the bags have napped fasteners that can be opened if a cosmonaut feels hot. (365)(366)

Sleeping facilities are in the widest portion of the Salyut, in the vicinity of the refrigerators and the food supply cabinet. (543)

For sleeping, the cosmonauts usually take their clothes off, but put on fur boots. This is because weightlessness prevents normal blood circulation to the feet and feet get cold. (365)(366)

Ryumin's height caused problems: He had to strap his bed to the floor and tuck his arms in because he was unable to squeeze into his allotted sleeping area on the ceiling. (168)

In order to avoid breathing dust or mechanical particles during sleep, special screening encloses the sleeping area. The screening is similar to mosquito netting. (70)

Cosmonauts have reported that they feel like they are suffocating at times due to slow air movement. (392)

B. Time Spent Sleeping:

Cosmonauts generally sleep at least 7 to 8 hours per day. The FCC will grant the cosmonauts more sleep time if it is needed (indicated by fatigue and irritability, for example). During some international flights the crew would get only 3 hours of sleep because of the added work load. (42)(341)

Earth Circadian rhythms should be retained by cosmonauts for maintaining health. (See 3.1.2.11 Biorhythms.)

Individual deviations in the soundness and duration of sleep were noted for several cosmonauts.

Sleep should take up about eight hours a day. The duration of uninterrupted sleep should be no less than four hours. (114)

ONBOARD STUDY

An analysis of daily cyclograms onboard showed that the time planned for sleep constituted a mean of 8-9 hours for the duration of any mission. However, on some days it reached 9-11 hours (after performing important and time-consuming work in experiments, on days off, etc.) (224)

C. Sleep Help:

Sleeping pills are taken at times. (42)(341)

During one long-term mission a cosmonaut had a sudden personality change. The main cause was that he had taken excessive doses of sleeping pills because he had been unable to rest. (See 4.1.3 Psychological Stability.) (559)

"Before sleeping it is pleasant to read the newspaper that I have already read a dozen times." (106)

3.1 Program Structure

D. Lack of Sleep:

Sleep is the main function in determining the productivity of any work-rest cycle. (See 3.1.2 Scheduling, 4.1 Alertness and Performance.)(224)

GROUND-BASED
CONTINUOUS WAKE TEST

This isolation chamber test with eight subjects showed that fatigue caused by lack of sleep can lead to a deterioration in the quality and effectiveness of work.

The test lasted 10 days. It used a regime of continuous activity which began on the fourth day and lasted 74 hours. Before the beginning of the tests, the operator became familiar with the skill of working the test device.

The increase in the quality and effectiveness of operator activity after allowing sleep and the deterioration of these indicators on the second day following the continuous activity regime deserve attention. From this one can note that:

- Continuous work activity leads to the development of fatigue and a decrease in work capacity
- Quality deteriorates
- The more complicated the activity, the greater the changes that are noted (325)

E. Dreams:

Cosmonauts report they dream every night. The usual dreams are about Earth.

Dreams show that the cosmonauts have become accustomed to living in the unusual conditions of space.(104)

3.1.2.7.1 SLEEP TIME/CREW HIGHLIGHTS

Salyut 6: During the Salyut 6 Missions there were certain periods of the flight when there were signs of fatigue at the end of the working day because of lack of sleep. Emotional flare-ups also occurred because of imprecise times of transmission and information, exacerbated by the lack of sleep. (476)

Salyut 7:

211-Day Mission:

This crew had problems sleeping, particularly at the beginning of the flight and the middle of the flight. (45)(213)

Lebedev: "I didn't sleep at all. Thought about home, the flight, friends, work. I should have slept at least a little while, but I couldn't..." (45)

By the end of the flight the cosmonauts were allowed to sleep for 12 hours a day instead of the usual 8. (176)

150-Day Mission:

During the early part of the mission the cosmonauts felt a need to take sleeping pills due to "unpleasant sensations." (103)(104) Later in the flight it was reported that they requested a shortening of their sleep time from 8 to 7 hours. (103)

However, Lyakhov reported that his sleep worsened as the mission length increased. (106)

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3.1 Program Structure

3.1.2.10 HOUSEKEEPING

With the second Salyut 6 crew, cleaning was done more frequently, as a means of keeping contamination down. (385)

The station is cleaned with a vacuum cleaner. Internal surfaces are cleaned using a cloth moistened with a disinfectant substance. (169)(385) [On the Salyut 7, new leather wall materials replaced the difficult to clean hero cloth. See 1.1.8 Walls.]

Cosmonauts clean the fans of the thermal regulation system. (169)

Lebedev, 211-Day Mission: "It might seem like a trifling matter to put things in their place and secure them properly. But this kind of thing is no longer trifling under conditions of weightlessness, and can cause pure wasted time." (405)

3.1.2.11 BIORHYTHMS

Productivity is maintained by adhering to a regime of:

- Work
- Rest
- Nourishment
- Motor activity based on biorhythmology:
 - Special methods have been developed which make it possible to discern a human's approach to a state of exhaustion at an early stage: mathematical analysis of the heart rhythm

The main biological rhythm is the diurnal (24-hour) rhythm of wakefulness and sleep, which protects the brain cells against exhaustion and insures normal activity.

It is difficult for a person to get used to an inverted daily rhythm (sleeping during the day and working at night) or to a fractional schedule (multi-phase activity and rest) and other altered rhythms.

The Soviets have assumed biological rhythm is a conditioned reflex. They therefore try to maintain a 24-hour day, 5-day work week, synchronized to Moscow time. (548)

It has not always been possible to construct activity around Circadian rhythms on all the space flights due to assignments in observation, research and self-service.

Seasonal rhythms are inherent in people: (114)

BIORHYTHMIC RESISTANCE

The Soviets are working on the theory that it is possible to increase a person's resistance to electromagnetic radiation, heat, noise and other unpleasant side effects. It has been found that people can be made stronger and more resistant by slowing down the cell processes, which increases the cell's resistance to a number of external factors. An individual's reaction time can be changed and latent resources mobilized by influencing the biorhythms of the body.

3.1 Program Structure

A human's normal state is disturbed in one way or another whenever she changes time zones or flies over the ocean. Each person reacts to these changes in their own way. The biological clock is linked with periodical changes in the environment, alteration of day and night, work and rest periods, wakefulness and sleep. In other words, people are not the same at different times of the day and night because of the chemical changes occurring in the body.

The body has a clock that coordinates the processes of biochemical processes. Many chemical compounds that enhance the resistance to radiation, for example, have the effect of slowing down cell division. In this way cell development is suspended. This is called a blocking of cell division. Nature has made provisions for blocking in the event of an emergency. This blocking mechanism can be turned on by the body itself as a defensive reaction to an external factor in order to slow down cell division. Experiments have shown that the length of the slowdown depends upon the intensity of the unfavorable external influence.

Rhythmical processes are disturbed by noise. Hormone production is affected by external influences. It has been proven, for instance, that noise levels above 90 decibels stimulate hormone production. It is known that an excess of a steroid like hydrocortisone tends to reduce the liver's immunity to harmful substances.

If used regularly, narcotic drugs and all kinds of artificial stimulants are dangerous to one's health because they speed up the biological clock, thus making cells divide at a fatal rate. A prolonged acceleration of life processes has a disastrous effect. (210)

Cosmonauts rarely use the alarm clock. Ivanchenkov, 140-Day Mission: "I've been getting up at 7 o'clock in the morning all my life and my biological clock works in space too." (365)(366)

The response to the consumption of drugs and alcohol is dependent on when they are administered during normal biorhythm. (548)

Emotional disorders are more readily manifested during alteration in the usual biorhythm. (114)(548)

3.1.2.11.1 SELECTION

Based on their studies, the Soviets believe that biorhythm is individualistic. Therefore, they select cosmonauts with specific biorhythms suited for particular space missions. (548)

In general, individuals with similar biorhythms seem to function better in a restricted environment. (See 4.4.3 Compatibility.) Crew members with similar biorhythms facilitate the coordination of various activities so that the crew is at optimum efficiency during the time work is required. They are all then able to rest during prescribed rest periods. (548)

3.1.2.11.2 EVA

The Soviets prefer early morning Moscow time space walks (See 2.2 EVA.) to maximize post contact daylight, but they accept the impact on crew and flight controller Circadian rhythms. (274)

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3.1 Program Structure

3.1.2.12 SCHEDULING PERSONNEL

Schedules are made daily on the ground in cooperation with the flight crew, scientists and others. (33)

Crew members participate in some aspects of scheduling (such as the work and rest regime). (87)(213)

Shatalov: "...Life itself put up problems we could not simulate on Earth." (33)

A. Analyzing:

Specialists on ground analyze the crews' work/rest regime. Data is a subjective analysis by cosmonauts (on work capabilities) transmitted every 24 hours to medical supervision posts. (385)

B. Designing:

Psychologists are also involved in designing all the activity for the cosmonauts. This includes:

- Work day length
 - Alteration in time
 - Kinds of rest:
 - To facilitate working capacity and enthusiasm (For example, preparing new video programs or musical entertainment.)
- (122)(231)(237)(383)

"Psychologists should design the activity of the cosmonaut as precisely as the engineer designs the operation of technical components of the spacecraft control systems." (237)

Russian crews repeatedly asked to have some options in the day-to-day organization of their work and leisure schedules--options allowing them more control over the effectiveness of their work. (58)

3.1.2.13 VOLUME AND MOTOR ACTIVITY

Motor activity remains constant for different species and is genetically determined by their size. Studies show that people who lead a sedentary life try to maintain their motor activity on a constant level inherent to each individual.

Under hypokinetic conditions there is a restriction of muscular activity. The following ground-based study was done to test the relationship between the decline of muscular activity and the degree of hypokinesia: (281)

GROUND-BASED MOTOR ACTIVITY WHEN IN A RESTRICTED SPACE

Results: There is a decrease in activity when muscular activity is restricted, and the decrease is the result of adaptation to hypodynamic conditions. There is also a lack of interest in exercising.

The study involved 4 men, 30 to 42 years of age.

Muscular activity was restricted by a 50-mA2D pressure chamber. Two men were restricted for 120 days, one man for 86 days and one man for 37 days. Their movements were not restricted and conditions were the same for all.

Eight to ten hours per day the men were involved in operator work and the performing of psychophysiological and medical tests.

Pedometers were used to determine the motor activity for two weeks before the study, during the stay in the chamber, and after it. A daily record was kept of the mean number of steps per day.

Result:

Before the study the mean (based on the four men) was 16,000 steps per day. At this time the motor activity was not restricted.

In the pressure chamber the mean was 2,000 to 4,000 steps per day. Also, subjects had no desire to be more active.

On some days activity rose and this was related to increased work. The number of steps increased with an increase in workload, but never exceeded 6,000 per day.

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

Note: (There are some problems with the use of pedometers. A pedometer reacts to any jolt and includes it as a reading of a number of steps. At the same time, it doesn't react to steps if they are made too smoothly. But the researchers felt that this method was still applicable.) (281)

3.1.2.14 MISSION HIGHLIGHTS

During the Salyut 6 Missions, crews were at first scheduled for 6 days of work and then one day of rest. Due to crew fatigue, this was changed to 5 days of work and one day of rest. With continued indications that the cosmonauts required more non-work time, the schedule was finally set at 5 days of work with Saturday and Sunday as days of rest. Some time on Saturday was used for sanitation. (See 3.1.2.10 Housekeeping.)

SALYUT 6:

96-Day Mission:

- First two months evaluated as high
- Third month was evaluated as satisfactory:
 - Fatigue was apparent during the first one-half of the day and the end of the day (385)

Gretchko liked to work with a camera and sketchbook near the portholes in the transfer compartment. Romanenko spent most of his free time rechecking the operation of control systems. (548)

140-Day Mission:

Productivity and mood were good during the entire flight.(87)(385)

175-Day Mission:

Their productivity was good. Later in the flight the crew felt a need to perform more than that which was scheduled. The FCC told the crew to adhere to the work/rest cycle so they wouldn't get tired. The FCC physicians noted that giving the cosmonauts too much work to do would leave them in the same physical and emotional unstable state as they would have been with too little to do. (170)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

During the May Day festivities, the crew was given a five-day vacation where they did not have to perform any scientific work. They did have to keep up with their exercises. (548)

185-Day Mission:

This was the first crew to be given every fourth day off from exercising. (548)

SALYUT 7:

211-Day Mission:

This crew adapted well to weightlessness so they began making visual observations from the very first day of flight.

Their first work included activating the life support system, the water recovery system and the power supply system. The workload was kept light to avoid tiring the crew.

FCC allotted three days for getting Salyut 7 into working order. The cosmonauts were then scheduled to prepare the scientific equipment, much of which was rigidly bolted down to protect it from the stresses of launch. The scientific research was scheduled to begin one week after launch. (167)(340)

Lebedev recorded in his diary that he worried about the increasing tedium of the mission and about what officials on the ground thought of his work. (646)

Lebedev, in a radio message to the station commission: "...When considering...the schedule for...our work aboard the...complex, we earnestly request that you take into account our desire, attitude and readiness to carry out the additional work program." (213)

Twice when there was a visiting expedition present there were five cosmonauts on the station. Program planning and distribution of functions had been done preflight. Some things had to be amended during the flight because cosmonauts would sometimes get in each other's way. This was something that had not been considered during training on Earth. (30)

150-Day Mission:

At the beginning of the mission the cosmonauts asked for an end to planned leisure activities so they could work more on experiments.

By the fourth month they were asking for an end to the experiments so they could have more free time. (144)

Sleep time was cut from 9 hours to 8 hours. The hour was added to the work schedule. (235)

Saturday was turned into a half day for rest and a half day for working. (This was done as an experiment.) (473)

During adaptation, the crew worked temporarily below peak efficiency because of physical problems. (as noted by the time and motion study. See 3.1.2.12 Scheduling Personnel.) (231)

After 100 days, Aleksandrov said they were tired and that their fatigue was building. (455)

During EVAs (See 2.2.10 EVA Missions.) the crew's schedule was disrupted. The evening before EVA they had to go to bed after lunch and wake up just before midnight. (139)

SOVIET SPACE STATION ANALOGS, Ed. II
3.1 Program Structure

237-Day Mission:

Crew members asked FCC not to assign tasks to specific crew members. They asked that the distribution of duties be left to them. (FCC complied.) (456)(545)

Crew work time was increased to 8-1/2 hours per day. (105)(132)(308)(545)(637) (Not all physicians agreed with the increase.) (132)

The crew's program allotted 50% more time for scientific and technical experiments than programs for earlier missions. (516)

The crew would sometimes spend one to two weeks on a particular scientific discipline. (545)

Dr. Atkov assumed the main housekeeping chores along with his medical examinations and experiments. (308)

The crew spent some leisure time shooting a film about the Soviet-Indian joint flight. (454)(597)

3.1.3 EXPERIMENTS

Prior to the Salyut 7 237-Day Mission, experiments were done in turns. For example, on the same day the cosmonauts might do biological work in the morning, photograph the Earth's surface during the day, and begin a material science experiment in the evening.

This frequent switching meant:

- Frequent changes in the station's orientation
- Preparation of different pieces of equipment for operation
- Loss of time due to shifting the cosmonauts from one type of work to another

During the 237-day mission, the crew did research in blocks of 3 or 4 of the same type for several days or weeks in succession before switching to another "block" of experiments. (234)

Cosmonauts are partial to experiments that particularly interest them. (294)

SALYUT 6 EXPERIMENTS:

(A.) Medical/Psychological:

Cardioleader:

- Measured the physical effort exerted by a cosmonaut when using the bicycle or running track.
- Used to develop a controlled program of exercise in which the effort spent in physical exercise was proportional to the action of the heart of the person using the piece of equipment (548)

Audio:

- Studied noise levels and the frequency characteristics of irritating noise (as determined by the complaints from crews) (548)

Smak:

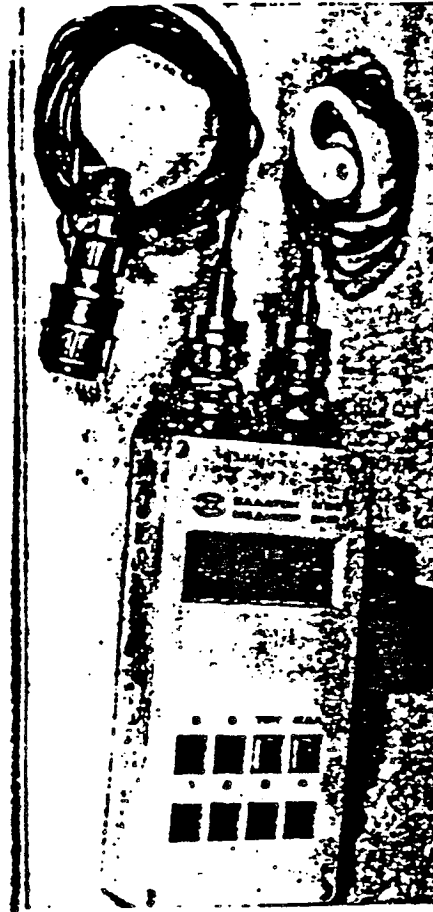
- Taste experiment
- Tastebuds were electrically stimulated to see how taste changes (Some of the cosmonauts have said that food that tasted great at the beginning of the mission began tasting like sawdust later.) (548)

Vremya:

- Time experiment
- Designed to test the crew's ability to react quickly to commands given by a machine or a human (548)

Speech:

- Studied was:
 - Tone
 - Volume
 - Rate
 - Characteristics of speech (548)



Hungarian "Balaton" instrument

Balaton:

- A test of mental ability and how long it lasts
- Measured the changes in the electrical conductivity of the skin and measured pulse. This data showed whether a given task had been performed easily or with effort:

For example, in one task a zero flashes on a dial and at the same time the cosmonaut has to press the button that has this same number. This becomes more difficult when there are 16 flashes in succession with numbers from 1 to 4. If the answer is accurate, the rate of flashes accelerates.
(114)(123)

SOVIET SPACE STATION ANALOGS, Ed.II

3.1 Program Structure

Opros:

- Questionnaire experiment (548)
- Questionnaire for the evaluation of the effects of the flight on the psychological state of the cosmonaut
- Monitored psychological health before, during and after the mission
- Studied the features of performing familiar operations and forming new work habits
- Studied appetite and sleep
- Studied interactions of crew members
- Self-assessment was based on 12 different indicators
(298)(299)(319)(371)(597)

Support Experiment ("Cuban Boot"):

- A special shoe was worn by a visiting Cuban cosmonaut to see if changes in the arch of the foot might be responsible for locomotory disorders (548)
- Provides a pressure of up to 60 torr to the bottom of the feet:
 - Makes the cosmonaut feel as though he is standing on solid ground
- Reportedly reduced the severity of spacial illusions and motor disturbances (58)

Cortex:

- Involved obtaining electroencephalograms of the cosmonauts (548)

Anthropometry:

- Determined the dynamics of change of some anthropometric indices (548)

Perception:

- Studied perception changes in the cosmonauts (548)

Dose:

- Measured radiation levels (See 2.5.7.1 Monitoring, Pille.) (548)

(B.) Biological Experiments:

Plants: (See 1.2.8 Plant Facility.)

Microorganisms

Tadpoles and flies (548)

(C.) Earth Resources Experiments:

-Observations of the Earth's atmosphere, land masses and oceans occupied 60% of the crew's work time. Four different cameras were used. (548)

MKF-6M Multispectral Camera: (See 2.4 Miscellaneous Equipment.) (548)

KATE-140: (See 2.4 Miscellaneous Equipment.) (548)

Biosphere:

-Visual observations were assisted by binoculars, chromaticity atlases and hand-held cameras. The objectives were to improve methods of space photography including:

- Selecting optimum angles for photographing specific natural objects in different states
- Selecting the best films, light filters and settings to best reflect actual land and water patterns
- Clarify how well photographs reproduce the chromaticity of the underlying surface
- Develop and improve methods of visual identification of objects and their state by the crew
- Investigate optical properties of the atmosphere in different conditions

Spektr-15 Spectrograph: (See 2.4 Miscellaneous Equipment.)

Land and Ocean Observations (548)

SOVIET SPACE STATION ANALOGS, Ed.II
3.1 Program Structure

(D.) Atmospheric Studies:

BST-1M Submillimeter Telescope: (See 2.4 Miscellaneous Equipment.)
(548)

Yelena Gamma Ray Instrument: (See 2.4 Miscellaneous Equipment.) (548)

Duga Electrophotometer: (See 2.4 Miscellaneous Equipment.) (548)

Refraction Experiment:

-Involved the study of optical phenomena in the atmosphere and
pollution near industrial areas. (548)

Zarya:

-Involved spectrographic measurements of the sunrise and sunset at
various altitudes to study the air density and temperatures in
the stratosphere and troposphere. (548)

(E.) Materials Processing and Other Technical Experiments:

Splav and Kristall Furnaces: (See 2.4 Miscellaneous Equipment.) (548)

Isparitel:

-Used in the development of the "Electron Beam Gun"
-Vaporizer (See 2.4 Miscellaneous Equipment.) (548)
-Used as part of developing a process for reconditioning various
surfaces
-For obtaining glass metals by simple heating and cooling
-To see whether metal can be vaporized in space (See 2.4
Miscellaneous Equipment.) (124)(191)(228)(233)(277)(280)(332)
(511)(657)

Lotus Experiment:

-Attempted to improve the method of obtaining structures from polyurethane foam. (No other details were released.) (548)

Biological Processing (In interferon): (548)

Holography:

-Holographic information was transmitted from the Salyut 6 to FCC and from FCC to the Salyut 6.

-The experiments revealed the nature of the losses of spacial and gradational information about the transmitted objects that arise during the exchange of holographic information over Earth-space television links:

--Only comparatively low-frequency information (such as an object displacement interserogram) can be transmitted without losses

--When it is necessary to carry out the holographic transmission of an image without losses, the rate of information transmission should be reduced (a single hologram should be transmitted in several frames) or the number of elements in a frame should be increased. (116)

-Additional space applications are:

--Evaluation of the condition of the station's portholes

--Measuring the velocity of gas expelled by the station's engines (See 2.4 Miscellaneous Equipment, Holographic Camera.) (548)

Navigation:

-The frequency with which navigation experiments were performed and the repeated references to the crew performing repairs on the navigation system suggest that there may have been significant problems here. (548)

SOVIET SPACE STATION ANALOGS, Ed.II

3.1 Program Structure

Systems Test:

-Resonance:

--Involved checks of the stability of the three-spacecraft complex (Salyut with the Soyuz plus the Progress) (548)

-Deformatsiya:

--To study the deformation of the exterior of the space station when one side was pointed towards the sun for a long period of time (548)

-Illuminator experiment:

--Concerned with studying changes in the optical properties of the station's portholes. Used were the Spektr-15 and Pentagon-6M cameras. (See 2.4 Miscellaneous Equipment.) (548)

(F.) Military Experiments:

The Soviet Union does not admit to using the Space Station for military purposes. (548)

SALYUT 7

211-Day Mission:

(A.) Medical/Psychological:

Ekhograf:

- Ultrasound location of the heart was made for the first time (30)

Poza:

- A study of the muscle responses while maintaining an upright position (30)

Weightlessness and Readaptation Experiments:

- To prevent unfavorable effects (208)

Aelita:

- Used to check the health of the cosmonauts
- Prior to its use, the Polinom was used. (96)(294)

(B.) Biological:

Plants:

- Continued work with the:
 - Magnitogravistat
 - Biogravistat
 - Oasis
 - Vazon
 - Fiton (See 1.2.8 Plant Facility.) (30)

(C.) Earth Resources:

- Visual and instrumental observation of the Earth's surface. (208)

SOVIET SPACE STATION ANALOGS, Ed.II

3.1 Program Structure

(D.) Atmospheric:

Seyfert Galaxy:

- Studied using an x-ray telescope
- X-ray radiation was observed that had 30 times the intensity of ordinary x-ray sources of average scale (208)

Astrophysical and Geophysical Experiments:

- Objects photographed by the Pyramig and PCN (See 2.4 Miscellaneous Equipment.) (208)

Dynamic Characteristic Study:

- Studied means of controlling the dynamic characteristic of the complex
- Used a mass spectrometer to study the composition and dynamics of the atmosphere surrounding the station:
 - It was denser than was thought [no indication as to how dense]
 - Knowing its characteristics will make it possible to assess its influence on the station's apparatus and experiments (208)

X-ray and Ultraviolet Radiation:

- Used the RT-4M telescope (96)

(E.) Materials Processing and Other Technical Experiments:

Korund Experiment:

- The Korund could make semiconductor materials in large batches:
 - Capsules of a given initial composition were loaded into a drum and the technological program for the experiment was selected from the control panel
 - The process was regulated automatically
 - Signals from the thermal sensor were fed to a computing device which analyzed and controlled the process
 - Cosmonauts monitored its status from an indicator board showing the parameters of the heat regime
 - The heat regime could vary between 20-1270° and at rates of 0.1-10° a minute

SOVIET SPACE STATION ANALOGS, Ed.II
3.1 Program Structure

- At the same time, the ampule itself could be moved inside the heated field at rates up to 100 mm a minute
- The crew obtained an 800 g cadmium selenide crystal 30 cm long and 30 mm in diameter (30)(96)(208)

Satellite Iskra-2 and Iskra-3:

- Launched from onboard the Salyut (208)

Gel:

- Property of gels is utilized in the production of superpure substances)
- Task: To obtain a gel of uniform physical structure. This was done, as in weightlessness uniformity was increased 50-100%:
 - Properties dependent on the uniformity of gel include its electrophoretic capacity
 - Useful to researchers in electrophoresis for detecting complex protein and other compounds (30)(68)(425)(500)

Kristall Furnace:

- Used to study the diffusion of melted lead and solid copper and the crystallization of alloys of aluminum and indium which do not mix on Earth (30)
- The problem with the use of this (as well as with the Korund) was that it was impossible to look into the ampule to see how the crystallization process occurred. (This was remedied on the 150-day mission.) (238)

Tavriya:

- Separation of complex substances by electrophoresis (55)(69)(314)(428)(487)
- Processes taking place in the Tavriya were recorded on the NIVA (See 2.1.2 Television Systems.) (30)
- Refined influenza preparations:
 - Preparations were several times purer than can be obtained on Earth (101)(133)(135)(278)(314)(456)(599)

SOVIET SPACE STATION ANALOGS, Ed.II

3.1 Program Structure

150-Day Mission:

(A.) Medical/Psychological:

- Bioelectrical activity of the heart:
 - While a cosmonaut rested (247)(522)
- Cardiovascular system's reaction to simulated hydrostatic pressure (247)(522)
- Body masses were measured
- Muscle conditioning (586)
- Scheduling experiment:
 - To try to find the "perfect balance" of work load/rest time and to maintain productivity. Question focused on what would work best:
 - A full week of work
 - 3 days of work, then 1 day of rest
 - How many days of rest each week
 - Whether it was desirable to shift sleep-wake cycles in the course of 24-hour periods
 - The crew had an increase in working time, night work and a series of operations having a "high emotional load." Activities during the working hours involved switching frequently from one job to another. Observations were made during this experiment. [No results have been available, although it should be noted that schedules have been changed to feature "blocks" and three days of work with one day of rest] (74)(238)

(B.) Biological:

- Oasis: (See 1.2.8 Plant Facility.)
 - To plant seeds of the dwarf wheat (238)(473)

(C.) Earth Resources:

- Color recording of the Earth's surface:
 - Using the Tsvet (247)
 - Determines how much the perception of color is distorted by the atmosphere (146)
- Study of the Earth's surface using:
 - MKF-6M
 - KATE-140
 - Two spectrometers:
 - Spektr-15
 - MKS-M (See 2.4 Miscellaneous Equipment.) (238)

- Statistical material gathered on:
 - Natural resources
 - Seasonal changes in agricultural lands
 - Biological productivity of the oceans (428)(487)(573)

(D.) Atmospheric:

- Measuring the Earth's surface:
 - Using MKS-M spectrometer
 - For making a study of the parameters of the atmosphere of the Earth's surface (See also C. Earth Resource studies.) (247)

Astra:

- Study of the atmosphere around the station to determine the content of substances escaping from the station and its surface
- Purpose: To determine whether this content was high enough to distort the results of optical observation (231)(519)

Yelena:

- To check the fluxes of high energy electrons in the Earth's inner radiation belt (238)(435)

(E.) Materials Processing and Other Technical Equipment:

Tavriya Experiment:

- See 211-Day Mission

Electrotopograf:

- Simple to use (290)
- Used for subjecting samples of various materials to space conditions without cosmonauts having to go outside the station:
 - A platform with 12 samples is placed in an airlocked chamber
 - The samples stay for a specified period of time
 - Samples are then transferred to the electrotopograf and an electrotopogram is taken (316)
- Tested materials are exposed to all factors of outer space:
 - Radiation
 - Temperature fluctuation
 - Micrometeorite hits

SOVIET SPACE STATION ANALOGS, Ed.II

3.1 Program Structure

- After the samples are retrieved back inside the station, they are photographed with an electrographical instrument. The pictures show all the defects which have formed. (479)
- Advantage of this over prior sample tests (where material had to be sent back to Earth for testing):
 - No alteration of results (which occurred in tests prior to the electrotopograf) (74)(197)(238)(316)
- Difficulties:
 - Samples must be taken from the airlock and examined quickly since even a short delay will produce electrostatic changes which will distort the actual results
 - On the other hand, after the exposure of several hours to space the airlock freezes, with its inside temperature dropping down to -150° C. If it were opened right away the resulting condensation would cause undesirable effects. Cosmonauts have to keep the airlock closed for six hours to bring its temperature even with that of the air in the station. This slows down the work and affects its accuracy. (479)
 - It is hoped that these investigations will help developers of space equipment in the choice of different kinds of materials (See 1.3.15 Construction and 2.4 Miscellaneous Equipment.) (199)(238)(290)(315)(412)(436)(487)(528)

Gel Experiment:

(See Gel, 211-Day Experiment.)

Resonance Experiment:

- To determine the complex's characteristics and the loads acting on it
- To determine the durability of some of its elements (519)(622)

Pion:

- To study the peculiarities of heat and mass transference in metiphase medium physics and zero gravity
- Experiment was to grow an indium crystal by drawing it from a melt through a shape-molding device (528)

237-Day Mission:

[For the first time, a medical doctor was part of the crew. Due to this, many of the experiments centered on the medical and psychological aspects of long missions.]

Many experiments examined the affects of weightlessness on the human body: the cardiovascular system, circulatory and immune systems, vision, equilibrium and the muscular system. Quite a few test results were analyzed onboard rather than sent back to Earth via the Soyuz and visiting crews, as was done in the past.

Goals of such tests were to counter the adverse reactions the body has to long-term weightlessness (readaptation) as well as finding ways to ease the affects of adaptation to weightlessness.]

(A.) Medical/Psychological:

Membrana Experiment:

- To ascertain how special substances which regulate calcium metabolism act on membranes: (131)
 - Experiments conducted earlier showed that the content of calcium and several other elements for the normal functioning of the heart decreases during long missions (131)
- Studied salt loss: (65)(67)(131)(582)(592)
 - Studied effectiveness of biochemical methods for retarding this process

Pneumatic Experiment:

- A deposition of blood in the legs was created with the aid of special pneumatic garters which hampered the redistribution of blood to the upper half of the body.
- Recordings were made of a number of indicators of the activity of the cardiovascular system
- Showed to be an effective preventive device for the adverse effects of early adaptation to weightlessness (For example, the rush of blood to the head was not so intense) (185)
- During the experiment, cosmonauts filled out questionnaires about their sensations and objective information about symptoms of vestibular disorders (161)(494)(520)(568)

SOVIET SPACE STATION ANALOGS, Ed.II

3.1 Program Structure

Eye Experiment:

- Research was carried out on:
 - Threshold of color vision
 - Depth vision
 - Eye capacity under various illumination conditions
 - Recordings of the processes of tracking
 - Eye-motor function
 - Vestibular vision interaction (568)(616)
- These were considered useful for preventing motion sickness and for preparing recommendations for performing visual observations (302)

Acceleration Experiment:

- To assess the extent of the disturbance in weightlessness of microacceleration vibrations and jolts caused by some mechanical systems. This does not affect people, but it may disturb or disrupt delicate experiments and future production processes in space
- Cosmonauts had to carry out three sequences of running and jumping to a calibrated signal. The running process consisted of 20 paces and the number of jumps 10. They had to run and jump in a set rhythm. Instruments recorded the consequences of all these actions. (592)

Ballisto Experiment:

- Studied the processes of the conversion of vibrational energy
- Studied the heart functioning as it is affected by changes of the position of the heart
- To expand possibilities for studying the contractile function of the heart in its right and left ventricles
- Extremely slight movements of the body were recorded from three mutually perpendicular axes
- Ballistocardiograms were recorded using a piezo electric accelerometer
- Three-dimensional pictures of the distribution of forces of heart contraction were obtained (65)(67)(228)(298)(299)(597)

Vektor Experiment:

- For improving quantitative and vector analyses of electrocardiograms
- Recorded the electrical activity of the heart and the chest vibrations caused by heartbeats (228)
- Gave additional information on the phase structure of the cardiac cycle and on changes in the filling of the ventricles during various periods of cardiac activity
- Gave compensatory-adaptive reactions of the circulatory system in detail
- This experiment used a number of new electrocardiograph and kinetocardiographic methods (162)(228)(299)(493)
- A portable vector cardiograph was developed for these studies (298)

Optokinez Experiment:

- Studied oculomotor functions and features of vestibular-visual interaction
- Checked a cosmonaut's speed of reaction to various light stimuli: (248)

OPTOKINEZ

In this experiment, a cosmonaut put his head inside a square box and watched for the appearance of streaks of light, then followed their movements on the screen of a videotape recorder.

Electrooculograms, electrocardiograms and pneumograms were recorded during the experiment. Results of the experiment were used to analyze (by seeing the reactions of the pupils) causes of motion sickness. (248)(298)(299)(319)(492)(496)(597)

Opros Experiment:

(See Salyut 6, Opros Experiment.)

SOVIET SPACE STATION ANALOGS, Ed.II

3.1 Program Structure

Yoga Experiment:

- For studying changes in the biomechanics of motion and impairments of coordination in space during the adaptation phase
- Motor activity of groups of muscles during the performance of exercises in static conditions were recorded (162)(299)(493)
- Cosmonauts' reactions were monitored as muscles relaxed
- Cosmonaut was strapped into position on the treadmill
- Yoga exercises were done for 25-60 minutes per day
(124)(161)(183)(185)(298)(319)(371)(492)(495)(520)(575)(597)(626)

Sport Experiment:

- While physical exercises were being performed (such as walking, running, and work on the bicycle ergometer), basic physical parameters were recorded using an electrocardiogram, including:
 - Arterial pressure:
 - Breathing rate
 - Pulse
- Analysis of the results at different stages of the flight were made to evaluate the cosmonauts' work capacity and state of health (301)(489)
- Four regimes of exercising were used. The first one was one that had been used previously and the other three were experimental. The experimental ones took less time, but were more intense. (131)(143)(432)(496)(497)

Hygiene Experiment:

This study included:

- Dust in the quarters (to find out where it comes from and where it piles up)
- Do the fans create drafts which can lead to a cold ?
- Are the work areas sufficiently luminated ?
- Are the personal hygiene facilities effective ?
- Is the clothing and footwear comfortable ? (72)(132)(143)(151)(301)

Biokhim Experiment:

- Analyzed blood electrolytes:
 - To see what effect long missions have on mineral metabolism and to determine some of the regulatory mechanisms that affect the development of negative electrolyte balance in the blood (162)
- Analyzed calcium metabolism
- Blood was taken from cosmonauts' veins for the first time with the Biokhim (301)(432)(553)

(C.) Earth Resources:

Every day crew members worked on a program studying the Earth's material resources and environment. All information was transmitted immediately to FCC. (580)

Terra:

- Color photos used to gain information about:
 - The level of air and water pollution and the extent to which industry is responsible
 - Determine new and better fishing areas (124)
 - Find new mineral deposits (124)(441)(533)(575)(595)(657)
 - Photos were made with hand-held cameras, the MKF-6M and KATE-140 (See 2.4 Miscellaneous Equipment.) (511)

Black Sea:

- To determine characteristics of water surfaces (612)
- Data can be used to optimize the operation of satellite systems for observing the ocean (456)(612)

SOVIET SPACE STATION ANALOGS, Ed.II
3.1 Program Structure

(D.) Atmospheric:

Siren:

- Measurements made of spectra of x-ray sources of galactic and extragalactic origin in the constellation Sagittarius, Cygnus, and in the Crab Nebula (605)

Astra:

- Studied the structure of the Earth's atmosphere (532)
- Determined parameters of the atmosphere around the Salyut (431)(532)(592)

Ekstinktsiya Experiment:

- To determine the density of aerosol layers of cosmic origin in the Earth's atmosphere
- Experiment performed using an EFO-1 photoelectric photometer
- Measured the change of brightness of stars as they set behind the atmosphere (thereby getting a cross section of the layers of aerosols) (607)

Yelena:

- See 150 Day Mission

Crommelin Comet:

- This was photographed to study the interplanetary medium, galactic and extragalactic sources of radiation (234)(435)(458)(639)

(E.) Materials Processing and Other Technical Experiments:

Ispartikel:

-(See Salyut 6 Experiment)

Kristall:

-(See 211-Day Mission, Kristall.) (553)

Light Fluxes:

- Measured light fluxes falling on the Salyut at different altitudes of the Sun over the horizon
- To determine the efficiency of the solar batteries in different flight modes of the station (589)

Infrared Radiometer:

-For studying the temperature of various elements of the Salyut by remote methods (605)

Tamponazh:

- To obtain sealing mixtures from various model materials in zero gravity (432)(494)(599)
- To clarify the mechanism of stages in the solidification of cement-like binding solutions (516)

Mortar:

-To see how the process of pore formation proceeds in mortar and whether a relationship exists between this process and the settling of particles (101)(620)

Tavriya:

-(See 211-Day Mission.)

SOVIET SPACE STATION ANALOGS, Ed.II

3.1 Program Structure

Torsion:

- To study the effects of space on structural materials:
 - Changes in physical-mechanical characteristics of materials were determined by evaluating the parameters of free damped vibrations that were periodically transmitted to the specimens being examined (491)(589)(616)

Electrotopograf:

- This experiment continued (See 150-day mission for details on the experiment.)
- During this mission, Kizim positioned the station so that the sun's rays warmed the airlock to a temperature equal to the air inside the station. This solved some of the difficulties that have occurred with prior test results. (479)

June-September 1985 Mission:

(A.) Medical/Psychological:

Optokinesis Experiment:

- To evaluate the causes of the occurrence of vestibular disorders in the critical period of adaptation to weightlessness (644)

Signal-RD Experiment:

- To study reflex diagnostics. (644)

Reflexodiagnostic Experiment:

- To study reflexodiagnosics in evaluating humans during the period of adaptation to zero gravity. (656)

Acupuncture Experiment:

- To study the points on the skin of the human body which are linked to internal organs
- It was reported that the first experiments show that 75% of the data received coincide with the results of other tests (650)

(B.) Biological:

Biological experiments continued to determine optimum conditions for cultivating higher plants in space hothouses. (623)

SOVIET SPACE STATION ANALOGS, Ed.II

3.1 Program Structure

(C.) Earth Resources:

Black Sea -- '85 Experiment:

- A series of studies of the Black Sea basin and the atmosphere over it
- International experiment: Scientists from the USSR, Bulgaria, Poland and the GDR took part
- Purpose was to determine the size of the mineral and biological resources of the Black Sea
- Specialists believe that the Black Sea offers good possibilities for studying relationships between the air and the water basin
- The experiment used what is called a tier principle of research:
 - Studies at the first tier immediately on the sea surface were conducted by the USSR and Bulgaria
 - Aerial photography was carried out from heights of 200-6000 meters by Soviet and Bulgarian planes

Geophysical Research:

- Experiments to study the structure of the Earth's atmosphere and to determine its spectral and optical characteristics
- Observation of land and ocean
- Photographed by hand-operated cameras and a stationary camera (434)(651)

(D.) Atmospheric:

Atmospheric Studies:

- Study of the structure of the Earth's atmosphere
- Study of the Earth's optical properties
- Study of water and ozone vapors in the atmosphere and the properties of aerosols (644)

Cupola Experiment:

- To evaluate atmospheric pollution over big industrial centers
- Used photographic, spectrometric and radiometric equipment (434)

(E.) Materials Processing and Other Technical Experiments:

Electrotopograf Experiment:

- This experiment continued (623)(656) (See under 150-Day Mission and 237-Day Mission.)
- A new electrophoresis installation was delivered (656)

Resonance Experiment:

- To determine the dynamic characteristics of the orbital complex
- To measure the loads experienced by its structures (656)

SOVIET SPACE STATION ANALOGS, Ed. II

3.1 Program Structure

3.1.3.1 ECONOMICS

Photosurveying materials to be relayed from space are helpful in:

- Charting maps for land utilization and control over the state of the coastal zone
- Cartographical work
- Oceanographic studies
- The study of conditions of forests, internal water bodies, farming crops and environment

The results of observations from orbit are being used to formulate predictions about the cutting down of forests, protecting green spaces, solving problems concerning the use of land and construction of new cities and large main transportation lines.

Experiments with alloys of different compositions will be used for practical work in obtaining diverse alloys used in modern engineering.

The electrotopograf experiment (see 3.1.3 experiment, 150-Day Mission) can help determine which materials are best suited for future space construction. (S.428, S.480)

3.3 ROLE RELATIONSHIPS



3.3.1 INTERNAL

The ability to understand and sympathize with others is important.

A cosmonaut has two interdependent roles:

- Biological (must be protected against various stressful inputs)
- Operator

Both roles influence the reliability of the spacecraft-human system.

The rational allocation of functions in organizing crew activity is critical:

- Between ground and crew
- Between automatic on-board systems and crew
- Among crew members

The commander must have an excellent knowledge of his functions and the ability to quickly evaluate. (221)

SOVIET SPACE STATION ANALOGS, Ed. II

3.3 Role Relationships

3.3.1.1 SEX ROLES

Cosmonaut Svetlana Savitskaya participated as a visiting crew member during the 211-Day Mission and the 237-Day Mission. She was promoted from researcher to flight engineer for her second Salyut flight.

Her participation in space flights appears to show a willingness by the Soviets to give women larger roles in the space program. (284) Savitskaya, as well as other sources, have said that there are at least ten women in training, representing different specialities. (64)(216)(284)(387) It is also stated that women tend to be treated the same as the men, but that may not always be the case:

Beregovoi, Chief of the Cosmonaut Training Center: "We have noticed that in training and study the whole work atmosphere and the mood in a crew of men and women are better than in a men-only one. Somehow the women elevate relationships in a small team, and this helps to stimulate its capacity for work." (370)

"In planning for the observation of fine color images--twilight phenomena, the colors of Earth's horizon--they had taken into consideration the 'women's eye for things.' At the same time the female pilot's experience in identifying local reference points can also prove valuable." (512)

Lebedev (on Savitskaya's visit): "[She] spent a long time in the transport vehicle getting herself ready...like any woman she was preening herself..." (213)

"...the Soviets believe there is a psychological advantage to having a woman as part of the space crew." (548)

When Savitskaya was onboard, the five male crew members acted differently. They were shaving almost twice a day and trying to help her with space biology experiments. She took on some of the cooking cares and Solovyev, who did not like potatoes, was eating them "with pleasure" now that they were cooked by Savitskaya. (599)

SOVIET SPACE STATION ANALOGS, Ed. II
3.3 Role Relationships

Beregovoi: "Women are more emotional and are upset easier." (34)

Shatalov has said that he does not want to subject women to the physical strain of longer flights.

More recently he commented that women would be included on future flights, but there would always be a certain division of labor. He feels that the installation of bulky structures and the unloading of Progress should be done by men. He thinks that medical personnel and meteorologists could be women. He does not rule out the possibility of flights by crews consisting entirely of women. (249)

It has been said that Savitskaya's presence created an extremely businesslike atmosphere, yet also kept the men in a good mood all the time. (244)

The male cosmonauts noted that women are pleasant to work and socialize with. (646)

Savitskaya felt that she had to be very careful not to make mistakes during training, etc., "...otherwise your mistake is held against women in general." (283)

Based on Savitskaya's flight records, doctors have not detected any substantial differences in the reactions of the male and female bodies to the conditions of space flights. (194)(512)

Dr. Atkov, Salyut 7, 237-day mission: "I think that the opportunities for men and women are fairly equal...I am positive that women astronauts and women cosmonauts will prove this in the near future." (408)

A health official said that women might take part in long flights after they have participated in shorter missions involving mixed and all-female crews. (649)

SOVIET SPACE STATION ANALOGS, Ed. II
3.3 Role Relationships

Yeliseyev: "The initial flights with female cosmonauts are considered as a technical step we need as part of the overall Salyut space station program. We need to make some changes in the station's arrangement to accommodate the women crew members." (549)

Savitskaya herself has commented:

"A hundred years from now no one will remember it, and if they do, it will sound strange that it was once questioned whether a woman should go into space." (370)

"At a minimum, women are equal to men in space. Women are actually better at some space tasks than men. They are better at dealing with precision tasks. They are more meticulous. They are more flexible at switching from one task to another. Men, of course, are better where heavy exertion is required."

From a news report: "Appearing slightly irritated by frequent references to the pleasant atmosphere a woman brings to a space station, she [Svetlana Savitskaya] said, 'We do not go into space to improve the mood of the crew. Women go into space because they measure up to the job. They can do it.'" (646)

She has also said that it would be a good idea to include husbands and wives on long-mission crews. (351)



Visiting Crew That Includes Indian Cosmonaut

3.3.1.2 OUTSIDERS: INTERNATIONAL/VISITING CREWS

Lebedev, Salyut 211-Day Mission:

"Our attitude towards the visiting expeditions is complicated. On the one hand, I associate their arrival with a lot of commotion. We had to tidy up the station, ready apparatus, documentation and the working and sleeping sections, then feed everyone. Well--you know what it's like receiving guests. On the other hand, you wait for them like brothers and the joy of personal contact makes up for the difficulties." (417)

SOVIET SPACE STATION ANALOGS, Ed. II

3.3 Role Relationships

Lebedev: "We are waiting for our guests with some anxiety. We finally settled in and here new people are coming. Just so long as they don't rock the boat. The two of us are already used to each other and now it's going to be like starting all over again." (45)(106)

Most cosmonauts seemed to enjoy the addition of an international team for part of their mission. Most reported that they got along well with visiting crew members and were sad when these part-time crew members had to leave. (34)(39)(114)(339)

Ryumin: "...it was the visiting expeditions that gave us the major psychological support." (400)

Berezovoy: "...no matter how pleasant...radio meetings are,...to open a hatch behind which are three friends is much nicer..." (100)

Both the visiting crews and main crews generally get less sleep at this time due to an increase in experiments. (110) Crew members have to use working time set aside for physical exercise, eating and sleeping. (114)(385)

SOVIET SPACE STATION ANALOGS, Ed. II
3.3 Role Relationships

Lack of time and sleep and a schedule disruption are not the only problems that can occur. With an international visiting crew, some of the possible problems are:

-Language:

RUSTON

On the Soviet-American flight (Soyuz-Apollo), the crew members were able to communicate with each other through a language that they jokingly referred to as "Ruston" (coined by combining the words Russian and Houston).

This combining of languages was supposed to have solved the problem of bilingual communication. However, this language caused problems for the translators and technical personnel. (334)(378)

--Problems to be considered:

- The capacity to learn another language
- Interior translation to another language and the amount of time it adds to the communication process
- Articulation habits
- Behavioral differences (334)

-Behavioral differences:

- Concepts about privacy and cleanliness
- Problem of choosing a means and method for contact
- National ethnic characteristics (34)(45)(114)(237)(334)

To aid in mutual understanding, each new crew member should:

- Have a knowledge and an understanding of foreign crew members' culture, customs, traditions and language
- Recognize the value of own actions, actions of others and the group
- Have similar personalities and ideas, a "union of like-minded people"
- Trust other crew members
- Have a united formal and informal structure (this is important for solving problems) (221)

SOVIET SPACE STATION ANALOGS, Ed. II

3.3 Role Relationships

A French crew member who briefly visited the Salyut 7 confided to friends that he never quite felt included in the cosmonauts' tightly knit group. (45)

One cosmonaut was reported to have said that the visits of a visiting crew had caused the three-person, 237-day Salyut 7 mission crew psychological problems because it had upset their normal working rhythm. (545)

The organization of international flights has shown the need for special (including psychological) training. (237)

Training foreign cosmonauts for space flight includes 1-1/2 to 2 years of intensive training. Classes include physical conditioning, space flight theory and Russian language lessons. Foreign cosmonauts take their lecture notes in Russian after six months of training. (161)(216)

"...the coordination of international crew activity is...conditioned by a good knowledge of Russian." (334)

When foreign cosmonauts are used with the Soviet cosmonauts, the foreign cosmonauts study and improve their knowledge of Russian. It is especially difficult for them to master space terminology, which is characterized by changed and abbreviated names and symbols. (334)(50)

LEARNING RUSSIAN

When the Indian cosmonauts Sharma and Malhotra met their Soviet comrades two years before going into space, they could not speak without an interpreter. The language barrier was the first obstacle they needed to overcome. Not only did they have to learn Russian, they had to learn Russian space terms and their meanings. (See 3.4.1 Ground Training.) (546)

"...the era of international flights raises totally new questions in the field of verbal communication, which has not yet been dealt with by cosmonautics." (334)

A communication bridge via space was established between the Salyut 7 and the Indian capital during the international Soviet-Indian flight. (575)

Crew members from the other countries bring along foods (See 1.10.1 Types of Food and Preferences.) and music (See 1.9.1.2 Music.) of their own choice. (454)(646)

International crews take symbolic items from their country. For example, when the Indian cosmonaut visited during the 237-day mission, he took pictures of Ghandi, Nehru and other Indian statesmen, samples of soil from the Mahatma Ghandi memorial, an Indian flag, and pennants of the different research organizations who prepared experiments and instruments. (372)

3.3.1.2.1 ECONOMIC ADVANTAGES

International crews are valuable because the participating countries can contribute new ideas and experiences. (216)

The scientific program of each international flight always takes into account national economy oriented tasks. (373)

"...in future flights, programs provide for visiting expeditions. This would facilitate work. It would be possible to send work results back to Earth, process them there, and to bring back corrections." (339)

Visiting crew members also:

- Train long-mission crew members (as Dzhaniybekov did during the 237-day mission). (See 2.2.10 EVA Missions.)
- Do special experiments (419)

SOVIET SPACE STATION ANALOGS, Ed. II

3.3 Role Relationships

3.3.2 EXTERNAL

3.3.2.1 FAMILY AND FRIENDS

Aleksandrov: "I miss my family a great deal." (104)

Experience during missions has revealed that there is a great need for contact with families. This need becomes more important toward the end of the mission. (256)

DREAMS OF HOME

In February, 1984, when the crew of the Salyut 7, 237-day mission arrived at the station, they agreed that they would not mention the word "landing" for as long as they could.

The first to break the promise was Kizim, who had a dream one-and-a-half months before their mission was to end.

He dreamed about his wife and the baby daughter who was born several months after he went into orbit. The dream was so vivid that it woke him up and he could not get back to sleep.

"I'm probably homesick," he thought. In the morning he told the other crew members about his dream and admitted that he was counting the days left before landing. (246)

"You talk with your wife and can guess from her intonation and intervals between words a lot more than what she is actually saying." (417)

Cosmonauts report that the most enjoyable television transmissions are encounters with their families. Family and friends can also pick up the nuances of mood more precisely and give advice to the flight directors. (39)(417)(421)

SOVIET SPACE STATION ANALOGS, Ed. II
3.3 Role Relationships

Maintaining a connection with family is important for the morale of the cosmonaut. The video cassettes are watched many times: (405)

During one Salyut 6 flight, a cosmonaut received a video cassette that showed his daughter's birthday celebration. "I would put it on when I felt particularly homesick. You watch, get engrossed in it, and it seems like you're with your family." (417)

Television transmissions that set up communication between cosmonauts and their families play a positive role in psychological support. (91)(213)(340)(503)(515)

Letters are important: (106)(213)

Lyakhov: "For us a letter is an extraordinary event. We read them over and over many times. Letters from dear ones, relations, friends..." (104)

Aleksandrov: "...I received a letter from Natasha via teletype. More joy..." (249) (Aleksandrov's wife worked at FCC during his flight.) (249)(453)

3.3.3 PROFESSIONAL

3.3.3.1 CAREER PATH AND PROFESSIONAL GROWTH

Many cosmonauts have become doctors and candidates of the sciences. Some of them hold high administrative and management positions. (13)

Ryumin is a cosmonaut who spent 360 days in space over a two-year period in 1979 and 1980. He now directs space flight activities. Ryumin has also been involved in the design of the Salyut stations. (194)(401)

Space experience is very valuable for those who work as flight directors. (294)

SOVIET SPACE STATION ANALOGS, Ed. II

3.3 Role Relationships

3.4 TRAINING AND SIMULATION

3.4.1 GROUND TRAINING

"[Being a] cosmonaut is one of the few professions for which it is...impossible to gain experience of actual activities during the training process. The main task of the cosmonaut training system is to form professional knowledge, skill and habits by...creating...activity that approximates the reality as closely as possible with...corresponding emotional and psychic stresses." (261)

A. Areas of Training:

Cosmonauts are trained in four basic areas:

- Preparation for spacecraft control and operation and maintenance of the onboard service systems
- Training in the testing of space equipment and the performance of scientific experiments and studies
- Preparation for the effect of space flight factors
- Moral-political and psychological training (83)(84)(261)

Training is no longer dominated by physical and psychological considerations, but by the development of practical skills for Earth observations--geology, oceanography and meteorography. (167)

Cosmonauts are trained in two phases:

General Training

(This is done in groups of trainees. Crews have not yet been formed.) (26)

- Theoretical basis of cosmonautics
- Medical-biological
- Physical
- Flight dynamics
- Navigation
- Astronomy
- Computers
- Ballistics
- Medicine
- Consideration of psychological compatibility (27)

SOVIET SPACE STATION ANALOGS, Ed. II
3.4 Training and Simulation

General training includes studying:

- The space station
- Onboard systems
- Launch vehicle flight control
- Launch complexes (126)

They also train by:

- Flying on aircraft
- Parachute jumping
- Physical training
- Medical and biological preparation (83)

They must have a basic knowledge of:

- Mathematics
- Physics
- Astronomy
- Geography
- Biology
- Medicine (126)

The general training program is designed for two years. Upon completion of the first training phase, cosmonauts undergo personal interviews, course tests and examinations. When general training is completed the crews are formed.

Direct Training

(This concerns immediate training for a specific flight and is conducted on a crew basis. This program usually involves 2-3 crews: the base crew and the back-up crew. Soviet cosmonauts train as back-ups before being assigned to their own missions.

During this second stage, the cosmonauts work on controlling space equipment:

- Exercises in various types of trainers, mockups and modeling stands (to practice controlling the spacecraft)
- Detailed study of the flight program:
 - They work out each operation and entire flight stages
 - Switch to an integrated trainer to simulate an entire flight from take-off to landing
- Study of onboard and flight documentation
- Techniques for performing research and experiments
- Interaction with ground

SOVIET SPACE STATION ANALOGS, Ed. II

3.4 Training and Simulation

Cosmonauts perform training exercises in different climates and regions to acquire skills of making use of whatever is available to survive and stay fit until search groups arrive in case there is an emergency landing. (13)(26)(83)(84)(154)(186)(262)

Other training includes:

- Space natural history, which includes several stages:
 - General theory courses (lectures on the principles of space natural history)
 - Visual observation training (theory reinforced with practice)
- Visual observation training:
 - Cosmonauts learn how to find necessary objects from the air (336)(389)
 - Learning to "read" surroundings and to quickly fix on what has been seen. Training for this involves special exercises using a television screen which reproduces space (389)
- Practicing the receiving and interpreting of space photographs (389)
- Assembly, disassembly and repair operations (an integral part of training) (355)

Technical training is the most important. The crew must know the equipment completely. (84)

Detailed Training is given in:

- Ejection into orbit
- Orbital flight with orientation of a manned spacecraft on the Sun, the Earth, terrestrial orientation points, the stars, and the planets
- Orbital flight with orientation and navigation on the basis of objects in space
- Maneuvering in orbit
- Finding, approaching and docking with other spacecraft
- Undocking and descent from orbit (304)

The first extended flights in the station showed that the value of research increases if the cosmonaut knows both equipment and the aims of the research down to the last detail. (112)

SOVIET SPACE STATION ANALOGS, Ed. II
3.4 Training and Simulation

If it is necessary to improve the skills of the operator's activity, programmed and independent training should alternate. (381)

There is a subjective examination of each cosmonaut's performance (123)

B. Problems With Training:

- Correspondence of training operations to activity in flight
- Quality of training operations
- Creation of emergency situations on a trainer
- Principles of building trainers and training complexes (84)

The greatest difficulties that arise during training are simulating cosmonaut activity under terrestrial conditions. (237)

"No laboratory experiment can provide those complex conditions of activity which arise on the space flight." (296)

Training should give the cosmonaut the maximum amount of reliable information for creating the conceptual model of a real situation, since "...the cosmonaut works in space on some object but trains on the Earth on others." (37)(364)

C. Training Period:

Training for a specific flight takes 3-4 years, but the cosmonaut has to study the theory, the equipment and must also participate in the development of new instruments, in the creation of spacecraft and stations, in flight control and in back-up. This additional training usually takes 5-6 years. (112)(502)

The daily schedule is rigid. Classes are held from 9:00 a.m. to 7:00 p.m. If a problem comes up, training continues until 11:00 p.m. (476)

3.4 Training and Simulation

Cosmonauts have their day scheduled, but are also given personal time to use the various systems. (312)

D. International Crews:

International crew members usually train for a couple of years with Russian cosmonauts. (546)(548)

The Indian cosmonauts had 50 flights, each 4 hours long, carried out on a simulator. They also had workouts on special simulators in the hydrosphere with full load in laboratory aircraft in the centrifuge, parachute jumps, training under different climatic and geographic conditions. (546)

International crew training :

- First stage: Theory, which also includes studying the spaceship and space station design, flights on airplanes, parachute jumps and work with photographic equipment.
- Second stage: Training with experienced Soviet cosmonauts who are the other members of the upcoming missions' crew and back-up crew.

Examinations are taken after the first stage and second stage of training. (49)

E. Multiple-Expedition :

Training for multiple-expedition missions entails a number of special features and difficulties:

- Need to train a large number of crews simultaneously (including backup crews)
- Differences in the training programs for each mission in terms of tasks
- Coordination in training crews for tasks connected with the interaction of a main mission crew and a visiting crew (261)

3.4.1.1 EXERCISE AND PHYSICAL TRAINING

The physical training of crews takes between 12 and 18 months. (388)

Medical-biological and physical training are conducted in all phases of training. (13)

During training cosmonauts study methods of overcoming:

- Short-term overloads
- Acceleration
- Weightlessness
- Other processes occurring during space flight (20)

Exercises are done every day and individual needs are taken into account:

INDIVIDUAL NEEDS

Doctors were concerned that Lyakhov, a solidly built person, might on his first encounter with weightlessness experience problems. Therefore, they concentrated the greater part of his training on tuning his vestibular system. Ryumin's training concentrated on his cardiovascular system. (20)(174)

Physical training incorporates:

- Running
- Skiing
- Swimming
- Diving
- Vaulting (over a trampoline net)
- Rowing
- Cycling
- Acrobats
- Gymnastics
- Exercises with weights (20)

All these improve the working rhythm of the heart, the lungs and the whole physical being under a constantly increasing load. In short, cosmonauts' physical training must be extremely varied. (20)

SOVIET SPACE STATION ANALOGS, Ed. II

3.4 Training and Simulation

Physical training for increasing psychological resistance plays an important part in maintaining the readiness of crew in stressful situations.

Physical training facilities can increase resistance to G-forces by 30-40%. Investigations have shown that the conditioning effect of physical training appears after 20-30 hours of exercises. Therefore, one hour of special exercises should be conducted three times a week. To be included:

- Walking
- Running
- Developmental exercises
- Abdominal-muscle exercises
- Trunk exercises (239)

Adaptation to weightlessness appears to be enhanced by the exercises the crews perform before a flight. (87)(239)

3.4.1.2 GROUP DYNAMICS

Berezovoy, 211-Day Mission: "Valentin and I underwent a short, highly intensive preparation period. There were certain human-interrelationship questions...we were unable to resolve conclusively on Earth. They accompanied us into space, and there we handled them. It would be better if our successors need not do this." (417) (There were indications that the cosmonauts on this mission were not getting along. This was usually blamed on fatigue and frustrations over equipment problems.) (269)

In group training, attention is paid to the development of skills of joint actions, particularly in critical and stressful situations. Group interaction is also studied: (237)(266)

JOINT TRAINING

Cosmonauts get to know each other's inclinations, capabilities and peculiarities, develop cooperation and the ability to understand one another at a word or glance. It is important to learn to work together as a team. Group games are incorporated. (20)(341)

Psychological training is necessary, particularly compatibility within the crew. Crews spend free time together before a flight. This is a way of minimizing stressful situations. (34)(220)(388)

3.4.1.3 PSYCHOLOGICAL TRAINING

"The ultimate success of a mission may very well depend on the psychological fine tuning of the cosmonaut." (548)

Since the beginning of their space program, the Soviets have included a social and psychological testing and training program before flights. They stress the importance of this type of training. Says Beregovoi (who is in charge of Cosmonaut Crew Training): "Most men die psychologically before they die physically. They are not prepared." (34)

Psychological training:

- Psychological stress training is practiced on the ground to emotionally prepare the cosmonaut for the unexpected
- Training programs prepare crew members for stresses other than a crisis:
 - Isolation
 - Boredom
 - Confinement (548)
- Cosmonauts are prepared psychologically for the rigorous exercise conditions (See 3.1.2.6 Exercise Time.) (26)
- Training includes:
 - Personality factors
 - Group compatibility
 - Psychological requirements made on any given activity (20)(395)
- Individual psychological characteristics of each cosmonaut are taken into account:
 - Human characteristics under conditions of space flight make it clear that cosmonaut training cannot be standard and stereotyped (29)(237)(266)(364)

SOVIET SPACE STATION ANALOGS, Ed. II
3.4 Training and Simulation

- On the basis of an in-depth study of the personality of the cosmonaut, individual psychological-emotional training is devised to train each cosmonaut in methods of self-control and self-regulation of functions. Psychotherapeutic procedures based upon principles of biofeedback are used (34)(181)(266)
- A psychological diagnosis is made and formalized by the base properties of the personality:
 - The strength of the neuro-processes
 - The cognitive process (characteristics of perception, memory, intellect)
 - The sociopsychological indicators of personality social experience and orientation)
 - The emotional sphere (emotional maturity and stability under conditions of stress)
- Group attitudes
- The ability to disassociate from a situation at the necessary moment:
 - Preserves working capacity
 - Necessary for psychological readiness for conscious action (362)

"There is no scientifically founded and effective program of psychological training of the crew. The coordination of the crew as a group takes place at the level of common sense. In most cases, coordinated and friendly space crews are selected, which rules out the possibility of serious conflict in flight." (346)

"Specific knowledge, life and professional experience, the level of preparedness, training, the effect of the environment and other factors have a significant effect in the process of professional training of the cosmonaut...Taking into account the individual cognitive tactics of behavior...makes it possible to...correctly orient psychologists, educators, and methodologists at all stages of the psychological training of the cosmonaut." (364)

SOVIET SPACE STATION ANALOGS, Ed. II

3.4 Training and Simulation

3.4.1.3.1 METHODS

Methods include:

- Individual in-depth personality study (181)(237)(266)(364)
- Psychotherapeutic procedures based on the principles of biofeedback (181)(266)
- Isolation chamber (long stay in a limited space)
- Aircraft
- Parachute jumps (20)(181)(377)
- Autogenic training (self-discipline; knowing how to control one's emotions) (34)(114)
- Self-regulation of physiological functions:
 - Modern investigations show that under certain conditions humans can learn to be cognizant of, and voluntarily regulate, certain unconscious physiological functions so as to regulate the reserve of the whole. It is thought that methods of training for autogenic regulation should become a component part of cosmonaut training. The physiological functions that can be regulated include:
 - Frequency of heartbeat
 - Arterial pressure
 - Skin galvanic reaction
 - Electrophysiological process of the brain (237)
- Observation
- Meetings
- Experimental tests
- Test examinations (364)
- Survival test:
 - Cosmonauts are left in a remote and hostile location and must survive on the basis of their wits, skill, and self-control (34)
- Emotiogenic conditioning:
 - This is to form an emotional state that approximates the real one. These emotiogenic conditions should only include assignments which are the basis of the activity of cosmonauts (perception, analyzing information, making the decision, and its realization). Training should be done on aircraft and during parachute training. Using these methods assures the development of real stress. This is a necessary for psychological training:

SPACE WALK/PARACHUTE JUMP

One cosmonaut summarized his space walk in the following way: "The sensation is the same as during the first parachute jump -- as if one is standing at the open door and is waiting the command "jump." Analysis of the situation occurs rapidly. Emotional stress at this moment is high..." (377)

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3.4 Training and Simulation

3.4.1.3.2 GOALS

Goals of Psychological Training include:

- Self-control and self-regulation (181)(266)
- Help determine the nervous and psychological resistance to long stay in a limited space (20)(181)
- Attention, observation and memory (237)
- Crew compatibility (395)
- Preparation for:
 - The duration of the flight
 - Isolation
 - Unexpected circumstances
 - Stress (237)(341)(377)(548)
- To help cosmonauts form a conceptual model of the upcoming flight
- To teach cosmonauts to realize psychophysiological reserves (29)(237)(364)

3.4.1.3.3 OUTCOMES

Outcomes of Psychological Training are:

- Improved safety (29)
- Self-control (181)(237)(266)(362)
- Stability under stress
- Group compatibility
- Effective activity (364)
- Improved capacity for stress (237)(377)

3.4.1.4 TRAINING EQUIPMENT AND FACILITIES

"All training facilities...are made as close as possible to actual flight conditions since the...facilities on the ground are the sole means of preparing for any space flight." (13)

Facilities for training:

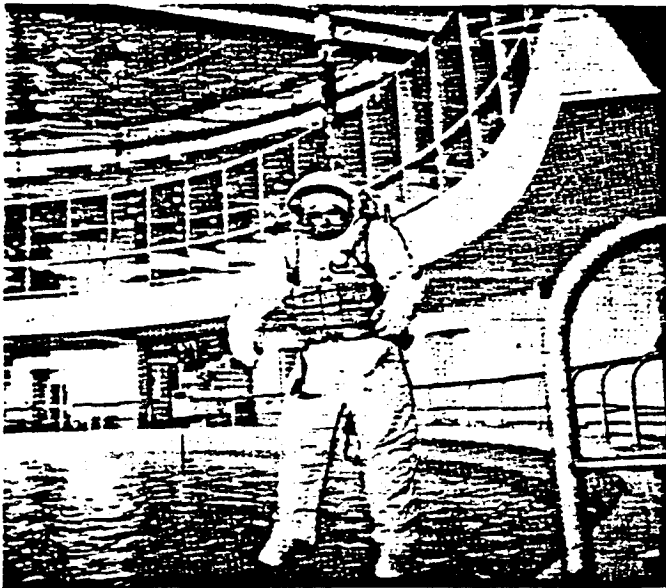
Centrifuge:

- Shoulder length: 18m
- Helps to develop habits for conducting work where high acceleration loads are active (13)(20)(26)(262)
- Centrifugal forces are increased gradually concomitant with greater time intervals between G-force exposure:
 - Effective for enhancing tolerance levels
 - Cosmonauts have been exposed to transverse G-forces up to 10 G. (548)
- On the centrifuge shoulder is a cabin that can hold one person:
 - The cabin is either rigidly attached or mounted in a Cardan device
 - If the Cardan device is used, it can have several df while rotating in different directions:
 - Rotation must be smooth and rapid
 - All information on the centrifuge is monitored (13)

Hydrolaboratory:

- The hydrolaboratory houses the hydropool, which is 23m in diameter and 12m deep (13)(20)(26)(262)
- A mock-up of the Salyut is on the bottom of the tank (about 12m below the surface): (548)
 - The mock-up can be lowered to full depth or raised
 - A Soyuz simulator can be "docked" to the Salyut (26)
- Training includes:
 - Walking into space
 - Use of hatches
 - Assembly and disassembly
 - Refining EVA interaction
 - Unloading cargo ships (13)(20)(262)
- Special pressure suits are worn:
 - There are pockets on the suit
 - Lead weights are put in the pockets to give cosmonauts zero buoyancy (13)(416)

- Cosmonauts are monitored via television (548)
- Using the hydrolab is useful because of the similarities between cosmonauts and aquanauts:
 - Limited space
 - High emotional loads
 - Artificial atmosphere
 - Condition of "weightlessness"
 - Necessity of using special equipment (83)



Ed. I

Cosmonauts have said that the only real training was experience accumulated during the flight. They noted that the longer the stay in space the more efficient the work becomes. (163)

Flying Laboratories:



- Cosmonauts are trained for observation work in high altitude aircraft (26)(154)(548)
- Permits brief exposure to zero gravity (548)
- Since 60% of the crew's time is spent in observing the Earth's atmosphere, land masses and oceans, the aircraft also provides a classroom for lessons by geological and scientific experts (548)
- Cosmonauts become familiar with territory from altitudes of 9 km. This helps in locating designated sites when they are on the Salyut (154)
- Used to familiarize cosmonauts with weightlessness

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3.4 Training and Simulation

- Flight and parachute training are mandatory. These help shape:
 - Effective thinking
 - Emotional stability
 - Psychological readiness
 - Capacity to tolerate the effects of space flight factors (84)(262)
- Parachute training develops:
 - Self-confidence
 - Discipline and steadiness during an unexpected or emergency situation
 - Constant skill and coordinated movements during free fall toward an object
 - Helps in quickly evaluating and analyzing a situation and meeting its changes with accurate, coordinated movements (83)
- Day and night parachute jumps are taken from different altitudes (20)
- Every cosmonaut makes at least 100 parachute jumps while performing tasks that become successively more difficult. (This is to develop the ability to concentrate under stress.) For example:
 - Simple task: The cosmonaut must count to 20 before opening the chute
 - Difficult task: The cosmonaut is equipped with a two-way radio. He has to listen for and identify locations on the ground before opening the chute (34)(548)

Pressure Chamber:

- Stationary, hermetically sealed room
- Barometric pressure can be varied
- Spacesuits are worn (13)

Heat Chamber (Thermal Altitude Chamber):

- Temperature can be varied
- Larger than chambers on the Salyut
- There are sectional chambers in which a mock-up can be placed (13)
- Every one is examined to see maximum mobilization capabilities and to disclose and determine the reserve margin of strength (20)

Mock-up:

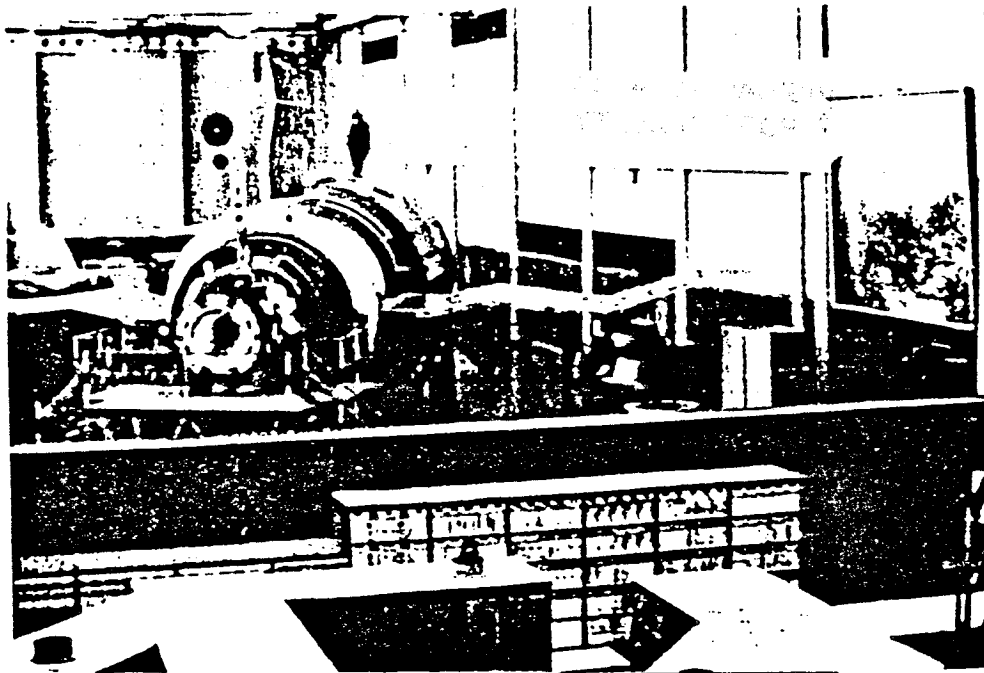


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Pic. 525

- Has a cabin with actual interiors, standard apparatus systems, units and work station
- Length: 28m
- During training exercises, the cosmonauts are in the simulator cabin for long periods of time so the simulator includes a system for air conditioning and controlling the supply of air in the cabin and spacesuit

3.4 Training and Simulation



Ed. I

During training the crew learns to:

- Test station equipment
- Monitor all systems
- Control the craft for orientation by the Earth and the Sun
- Carry out maneuvers
- Assemble and dismantle replaceable equipment
- Detect and eliminate malfunctioning systems
- Work as a crew in emergency situations
- Interact with one another
- Interact with FCC (13)(158)(262)

Modeling Test Stand:

This includes:

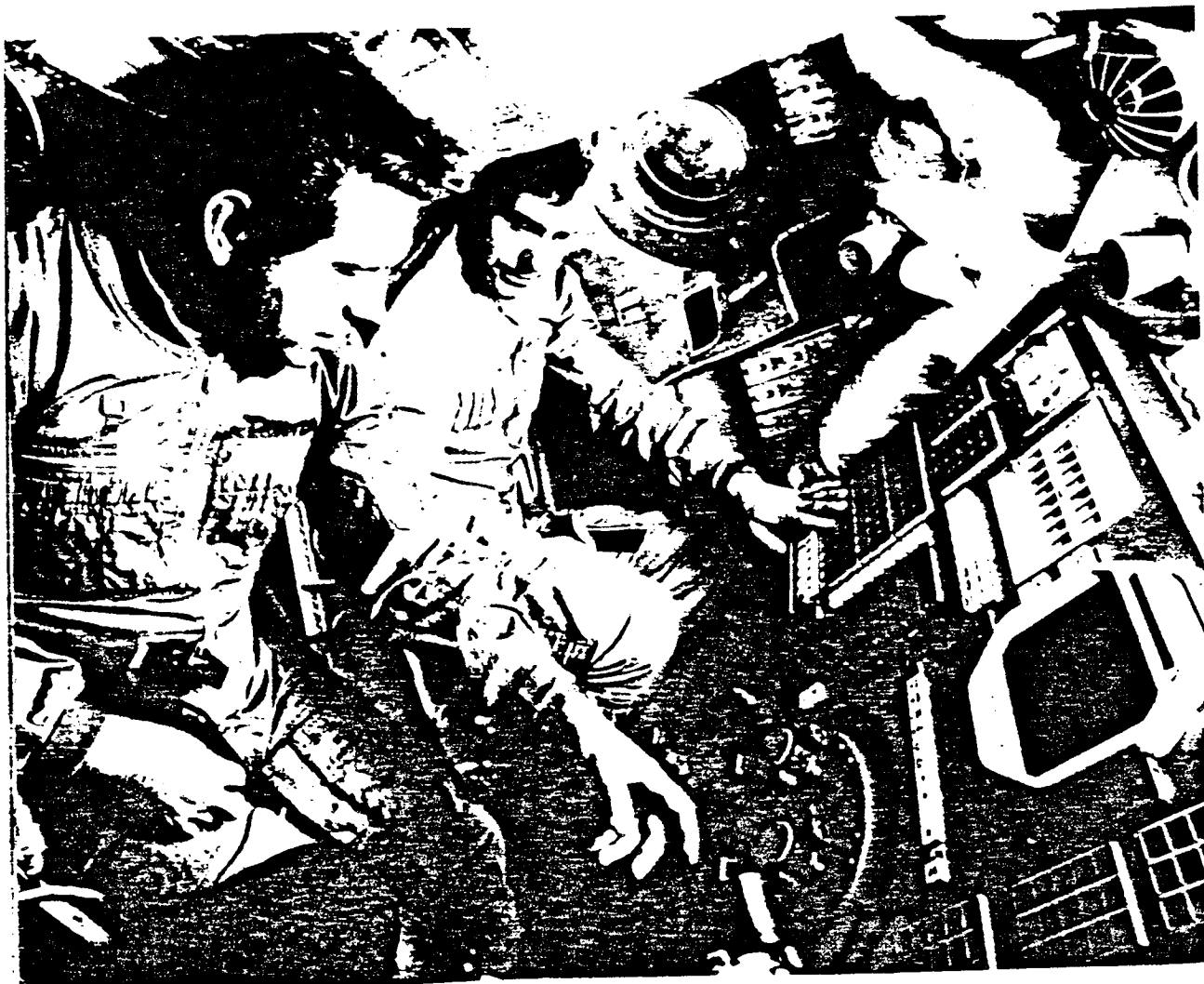
- An analog-digital complex
- Simulators for external circumstances (Sun, Earth, stars and portholes of the station)
- Control operation (198)

Swivel Chairs

Khilov Plane-Parallel Swing (20)

Simulators:

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In the Soyuz Simulator

- Used for complex operations such as docking and navigation
- Includes a Salyut and Soyuz fixed-based simulator: (216)(548)
 - Makes it possible to work out all stages of a flight in sequence (219)(532)
- Simulator reacts individually to the actions of the "crew" (26)(312)
- Can present non-standard situations:
 - To see if crew members can demonstrate their knowledge and capabilities by correcting problems (312)
- An illusion of movement in space is created (26)
- Cosmonauts are trained in how to pick the right time for worthwhile photographic experiments (126)
- Final stage in preparation is a combined training session in the simulator. The flight plan is set up in real time with a time period of up to several days. The environment is made as close as possible to that of an actual flight, except for simulation of the load factors and weightlessness (219)

Electromechanical Starry Sky Simulator:

- A dark globe with constellations
- A Cardan device makes the Moon and planets move (13)

Docking Simulator

- Exact duplication of the actual device
- Lights simulate the Sun and illuminate the model exactly like space conditions (13)

Assembly Simulator:

- A simulator to train cosmonauts for assembly work in space
- Cosmonauts learn to use multipurpose equipment on it
- Cosmonauts are expected to assemble various structures in orbit that will be brought by unmanned probes in part (456)

Computer Complex:

- Made of analog or digital computers with large storage and high response control:
 - Control of the trainer and simulators
 - Crew performance
 - Entry into the trainer of malfunctions to test crew alertness and training
 - Storage, processing and output of information (13)

Video Films:

- Any frame can be stopped and studied in detail
- Structures or wiring that are difficult to access otherwise can be viewed easily (13)

The training camp includes a stadium. (20)

A. Importance of Equipment:

Trainers allow crews to acquire skills in:

- Controlling the ship, onboard systems and equipment
- Performing the entire flight program from launch to landing
- Practice interaction with each other and with FCC
- Use of flight gear
- Working with onboard documentation (13)

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3.4 Training and Simulation

3.4.1.4.1 TRAINING METHODS

A. Taking Own Notes:

Cosmonauts develop their own notes and refer back to them during the mission. There is great emphasis on repetition in the form of lectures by specialists on a particular subject. These lectures are repeated at various times throughout the program. (216)(548)

B. Sleeping:

During ground training, cosmonauts spend time sleeping in a position with the head lower than the legs to simulate the effects of 0g. (541)

C. Red Book:

This is a book in which several hundred unusual situations and solutions to these situations that might arise during a mission have been delineated. Eliminating these situations is simpler and faster if they have been analyzed beforehand. The reaction to them is worked through many times on the ground and a controller is familiar with them before a mission. (30)

D. Mock-Up Activity:

In order to study the construction of the spacecraft and its systems, the cosmonaut participates in:

- The mock-up activity
- Layout of the ship
- Development and checkout of systems in the testing laboratories and on the launch pad
- Participates in technical meetings to resolve problems which arise
- Helps in writing and rewriting the flight plan and flight documentation. (219)

3.4.1.5 TRAINING PERSONNEL

The Soviets believe that each cosmonaut should actively participate in the training process. (37)

Cosmonauts who have been in space participate in the development of training devices. (114)

The originators of some experiments frequently are the teachers. (26)

Two to three years are spent training skilled instructors from among specialists. (312)

Cosmonauts are helped by physicians, trainers and cosmonauts who have already been in space. (20)(405)

A. Problems:

- The psychological interaction of the instructor and the crew:
 - The instructor and the crew should be looked on as a group
 - There should be objective control and evaluation which can enhance the functioning of groups:
 - In a situation when the evaluation can be obtained by automatic means, fewer prerequisites arise for conflict and mutual misunderstanding in the group (37)
- The crew begins training when the station is still in development
- There are no training documents, only the operating ones:
 - The developers and procedural engineers help the crews (84)

3.4 Training and Simulation

3.4.1.6 RESULTS OF TRAINING

- Better emotional and motor control:
 - As a result of training in short-term weightlessness (179)

- Better adaptation:
 - As a result of sleeping on beds which are lowered at the head:
 - Done 2-3 weeks before the flight
 - As a result of training on a turntable (114)(456)

- Limiting stress (both physical and mental):
 - As a result of acceleration:
 - Must be able to withstand 5-8 g on the centrifuge
 - As a result of training on the assimilation of many signals and information, all delivered at the same time (476)

- Feeling of competence:
 - As a result of training in conditions as close to real situations as possible (29)

- Feeling of group cohesiveness:
 - Cosmonaut Malyshev, Indian-Russian international crew, 237-day mission: "Despite the fact that a cosmonaut-researcher has a program containing somewhat less than the commander and flight engineer...the aim of training is that all three should work together as a single entity." (657)

- Reduction of SMS (space motion sickness):
 - As a result of passive conditioning:
 - The cosmonaut is strapped into or is otherwise an integral component of a piece of equipment that is mechanically activated. S/he either rotates about several axes or in some manner stresses the vestibular and optical system (548)

Results make it possible to:

- Trace the change in operator working capacity in the period of adaptation to unusual emotional conditions
- Identify the relationship of the quality of operator activity with the operator's subjective perception
- Investigate the nature of erroneous decisions (179)

3.4.1.7 OBJECTIVE METHODS

Training should be based around objective methods (such as mathematical methods):

The basic trends of objectivization:

- The construction of models of cosmonaut activity
- The development of a structure of training cosmonauts on simulators
- Adequate simulation of activity and labor
- Methods of monitoring training with the clear separation of functions of control personnel and the use of automated methods
- Methods of describing and evaluating the readiness of the crew

Training the crew and using an objective evaluation mean:

- Describing the structure of activities which are necessary for accomplishing programs of the space flight
- Description of the existing skills with the accent on individual style, as well as psychophysiological state
- Methods of evaluation, including quantitative ones
- Evaluating the readiness of the crew
- Development of a correcting action for achieving a controlling effect (37)

Ground training simulates varied situations which are specific for the activity of the cosmonauts, such as:

- Activity under conditions of a deficit of time, information, and isolation
- Sensory deprivation
- Receiving communications
- Reactions to new situations that might occur (266)

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3.4 Training and Simulation

3.4.1.8 TOOLS

There should be requirements for special training on space tools:

- Know what, when and where a tool is used
- How to approach the units to attach instruments
- Be skilled in carrying out operations for assembly and disassembly of lines with liquid and gas components (If precautionary measures are not observed, these components can enter the living compartment's atmosphere.)

It is necessary to learn to work with tools so that under weightlessness there is no damage to the instrument and the cosmonaut does not hurt himself.

Exercises with onboard tools are done on a simulator:

- Familiarity with the variety of tools and where they are kept
- Training in assembly-disassembly and repair-restoration work
- Practicing the sequence for replacing units, acquiring skills in using the tool, and studying the technical servicing instructions

"One of the most important stages in training crews for working with onboard tools is practicing with them aboard a Salyut station being prepared for flight." (205)

Continuous maintenance of the skill of operators is important. (377)

3.4.1.9 SEX ROLES

"Chivalry apart, no other allowances for differences in sex were made during training."

To be treated equally is to be treated equally whether one is studying the numerous onboard systems of the station and the ship, working on the research experiments, or undergoing training at the centrifuge. (370)

3.4.1.10 DIET

During their training for flight, cosmonauts receive only the kind of food they will have in space. (576)

During the period of preparing for the flight, crew members of the Salyut 6 had a food allowance of 3,130 calories. This was taken in four meals and was important for maintaining the health and weight of the cosmonauts. (44)

3.4.1.11 JOB SPECIALIZATION

Crew members include specialists of various professions. This has led to a differentiation in assignments for each crew member, as there are now cosmonaut-engineers and scientists of various professions in the crew. Their preparation differs from the preparation of pilots (crew commanders). After selection, these specialists continue to work at their basic professional activity, but they also study a number of other kinds of knowledge (communications, astronomy, and construction of the systems aboard ship, for example). They also undergo physical training twice a week and participate in two-week health improvement gatherings twice a year. The duration of this stage is usually one year. (114)

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3.4 Training and Simulation

A. Advantages:

-For construction:

--Specially trained cosmonaut construction workers would be advantageous (118)

-For larger crews (220)

-To raise productivity (402) (It has been noted that it is easier if crew members have their own specific research programs): (S.559)

The crew of the 150-Day Mission said that specialized expeditions would raise productivity. "If that were done the training for space flight would not be so difficult and lengthy...At present we both have to learn all these professions to be familiar somehow with all spheres. This makes our work slightly more difficult. (402)

Lyakhov, 150-Day Mission: "...the majority of the work in the program demanded the participation of both members of the crew...For certain work, the principal of so-called narrow specialization was applied. In the future, with an increase in the number on an expedition, the narrow specialization principle will, it appears, be the basic one." (482)

Shatalov: "...[it] is becoming progressively necessary to send into orbit persons who are more and more narrowly specialized." (5)

Blagov: "[Specialized expeditions] are one way of substantially raising the efficiency of scientific experiments. If a person is taught to have a deep understanding of one area of scientific research he will...do this more efficiently and better. He will lose less time on intermediate operations. He will have more time to spend on the actual experiment for which the cosmonaut has been sent..." (402)

On the 237-Day Mission there was a doctor onboard. In answer to why a doctor was not included before: Cosmonauts in the past had conducted many medical and biological experiments without specialized medical training. However, medical experiments were becoming more complicated and, at times, their results required preliminary evaluation onboard the station.

(143)(279)(307)(310)(432)

B. Disadvantages:

- Larger crews (See 4.3 Group Management Skills.) (632)
- Difficult because there are too many requests from scientific organizations and they have to try to satisfy them all (402)

* * *

"When a crew is conducting scientific experiments and research, virtually no differentiation of function exists among the crew members." (261)

Kizim: "All the crew members have known each other for more than a year. Our specialization was certainly taken into account in distributing the roles onboard, but at the same time the training has been sufficiently universal to allow interchangeability of the crew members in case of necessity." (630)

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3.4 Training and Simulation

3.4.2 ONBOARD TRAINING

Includes:

- Training to insure the transition from weightlessness to Earth's gravity (84)
- Skill maintenance:
 - Soviet observations have shown that long breaks between training sessions lead to an increase in errors.
- Recommendations:
 - There should be trainers onboard for flights that last longer than 3 or 4 months, so that skills can be maintained (219)(322)(590)
 - Devices should duplicate various conditions or devices (such as a miniature Salyut model) to ensure continuing pilot skills (322)
- Safety:
 - Refresher courses on what the cosmonauts learned before the flight
 - Lessons on how to leave the Salyut quickly, if needed
 - FCC trains the crew for complicated work which might involve increased risk (590)
- Training by visiting crews:

237-Day Mission

Visiting crew member Dzhaniybekov trained the main crew members for repairing the propellant system. He instructed them in how to use the hand-held pneumatic press. (See 1.3.8.2 Types of Tools.)

He also used videotapes, photographs and other teaching aids to instruct them in the repair work they were to do.

A "model" was sent up to them so they could practice before they actually performed the repair. (284)(309)(318)(470)(558)(568)

3.5 STATION DESIGN PROCESS

The use of the station for the maximum possible time is economically justified. These considerations are used as a basis for Salyut projects. (76)

3.5.1 CREW INVOLVEMENT

Salyut 7 was made more comfortable after designers took into account many of the 1,000 improvement proposals made by all 33 Salyut 6 cosmonauts on the basis of their onboard experience during a total of 676 days and nights of occupancy. (75)(112)(124)(168)(170)(188)(386)(400)

Cosmonauts should be involved in design. They should participate in:

- Mock-up activity
- Layout
- Development of systems in the testing laboratories and on the launch pad
- Participate in technical meetings to resolve problems
- Help in writing and rewriting the flight plan and flight documentation (219)

They should participate because:

- "Man is the critical link in the man-machine system." (114)
- The reliability of the equipment aboard a space vehicle can be evaluated most accurately in space. (351)
- Psychological problems permeate all stages of the flight: from the development of the spacecraft design to completion of the flight (237)

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3.5 Station Design Process

It is necessary to take into account the human characteristics and properties of the people who will live and work there:

- In the stage of designing
- During the determination of the volume and interior of the working and living compartments
- During choice of means of displaying information, controls, and communications systems (237)

Cosmonauts have been actively involved in development:

Atkov, (237-Day Mission,) took part in medical examinations of crews at the cosmonaut training center. He also developed the echocardiograph, which is used onboard. (161)(251)(418)

Solovyev, (237-Day Mission,) helped design Salyut 7. He also authored many flight books and preparation documents for the Salyut. (105)(132)(369) He helped design the engine and the refueling process of the Salyut 6 and Progress. (251)

3.5.2 HUMAN FACTORS AND HABITABILITY INVOLVEMENT

Problems of improving the technical operation of orbital stations cannot be resolved without engineering-psychological methods because operational reliability is determined to a significant degree by crew activity. (363)

3.5 Station Design Process

3.5.4 DESIGN PROCESS AND HABITABILITY

Design is important because the value of each miscalculation and of each defect will be multiplied proportionately by the difficulties and duration of the space voyage. Therefore, everything must be considered in designing a spaceship interior. The interior must be:

- Comfortable
- Functional
- Harmonious
- Attractive

Any interior will be perceived not only from a utilitarian, but also from an emotional aspect.

The physiological changes the cosmonauts go through must be considered in organizing the interior of the spaceship, which will help to conserve the work capacity of the crew and to increase the reliability of their work. Each flight must be thoroughly thought out from the standpoint of the optimal relation of links in the human-machine system. (See 3.1.1.1 Automation.)

Space stations should be designed for comfort, beauty and utility in accordance with the requirements of technical aesthetics.

The artistic design is closely associated with solutions to problems of habitability. (114)

In short-term flights, certain conveniences can be ignored, but on long-term flights conditions should be as close as possible to Earth. (354)

3.5.5 ECONOMIC BENEFITS

Yeliseyev: "...space flights today are coming close to being profitable. Many branches of the Soviet economy benefit from space research. Scientists believe that future orbital stations of various kinds...will yield millions of rubles in profits..." (387)

3.6 MOTION SICKNESS

Motion sickness is manifested in the first days of flight, usually disappearing within the first seven days (Although some Salyut 6 cosmonauts experienced symptoms during head and torso movement for up to 130 days). The majority of people do suffer from some degree of motion sickness, although the degree of expression of the symptoms is individualistic. These phenomena can be suppressed somewhat by willpower. Unfortunately, space medicine is still unable to predict the degree of expression of these reactions. (114)(279)(288)(432)(548)

GROUND BASED COLOR AND MOTION SICKNESS STUDY

Investigations conducted with rotation demonstrated the effect of color on the degree of motion sickness.

Chromatic fields of yellow and brown shades increased the sensation of nausea, and caused vomiting in a number of cases. Blue somewhat weakened the sensation of nausea.

The effect of color on other symptoms of kinetosis, as well as on nausea in cases of its complete absence, were not detected. The optico-vegetative system participates in the appearance of bodily effects during chromatic actions. (179)

Much of the studies on the 237-Day Mission had to do with motion sickness. (See 3.1.3 Experiments, Optokinez Experiment.) (430)

Soviets believe that the basic reasons for SMS are due to the action of mechanical forces acting upon the body and repeatedly communicating small, but multidirectional, accelerating forces. This results in the body simultaneously moving through space in multiple directions.

Situations aggravate the condition:

- Optokinetic stimuli on visual analyzers
- Multiple barometric pressure changes (similar to those experienced in the transition to 0g)

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3.6 Motion Sickness

Contributing to these are such factors as:

- High temperatures
- Lower partial oxygen pressure
- Gas fumes and noxious chemical fumes
- Psychological factors:
 - Overwork
 - Chronic fatigue
 - Emotional stress
 - Boredom

There are prophylactic and/or therapeutic medication. This medication consists primarily of central anticholinergic-acting drugs that augment central sympathetic activity. In addition to training and medication, consideration is also been given for the preselection of individuals more resistant to SMS. Providing biofeedback training and physically restricting head and body movement is also being considered.

Also beneficial:

- Physical devices:
 - Pneumatic thigh cuffs
 - Lower body negative pressure
 - Special headgear to restrict head movement:
 - The headgear, in particular, reportedly reduced space motion sickness. (548)

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3.6 Motion Sickness

3.6.1 PROPHYLACTIC METHODS

Bracelet Cuffs:

- These cause blood to be deposited in the leg vessels

Neck Pneumatic Shock-Absorber:

- Special head restraint helmet designed to reduce space sickness symptoms by limiting head movement
- The soft cap is secured by unstretchable straps attached to the shoulders:
 - This minimizes head tilt and turn
- Rubber cords which are attached to the cap also restrict movement unless the crew member exerts considerable force with his neck muscles

Results from the Salyut 6 missions indicate that this device did help in controlling the development of space sickness. (58)(99)(512)

Pharmacological Substances:

- The Soviets are still experimenting with these. A drug needs to:
 - Normalize the distribution of blood
 - Eliminate stasis in the basin of the pulmonary circulation and circulatory system of the brain
 - Prevent functional cardiac disturbances
 - Enhance orthostatic stability (288)

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3.7 GROUND PERSONNEL

A. Training:

Before anyone is permitted to control a flight, he must spend one or two months in training that simulates hundreds of unusual situations.

Ground personnel, as well as crew members, use the Red Book. (See 3.4.1.4.1 Training Methods, Red Book.) (30)

B. Qualities:

Qualities essential for a controller:

- Ability to remain unconfused
- Ability to establish (using incomplete information) how a malfunction can affect crew safety and fulfillment of a program
- Ability to localize an unusual situation in minimal time and offer the crew a recommendation (30)

C. Function:

The FCC autonomously, without the involvement of the crew or together with it:

- Can feed the necessary initial data into the onboard automatic equipment for the functioning of this equipment
- Can actively control the work of the crew and onboard systems
- Monitors the necessary flight parameters
- Plans the flight program
- Increases the stable work of the "crew-spacecraft" link
- Optimizes the system
- Provides necessary crew safety (94)

D. Work Schedule:

A fairly detailed program for each mission is drafted before the flight begins. (102)

A more precise program is prepared every two weeks in the course of the mission. When this program has been written, the daily schedules are then drawn up.

Mission Control personnel are organized into shifts. Each shift begins work at 8:00 a.m. and is on duty for 24 hours at a time. The shift's next work day is three days later.

Deputy Flight Director Blagov has said that last-minute revisions in daily schedules are avoided as much as possible, since this might result in a workload that is too hectic. As a result, requests for repetitions of experiments or for additional research and other changes in these programs must be made four days in advance. (102)

E. Received Information:

During each of the complex's 15 daily orbits, the FCC receives information that includes 2000 parameters of the Salyut 7 and its systems and 100 of the most basic parameters of the Soyuz T. Information is garnered from all types of sensing devices.

Measurements are received from individual sensing devices as often as 25 times a second. (102)

IV. PERSONALITY SYSTEMS

4.1 ALERTNESS AND PERFORMANCE

"...Organization of optimum work-rest cycles with consideration of the factors that affect cosmonauts during their activities should be considered one of the effective means of assuring reliability of crew performance..." (See 3.1.2 Scheduling.) (224)

Success in flights is determined by the effectiveness of work of the cosmonaut. (296) It is necessary to be sure that people cannot only endure a prolonged flight, but also retain a high level of performance. (351)

"Procedures for effective preventive measures are constantly being perfected. The entire experience of Soviet cosmonautics shows clearly that our scientists are on the right track in this regard." (373)

Factors that are important for alertness and productivity are:

- Adaptation to space:
 - Sufficient reserves of energy
 - Information and time
- Physical training
- Wearing training weight suits (no less than 8 hours a day)
- Pharmacological preparations
- Negative pressure on the lower part of the body during the last five days of flight (114)
- The design and operating characteristics of the systems and equipment (taking into account psychological, physiological and anthropometric human characteristics)
- The character of labor activity associated with the distribution of functions between automatic devices and the crew (including the organization of the crew's labor and rest)

SOVIET SPACE STATION ANALOGS, Ed. II
4.1 Alertness and Performance

- The psychological and physiological characteristics of the cosmonauts:
 - Preparedness
 - Training
 - Need for family and friends (See 3.3.2.1 Family and Friends.) (515)
 - "Assessment of mental work capacity is one of the most important problems of space psychophysiology. [This is because] both the assessment and forecast of mental work capacity...have a direct bearing on...the safety of space flights and reliability of spacecraft crews..." (130)
- Environmental conditions:
 - Being in closed quarters of limited volume for long periods of time makes people dependent on environmental factors which are hardly noticeable under ordinary conditions. This is expressed in the effectiveness and reliability of performance. Therefore, it becomes necessary to consider the entire complex of factors on which the life support of the crew and the organization of life onboard depend. (114)
 - Correct noise standards for the different compartments should be established. Productivity will then be maintained at an adequate level. (See 1.13 Vibroacoustics.) (391)
- Scheduling:
 - To prevent fatigue
- Working capacity of cosmonauts at different stages of the flight: (225)
 - Investigations performed during space flights show a deterioration in feelings and a decrease in working capacity in the first days in weightlessness: (179)(352)(362)

GROUND BASED
SPACE WORKING CAPACITY EXPERIMENT

This experiment was conducted in an isolation chamber with three subjects. Studied were: dynamics of the sensory motor reaction; dynamics of solving logical problems; activities of the operator in transmitting information; activity of the operator in accomplishing guidance operations.

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The operator had to solve logic problems in his head and give an oral response. The time taken to answer and the correctness of responses were recorded.

Results: The time and quality of accomplishing logical tasks depends upon the complexity of the task, the time of day of work of the operators, and on operator capabilities. The quality of work noticeably decreased from the 40th day on. The accomplishing of guidance operation deteriorated by the tenth day and then stabilized. Beginning with the 40th day, guidance time deteriorated and, prior to the end of the experiment, practically reached its initial value. Guidance time over the course of the experiment depended on the complexity of the task. (356)

- Reduction of unfavorable external factors (vacuum, meteorites, radiation, weightlessness, acceleration) (See 4.1.1 Weightlessness):
 - The Balaton was used before, during and after flights to look at work ability. Conclusions: cosmonauts' work capacity depended on adaptation to weightlessness. (See 4.1.2 Physiological Factors for more information on the Balaton.) (123)
- Food, water, oxygen, light
- Products that are harmful to health (These should be eliminated.)
- Requirements for movement, rest, information and normal working conditions should be met:
 - "As experience has shown, on a space flight no comfort is ever excessive." (188)
- Informational overload can lead to neuroemotional stress, which can lead to illnesses (hypertonia, gastric ulcers) (114)
- According to experiments done on Salyut 6 crews (results of three visiting crews), the speed of information-processing decreases in the cosmonauts flying for the first time, and the emotional tension unfavorably increases at the very beginning of adaptation to weightlessness. People who have flown earlier can preserve or increase their psychophysiological reserves. (123)

- Medical monitoring of health and maintenance of health (2)(114)
- Stress should be avoided (91)(114)(181)(219)

A. Fatigue:

Some of the factors of fatigue noted in flights:

- Fatigue is due to the long duration of the flight
- A large load of daily and multi-day work cycles at certain stages of flight: preparation and accomplishment of takeoff, docking, undocking, resumption of operations, work with the visiting crews
- Adaptive reactions to weightlessness
- The monotony of certain types of standard activities
- The shifts that sometimes occurred in the sleep-wake cycle which led to disturbances in the continuity of sleep (385)

INFLIGHT STUDY

From a study done on Salyut 6 and Salyut 7 crews, to assure reliable and efficient crew performance:

- Use appropriate sleep-wake schedules (See 3.1.2 Scheduling.)
- Use realistic planning of professional activities during the work day and conform all phases of the flight to psychophysiological and biorhythmological characteristics of the cosmonauts
- Use uniform distribution of work and rest periods for the crew (224)

"The results of prior flights indicate that wise planning of daily cyclograms of inflight crew activities is an effective measure, that permits solving complex problems and maintaining a high level of functional capacity in the cosmonauts regardless of flight duration." (See 3.1.2 Scheduling.) (224)

4.1 Alertness and Performance

B. Monitoring:

The psychological reactions of the crew are monitored during each mission. (34)

Psychological investigations should be included in the program of the flight itself. The most important way for deciding whether the cosmonaut is to be given manual control and whether the flight should be continued should be dictated by the psychological condition of the cosmonaut. Judgement is made according to physiological indices (EEG, EKG, for example). However, these are not always the most informative in estimating the condition of the cosmonaut. One of the promising trends in studying human physiological conditions is the analysis of human speech. (See 4.1.2.1 Voice Stress Analysis.)

STRESS AND ATTENTION

A number of investigations show that attention and operational memory are affected by stress. Therefore, it is important to develop special tests to evaluate these psychological functions during space flight. The cosmonaut's own personal feelings are one way of monitoring his psychological condition. (237)

4.1.1 WEIGHTLESSNESS

A. Adaptation:

Adaptation to weightlessness has varied among crew members. This has been attributed to individual factors and preflight training exercises. (87)

The most difficult period is usually during the first week. (383)

Soviet medical specialists note that there are three peak loads during the body's adaptation to weightlessness. They are:

- The initial onset of weightlessness
- During docking and transfer
- Emotional strain (174)

With the passage of time, responses to weightlessness do worsen. (127) Because of this, it is important that new means are developed for protection against harmful effects. (18)

The transition to weightlessness has been accompanied in almost all crew members by:

- Feelings of congestion in the head
- Stuffiness in the nose
- Face puffiness:
 - "...our weightlessness isn't that much of a pleasure. [Immediate reaction on docking] Our faces have begun to swell, so much that looking into the mirror I fail to recognize myself...I keep bumping into things, mostly with my head." (338)

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--The feeling of blood congestion in the head usually levels off at the end of the first week but is sometimes evident in a decreased form for the entire flight, increasing at the end of physical work and with fatigue. This is usually accompanied by a need for a large quantity of fluid.

(4)(85)(114)(385)

-Voice change

-Headache

Occurring in some cosmonauts in the transition to weightlessness:

-Short-term spacial illusions

-Decrease in appetite

-Feeling of discomfort that increases with head and trunk movement:

--The disruption of muscular perceptions lead to improper muscular movements, even in the case where these actions were perfectly developed on ground training devices.

--Several crew members aboard the Salyuts experienced the illusion of the body tipping backwards upon transition to weightlessness. After several hours, these cosmonauts began to experience a feeling of blood rushing to the head, which for some crew members reached a maximum on the third day of flight and then began to diminish. One cosmonaut had the feeling of blood rushing to his head for the entire flight; however, in his opinion, this had no negative effect on his work capacity.

---The sensation of blood rushing to the head decreased when they pressed tightly against the walls of the ship or attached themselves to the tension system of the complex training device and performed physical exercises.

-Vomiting after eating (4)(85)(88)(114)(179)(219)(383)

-Eye problems:

--There may be problems seeing (visual estimation, depth perception). This causes eye fatigue (fatigue of the muscular eye movement), which leads to errors in evaluating the location of objects in respect to one another, and spacial relations. This must be considered in developing visual systems of intra-cabin information reflection.

--These problems can lead to:

---Poor coordination

---Poor motor precision and speed

---Physical discomfort (114)(196)

Adaptation to weightlessness is coupled with readjustments of the following in a cosmonaut's psychic activity:

- Changes in reaction speed
- Changes in information volume
- Changes in processing speed

There are individual dynamics with these changes. (41)

Repeated flights enable cosmonauts to adapt to weightlessness more quickly and easily. (168)(174)(305)(361)(373)

B. Functional Changes

The mechanisms of functional changes in weightlessness are initially due to three causes:

- Change in afferent part of the nervous system
- Removal of the hydrostatic blood pressure
- Absence of weight on the skeletal-muscular system

Later on there is:

- Redistribution of circulating blood (blood passes from the lower part of the body to the upper)
- Influx of blood to the heart, increasing its intrathoracic volume:
 - This situation is perceived as an emergency by the nervous elements that control the volume and pressure of circulating blood. This triggers regulatory mechanisms that lead to a reduction of circulating blood volume. There is diminished production of hormones. Kidneys excrete more fluids and electrolytes. Concurrently, there is diminished thirst and negative fluid balance. The weight loss at the first phase of flight is attributed expressly to this.

The visible signs of the above are hyperemia, edema of the face and red eyes. As a result, the phenomenon of deconditioning of the cardiovascular system may appear after 2-3 weeks of flight.

With further exposure to weightlessness, there is removal of weight from the skeletomuscular system and signs of osteoporosis. (88)

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4.1.1.1 PROPHYLACTIC METHODS

[Much of the current literature states that the Soviets are still experimenting with prophylactic methods and means for preventing the unfavorable influences of weightlessness that occur at the beginning of each flight.]

The main efforts in dealing with weightlessness are directed toward working out measures and means for dealing with:

- Impairments of the cardiovascular system
- Water-salt exchange
- Skin and muscular system
- Circulatory system (261)

During long-term flights, attention must be given to maintaining functional activity of the cardiovascular system and normalizing the water-salt exchange. (114)

During weightlessness there are physiological changes within the body:

- Cardiovascular systems:
 - Blood pressure drops and the heartbeat slows (especially during sleep)
- Atonia of the heart and vascular system
- Reduced reserves (most obvious during inflight work and on return to Earth) (192)

The consequences of the change are difficult to evaluate. However, it is noted that 25 days after completion of 3-week flights, structural and functional changes generally disappeared. This testifies to their functional rather than their organic nature. (See 4.1.1.1 Prophylactic Methods.) (114)(192)

Questions concerning the possible impact of weightlessness on heredity and the processes of life activity require further study. (460)

On short duration visiting crew flights, the Soviets have studied the effects of weightlessness during the first few days. They have noted that there is an increase in the frequency of the crew members' cardiac contractions. This reaction smooths out during repeated flights. (512)

Effective control of the adaptation process also calls for a thorough understanding of problems of hemodynamics--the characteristics of circulation under the influence of weightlessness. (279)

Studies conducted during Salyut flights have shown that the physiological shifts which occur under the influence of weightlessness may be prevented by prophylactic methods:

- Physical means directed at reducing the flow of blood to the upper half of the body (See 1.4.6 Exercise Equipment.)
- Physical loads directed at maintaining conditions (including physical loads, weightsuits, skeletal loads) (See 1.4.6 Exercise Equipment.)
- Effect on the basic functions with the aid of medicinal substances (See 1.10.1.8 Vitamins and Supplements.)
- Regulation of nourishment (adding salts, proteins and vitamins to food, normalizing food and water consumption)
- Rational structuring of the work and rest regime (See 3.1.2 Scheduling.)

There are prophylactic methods that create a weight load on bone and muscle and eliminate the consequences of the abnormal distribution of blood and other physiological changes within the body:

Load ("Penguin") Suits:

- Create a constant load on the muscles and skeleton with the help of rubber braces that run along the body. These braces force the body to bend. This forces the cosmonaut to exercise muscles to counteract this effect.
- These are worn 16 hours per day (all the time except when sleeping)
- These are sometimes said to be uncomfortable
- The suit tension can be regulated

Running Track:

- The cosmonaut stands on the track [a cosmonaut will sometimes dress in the Penguin suit for this exercise]. He is held in by a restraint system. The suit distributes the forces on the waist band and on the shoulders while the legs are pressed to the track. It takes much physical effort, thereby maintaining the coordination of important motor skills.

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Veloergometer:

- A bicycle device that prevents deconditioning of the cardiovascular system.

Devices that produce lower pressure on the lower half of the body and facilitate the movement of blood to the legs:

Chibis Suit:

- To help maintain a higher degree of muscle and circulatory function
- It is a trouser-like garment made of crimped elastic material with a very tight waist and an attached top
- When water is evacuated from the trousers a negative pressure is created on the lower part of the body. This causes blood to be forced down toward the legs and simulates the gravitational conditions of Earth.
- During exercises:
 - Several days before de-orbit the crew exercises with this suit for 1-1/2 hours daily
 - The cardiovascular system is monitored by telemetry. If the blood flow is too strong, the cosmonauts become dizzy.

Leg Bracelet:

- A device fitted to the thigh to help control excess blood flow to the upper body. This was used for the first time on the 211-Day Mission. Preliminary data indicates that it is helpful.

Electro-stimulation of the muscles

Water-salt loading

Pharmacological preparations: The Soviets are testing pharmacological substances and special diets. (Information has been gathered from actual flights as well as simulations.)
Problems with drugs:

- Drugs traditionally used for functional disturbances may react differently under weightlessness
- Dosage requirements may vary
- Mode of administering may vary (See 3.6.1 Prophylactic Methods for Motion Sickness and 5.1.2.2 Mission Highlights.)

If prophylactic measures are carried out properly, and the work and rest regimes are observed, extended flights can be borne as easily as those of shorter duration. (See 5.1.2 Postflight, 3.1.2.6 Exercise Time, 3.1.2.2 Work Day Length.)

(20)(72)(85)(192)(215)(287)(288)(324)(373)(414)(476)(541)(585)(601)

4.1.1.2 ARTIFICIAL GRAVITY

It is important to solve the problem of how long a person can be under the effect of weightlessness. If adaptation is impossible, then it is necessary to create artificial gravity. This may be done by incorporating centrifuges. (346)(360)

It has been suggested that artificial gravity be incorporated. (287)(541)(548)

Problems are:

- Artificial gravity can cause vestibular malfunction. To counter this, the space system would have to have a large radius of rotation (10's and 100's of meters)
- Artificial gravity substantially complicates the design of the space system
- Complications related to the onset of Coriolis accelerations when people move (287)

There are several projects for creating artificial gravity on long-term space flights. All of them are based on replacing the forces of gravity with inertial centrifugal forces. For example, it is proposed that the spaceship be designed in the form of a gigantic rotating wheel whose "rim" serves as living and working quarters.

Studies conducted with the onboard centrifuge and on Cosmos 936 made it possible to conclude that the biological effect of artificial gravity under space flight conditions is, in principle, the same character as the effects of Earth gravity. This could prevent the undesirable effects of long-term weightlessness. (114)(603)

Others feel that special gravitation units are not necessary. This is a conclusion drawn by experts as a result of the long-term missions of Soviet crews. They reason that a well-trained cosmonaut (See 3.4.1 Ground Training.) can easily adapt to weightlessness if trained properly. (456)

Yeliseyev does not think that artificial gravitation units will be used within the next few years. This is because it is more difficult to conduct many kinds of research in them, such as astronomical or technological research. Also, continuous rotation causes a number of unpleasant side effects. (387)

4.1.1.3 RESEARCH

Salyut 6:

The study of weightless adaptation by the Soviets was primarily conducted on the Salyut 6 with:

- Polinon 2 M
- Rheograph 2
- Beta apparatus

This equipment and procedural modes provide insight into the Soviet's approach to the study of 0g and its effect on people.

Polinon 2 M:

This apparatus is a versatile electrocardiograph. The Soviets use it for three programs of cardiac monitoring:

- First program: Simple electrocardiographic examination, using twelve standard electrode contact points

- Second program: Study of the phase structure of the cardiographic cycle. This is done by:
 - Recording the femoral arterial pulse
 - Performing a kinetic cardiogram
 - Conducting measurements with the pressure cuff attached to the cosmonaut's arm

- Third program: Recording cardiograms at compression of the vessels around the tibia, at the right jugular vein, and at the arteries

Rheograph 2:

Rheograph 2 measures blood flow to the weightless body. Rheograms are done at the head, torso, forearm and the crus.

Beta:

The Beta instrument is an electrocardiograph that covers indices not measured by the Polinon 2 M. It is used to record an electrocardiogram, using a zonal system of fixing electrodes and sensors at the DS contact point. At the same time, a turbine-type sensor is attached to the cosmonaut by a mask to record a pneumogram. This assesses lung function, while another sensor records a seismogram of the heart to determine the rhythm and force of blood being pumped into the vessels. (324)

More research was performed on the Salyut 7 by using the:

Pion:

- This is a device that examines the peculiarities of weightlessness
- A dish (flat, circular container) made of transparent material and filled with liquid in which a flattened gas bubble floats is placed in the Pion. A light source is located at one side of it, and a movie or photo camera is at the other side. (There is a small window so one can see what is going on inside.)
- A special sensing device measures temperatures at different places outside and inside the dish. A clock is mounted inside the device. On the frames of the film, one can see a tiny clock that shows the exact moment the photograph was taken.
- Micro-acceleration sensors register vibrations of both the Pion and the station. (144)

One cosmonaut speculated after the 237-Day Mission that techniques used to minimize the effects of weightlessness might need to be more daring for future flights. (545)

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4.1 Alertness and Simulation

4.1.1.4 MISSION HIGHLIGHTS

211-Day Mission:

Although it had been almost 9 years since his previous flight, Lebedev noted that he felt as though he had successfully returned to weightlessness after only a day. For the first two days, both crew members on the mission noted the customary rush of blood to the head, but neither experienced vestibular problems. By the fourth day, they had adapted to their weightless condition. (167)

The crew's adaptation to weightlessness proceeded without complications, so the cosmonauts began active work on their first days aboard the station. (340)

This crew experimented with an echography system that allowed crew members to monitor the functioning of their heart and other organs, and to track the flow of blood in real time on a television monitor.

A visiting crew member had difficulty locating his heart with one of his sensors (which are placed against the skin). Soviet scientists said this was because his heart had moved upward in his body due to weightlessness. (215)

237-day Mission:

Atkov: "Our adaptation to weightlessness was surprisingly easy and fast. Virtually by the second day onboard the station we no longer felt the painful throbbing in our heads, from which many Soviet cosmonauts and American astronauts have previously suffered. The special training sessions we underwent at the Cosmonaut Training Center probably better conditioned us for this extended mission." (408)

Experiments called Pnevmatik and Profilaktika were performed during the 237-day flight for the purpose of perfecting methods and equipment for preventing adverse effects of weightlessness during the initial stage of flight. (494)

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Visiting Cosmonaut Savitskaya, who had several problems in adapting to weightlessness on her first flight, said that she felt tired the first day of her second flight, but she adapted much better. (284)

Beregovoi, Director of Cosmonaut Training: "Science cannot yet say that all the most subtle effects of weightlessness have been studied to the end. It is useful when a spaceship has a specialist onboard [referring to Dr. Atkov, crew member of the 237-Day Mission] who can directly observe the human organism's reaction to weightlessness and analyze in totality all the phenomena associated with it." (630)

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4.1.2 PHYSIOLOGICAL FACTORS

The human body is affected by factors which influence activity:

- Prolonged isolation in an enclosed space of limited volume
- Weightlessness
- Hypodynamia
- A specific regime of work and rest
- An elevated level of monotonous noises
- Specific nutrition and hygienic conditions
- Novelty and unusual circumstances
- Risk
- Possible psychological incompatibility in the group

Prediction is important as a way to improve work effectiveness. (356)

During short duration flights, most of the attention was given to human survival. For long missions, the emphasis is on determining the stages and effectiveness of adaptation. Research methods have been expanded. Onboard there is a well-equipped office for the comprehensive study of each cosmonaut's health. It includes:

- Complexes for recording the function of various organs and systems:
 - Motor functions, actions to increase the overall physical load, special types of in-flight training directed at improving the functions of the cardiovascular system, and support-motor apparatus play a significant role in ensuring productivity (114)
- Instruments for detailed studies of the cardiovascular system
- Devices for investigating:
 - Sight
 - Vestibular apparatus
 - Oxygen status
- Water-salt balance (603)

Creative, purposeful work facilitates the overcoming and suppressing of morbid physiological reactions and improves the reliability of the work of the cosmonaut. (346)

A. Monitoring:

There should be a means of automatic monitoring of the psychological and psychophysiological state of the cosmonaut. A technical device should be created which would collect the necessary information, process it and, depending upon the result, alter the flow of information transmitted to the person. Solving this problem requires the joint creative activity of psychologists, psychophysiologicalists and engineers. (237)

With an increase in the use of automatic devices, the speed of reaction time and operational memory have ceased to be the basic criteria which determine productivity. What must now be considered is the psychological characteristics of personality. (264)

It is necessary to create special devices for monitoring the cosmonaut's state and regulating the flow of information incoming to him. (346)

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4.1 Alertness and Simulation

4.1.2.1 VOICE STRESS ANALYSIS

The verbal activity of the cosmonauts has been studied by psychologists from the beginning of the space flight era. Electronic equipment is used to monitor the cosmonauts. Verbal expression can give information about the psychophysiological state of the cosmonauts. (34)(334)(548)

Speech reflects personality characteristics by the methods of:

- Lexico-grammatical analysis
- Psychoacoustical analysis
- Semantic analysis

EMOTIONAL STRESS AND SPEECH

According to tapes of radio conversations with crews and from the reports of parachute jumpers, it has been established that emotional stress is accompanied by specific changes in the semantic and phonic structure of speech signals:

- The level and tempos of speech rise
- Intonation and timbre of the voice change
- The time of the speech response either shortens or increases
- Difficulties in forming statements appear
- Slips of the tongue
- Repetitions
- Imperfect phrases
- Errors in perceiving spoken statements increases
- Effectiveness of intellectual activity decreases
- Stuttering

During fatigue the following are observed:

- The level and tempo of speech diminish
- Speech becomes monotonous
- Reaction is retarded
- Volume of speech production is reduced
- Construction of phrases becomes simplified
- Productivity of thinking diminishes
- The design to maintain speech contact decreases

Successful operations are characterized by:

- Low variability of level, tempo and intonation of speech
- High formality
- Simplicity of a linguistic structure of phrases

The external environment does influence speech to some degree. This should be taken into account in the analysis.
(263)(393)

4.1.2.1.1 MEASUREMENT

Speech should be measured by a specially trained group of experts.

Experts should have the confidence of the crew.

"Methods have now been developed for expert evaluation of the emotional intensity of speech. These are based on methods of psychological scaling and the meaningful analysis of speech reports."

Technical devices are being used successfully to analyze.

When analyzing speech, experts should be attuned to changes in:

- Style
- Content
- Intonation (263)

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Radio and TV communications are processed to determine the neuropsychical state of cosmonauts. Taken into account are:

- Phrase intonation
- Measurable parameters of dialog
- Nonverbal: mimic, gestures, body movements together with behavior (255)(256)

SPEECH EXPERIMENT

140-DAY MISSION

A "speech" experiment was done on this flight. It involved the cosmonauts using precisely the same phrases during communication sessions. These phrases were then recorded, cut up into small frequency ranges and analyzed. They were then expected to show to what extent speech is dependent on the psychological state of the speaker. The aim of the experiment was to highlight any work activities which exposed the cosmonauts to certain types of stresses and strain. (125)

4.1.2.2 USE OF FEELING

In developing a means of monitoring the psychological condition of the cosmonaut, it is necessary to take into account subjective data:

-Feelings (included in self-regulation)

For example, the sense of fatigue is a warning signal of the presence of fatigue. (237)

4.1.3 PSYCHOLOGICAL STABILITY

Personality and social psychology has a central role, both operationally and in terms of research, in the USSR. (122)

Life in a space station can lead to:

- Fatigue
- Poor mood
- Sleep disturbances
- Sensory deprivation
- Reduction in motivation

The system of psychological care used on the Salyuts (music, feedback on work, social contacts) has been effective. (119)

A. Factors in Psychological Stability:

An onboard study of various Salyut crew members has shown that there are a number of psychological factors that interact:

- (1) -Ecopsychological factors that characterize the environment:
- Confinement
 - Isolation
 - Monotony

These facilitate the development of sensory emotional deficiency and impoverishment of subjectivity

- (2) -Social psychological factors: These characterize the professional activity and communications sphere:
- Continuous and diverse work
 - Responsibility for the flight program
 - Executive functions and delayed feedback
 - Limited choice of work functions and leisure methods
 - Deficient or excessive time
 - Limited communications (particularly those that are seen as important to the cosmonaut, such as communications with family)
 - Variations in motivation, mood, work capacity

- (3) -Factors that characterize group and personality aspects of the working group:
- Crew size
 - Psychological structure
 - Scale of values and goals:
 - Methods used to achieve them and to meet individual requirements
 - Skills of social and individual self-control

These initiate changes in the psychological comfort and adaptation. (97)

-Rehabilitation of work capacity and emotional stability are closely related

-Social-psychological problems are very significant on long-term space flights. (Their solution is not always analogous to their solution under Earth conditions.) (114)

-There must be a continuing analysis of the psychological and emotional state. The longer the flight, the more significant the psychological factor is for maintaining productivity: (114)

--One method of increasing emotional stability: Methods of emotional aesthetic influence, such as background music and color music. (See 1.9.1 Color and Music.) (114)(177)

-The ability of a person to disassociate from the situation not only preserves work capacity, but also maintains psychological readiness for conscious action (114)(362)

-Hypodynamia and emotional stress must be considered in developing measures directed at the restoration of work capacity and creative energies: (114)

"RELAX" EXPERIMENT 140-DAY MISSION

An experiment called "Relax" was used to determine the most favorable conditions for rest in orbit.

-It involved the study of stresses and how to reduce them so as to keep the cosmonauts mentally fresh during flights. Various relaxation programs were drawn up in conjunction with the cosmonauts and also without their participation. Program included listening to music by Chopin, operatic music, and watching a video recording of a Cabaret. (128)

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Ryumin: "We relaxed either by frequently changing our routine tasks or by listening to music. But it was the visiting expeditions that gave us the major psychological support....Work is the best cure for anxiety and depression." (50)

GROUND-BASED PROPOSAL: INTERIOR VARIATION AND WORKLOAD

Relieving nervous-psychological load during space flight and stimulating the work of the cosmonaut is important. Individual psychotherapy is one way to accomplish this. One device has been proposed: During a relaxation session, the person sits in a chair about 1m away from a screen on which a rhythmically widening and narrowing light spot appears, imitating the motion of the rib cage during inhalation and exhalation. At the same time the subject hears the sounds of the surf through the headphones. The rhythmic changes in light and sound are synchronized. The rhythm of change of light and sound does not remain constant, but changes without the person noticing it from a frequent rhythm (approximately 20 cycles per minute) to a smooth one, similar to the respiration of a sleeping person (12-14 cycles per minute). Upon instruction, the subject must time his breathing with the rhythm of change in light and sound. When the light spot grows on the screen and the sound of the surf is heard in the earphones, he must inhale. When the light and sound diminish, he must exhale. After a pause, the cycle is repeated. As a result of the gradual slowing of the rhythm of change in light and sound, relaxation takes place. The session lasts for 10 to 15 minutes. (114)

-During long term flights even a comfortable but unchanging interior becomes non-optimal:

GROUND-BASED CHANGING ENVIRONMENT EXPERIMENT

Results indicate that any change in the environment, even a change for the worse, is at least at the beginning--a positive stimulus. It removes monotony and uniformity of environmental factors. During this experiment the level of illumination was sharply increased. The work productivity also increased. Then the illumination was sharply reduced, but the labor of productivity again increased. (114)

- A psychological relief room can be beneficial. (See 1.9.1 Color and Music for details.)
- It is important to maintain a constant internal stress for the accomplishment of work in order to preserve working capacity. Constant readiness is necessary. (114)(346)
- Excess information from the ground, combined with the limited information of instruments, can lead to neurotic disturbances:

INFORMATION OVERLOAD/UNDERLOAD

After performing a mission at an altitude of 6,000 meters above the clouds, an airplane pilot returned to the airport area and initiated a letdown through the clouds using the blind landing system. The airplane entered the clouds, broke out below the clouds, and suddenly zoomed up into the clouds to an altitude of 400 meters before finally descending and making a normal landing. The pilot said, "It seemed as if my thoughts just stopped. I don't remember what I did...it's as if I lost consciousness, but I really didn't." (219)

- The environment effects crew members' emotions:
 - Temperature
 - Humidity
 - Noise
 - Vibration
 - Illumination
 - Ventilation
 - Diet
 - Volume (219)

B. Monitoring:

The psychophysiological state and work productivity should be monitored. Solving this problem means obtaining information about:

- Sensory motor reaction
- The quality of attention
- Volume of operational and permanent memory
- Mood
- Motivation
- Behavioral tactics
- Intragroup relationships
- Effectiveness of activity
- The quality of receiving, processing, storing and utilizing information (263)

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Information about the psychological state should be transmitted to the ground. A psychological specialist on the ground should:

- Analyze this information
- Follow the condition of the cosmonaut
- Give him recommendations about methods of self-regulation (237)

Cosmonauts are monitored for stress through:

- Television monitors (external appearance can reveal emotional state) (143)
- Voice analysis: (121)(143)(459)
 - Some feel this could be done best by a constant onboard observer [For example, on the 237-Day Mission, Cosmonaut Atkov, a medical physician, performed the function of psychological observer.] (459)
- Self-assessment:(548)
 - The Soviets use a questionnaire experiment (See 3.1.3 Experiments, Salyut 6, Opros.) which requires each cosmonaut to answer nine questions about:
 - Eating and sleeping habits
 - Leisure time activities
 - Vision
 - Hearing
 - Smell
 - Posture
 - Need for medication

This questionnaire is for assessing the psychological adaptation to space. These questions are asked at various times throughout the mission. Each question has a value of 5, and the cosmonauts list the value reflecting his condition at that time. (319)(383)(546)(548)

-Expert appraisal:

- On the 237-Day Mission, the doctor onboard not only did physiological checkups on the other crew members, but also appraised the mood of the crew members and their regime of work and rest and nutrition. He had training in psychology which enabled him to study the psychological problems which can occur in small groups. (300) Atkov: "Since work in outer space is linked with great physical and emotional tension...it was also a kind of functional test. The successful completion of work outside the station was another evidence of the good state of health of the cosmonauts and the high level of their ability to work." (456)

C. Problems:

There have been no serious psychological problems up to now. Stability has been achieved by:

- Understanding the motivations for activity
- Effectiveness of psychological selection (See 4.4.2 Psychological Selection.)
- Satisfactory living conditions (See 1.1 General Layout and Design, 1.4 Crew Facilities, 1.7 Lighting, 1.9 Decor, and 1.10 Food for examples.)
- Balanced work and rest regime (See 3.1.2 Scheduling.)
- Psychological support (383)

This is not to say there have been no problems:

During one long-term mission, a cosmonaut underwent a sudden personality change and became irritable and troublesome. Medical experts found that the main cause of his behavior was that he had taken excessive doses of sleeping pills because he had been unable to rest. (See 3.1.2.7 Sleep Time.) He began complaining about the organization of work onboard, (See 3.1 Program Structure.) and his dissatisfaction with the difficult living conditions. (559) [No information as to which long mission or which cosmonaut this was.] (See also 4.1.6 Crew Highlights.)

SOVIET SPACE STATION ANALOGS, Ed. II

4.1 Alertness and Performance

4.1.3.1 Psychological Support

The psychological support group organizes crew leisure:

- Selection of sound and video recordings for transmission during rest periods
- Organization of crew meetings with their families and well-known personalities (30)(288)(548)(603)

One room at FCC is reserved specifically for this psychological support group. (217)

The psychological support for the crew is very effective in maintaining motivation and emotional stability. (382)(548)

This group watches the activity televised from the Salyut cabin, noting such things as how far the people stay away from one another. This social distance information can reveal unspoken tensions. (45)

The Soviets will sometimes keep crews busy to avoid psychological idleness. (545)

A Soviet report credited the 237-day crews' good humor to the communication sessions crew members held with the psychological support group during the mission. (545)(546)

Lyakhov, 150-Day Mission: "The psychological mood in the crew was favorable; [because of] weekly meetings with families, friends and popular artists in communication sessions." (238)

A. Methods:

Psychological support methods include:

- Psychological
- Aesthetic
- Rehabilitative
- Assisting measures

The Onboard methods are primarily involved in leisure arrangement (See 3.1.2.4 Leisure Time.)

Different methods of psychological support are used depending on the space flight stage:

-First Stage:

--This is the first 2-6 weeks of flight. During this period the cosmonaut is getting to know his/her new environment and adapting to the new work and rest cycle.

The cosmonauts' days are strictly controlled by FCC. This is because the cosmonauts are adapting to a whole range of experiences that vary from cooking and hygiene in space to performing operations and scientific experiments.

During the first stage: The shock of performing new experiments needs to be alleviated.

Musical and TV programs and news broadcasts are most efficient.

Second Stage:

--This includes the remaining flight time. This is characterized by manifestations of the so-called deprivation effects:

---Potential psychic changes due to prolonged emotional influence of isolation

---Monotony and deficient stimulations

----Lack of sound, smells, colors, social contacts, etc.

--During this stage, the novelty has worn off. Life begins to get monotonous. This results in problems in the work/rest cycle, variations of moods and loss of interest in some duties.

--The goal is to control the monotony and to thus prevent deprivation effects.

--Talks with family members, specialists, consultants, celebrities, and visiting crew members are the most efficient.

When providing psychological support, it is important to take into consideration the preferences of individual crew members.
(33)(89)(97)

THE SALYUT 6 MISSIONS

It was found that during flight days 28-49, crew members frequently demanded rhythmic-dynamic pieces of music and Earth sounds and noise. This indicates that humans need exogenous stimulation to control increasing monotony.

The results of these flights have shown that:

-The requirement for emotional contacts increase with flight time.

-Crew members are highly motivated in their work

--The aim of psychological support here was to provide them with information that helped them in their work and stimulated their interest in unresolved scientific problems. For this, consultations organized by FCC were important.

-There is a correlation between good health and high performance, and psychological support measures. (97)

Social contacts and the lack thereof can be replenished with the aid of famous people. Cosmonauts are given their preference as to whom they would like to speak. However, "it has frequently happened that the celebrities that were initially preferred later become disliked. These likes and dislikes often depend on how vividly and emotionally the celebrities as a source of new information are."

People that are invited to talk with the cosmonauts get special instructions and briefing about the flight and the status of crew members. (97)

4.1.4 MORALE

The psychological support group is very diligent near the midpoint of the mission, when morale usually drops to its lowest point. (45)

Organization measures that improve morale:

- Planning on the basis of social psychology
- Information should be as complete as possible in all matters
- Well-organized, active leisure:
 - Good choice of musical programs, books, games, movies
 - Special foods, surprise treats: (121)
 - On the 96-Day Mission, a New Year's tree and toys were provided to help the cosmonauts celebrate the beginning of 1978 (548)
- Feedback (373)

To assure high morale: "...nothing could compare with the effect...of a visit by other crews..." (264)

SOVIET SPACE STATION ANALOGS, Ed. II

4.1 Alertness and Performance

4.1.5 ISOLATION

A. Results of Isolation:

Studies have shown that the likely consequences of isolation are:

- Emotional neurotic reactions to the absence of feedback
- Post-isolation hypomanic syndrome
- Phenomena of "catathymic negativism" (refusing an activity that does not conform with the emotional tone of effect)
- General drowsiness
- Sleep disorders
- Psychological stress:
 - Some specialists feel that the cause of psychological stress in human interrelationships under conditions of isolation can be such factors as:
 - Exhaustion
 - Information exhaustibility
 - Constant publicity

All of these are caused by both biological and social prerequisites. (218)

The above results of isolation are based on studies that were done in an isolation chamber, which reproduced the psychological distinctions of a space flight. This method has been used in the training and screening of cosmonauts. However, analysis of early flights has failed to demonstrate any noticeable psychological disturbances in the cosmonauts, although there were nervous and emotional stresses due to working in weightlessness under the shortage of time and altered information. According to this analysis of early flights, it was found that people can adapt well and work efficiently for a long period of time in a isolated state. (256)

B. Isolation Tests:

Many isolation tests have established that behavior depends on:

- Correctness of the advance hypotheses
- Perfection of probablistic prediction
- Correct evaluation of the external environment
- Self evaluation

Correct orientation and self evaluation are achieved by a person only through intellectual activity. (364)

C. Productivity:

Solitude is particularly difficult to bear in the absence of any goal-oriented activity. In future long-term space flights cosmonauts will be faced with numerous manifestations of sensory deprivation.

In flights that have already occurred, there has been a reduction in work capacity and deterioration in sleep.

Goal-oriented action sharply improves the tolerance for isolation. Experiments have shown that when people are engaged in some type of activity with a goal-oriented action, this hinders the occurrence of hallucinations.

Loneliness is easier to bear if a person is occupied with work:

GROUND-BASED STUDY
SOLITUDE

Experiments in small volume areas show that solitude causes many unpleasant sensations, as well as changes in the neuro-psychical and emotional spheres. Loneliness is manifested with an increased desire to socialize with people. The need is particularly strong in the absence of a sufficient work load or during night time. (114)

SOVIET SPACE STATION ANALOGS, Ed. II

4.1 Alertness and Performance

4.1.6 CREW HIGHLIGHTS

96-Day Mission:

In the second month in space the cosmonauts had unsteady moods, and from the 40th to 96th mission days vegetative-somatic disorders (blood rushing to the head and sleep disturbances). At that time the cosmonauts said they felt tired not only by the end of the working day, but even shortly after awakening. (91)

140-Day Mission:

This crew's work capacity increased in comparison with the 96-day flight. Reasons:

- Fulfillment by the crew of the work and rest regime which they helped to draw up
- Rapid adaptation to weightlessness (this may be explained by individual physiological features and by the preflight training exercises)
- Sufficient consumption of water
- Adequate amount of exercise
- Good communication between FCC and crew
- Videotapes of family (600)

211-Day Mission:

Lebedev's diary revealed loneliness, insomnia (despite a tiring workload) and difficulty establishing a working relationship with crew members: (548)

Lebedev: "The most difficult thing about this flight is keeping calm in dealing with [FCC] and with other crew members, because pent-up fatigue could generate serious friction." (646)

"...even though the work is intense it is healthy. And no matter how tired we get, morale is good, and when there is a break in the intense work the little cares creep up on us, and they are even more tiring." (213)

After five months in space, the crew still performed their work well. Some fatigue was seen, but it was of an up and down nature. Fatigue peaks hit during docking and the space walk, whereas the largest burst was produced by the visiting expedition. (182)

Unconfirmed reports said that on this mission the crew members were experiencing some psychological difficulties towards the end of the mission. (548)

150-Day Mission:

On this flight it was reported that the crew was becoming depressed. Their work schedule was changed (See 3.1.2.1.4 Mission Length and Design.) and, as a result, by mid-October they were sleeping better and they had good appetites. (175)

4.2 EXPECTED ATTITUDES

-Self control: (85)(372)(417)

--Ryumin: "...in a profession like mine, where there is constant stress, a cosmonaut must have control over his feelings and emotions." (339)

-Positive disposition (339)(512)

-Attuned to fellow crew members (417)

-Tolerance and patience: (96)(365)(405)(456)

--Lebedev, 211-Day Mission: "...should work on cultivating ...greater patience." (405)

--Berezevoy, 211-day mission: "During a long mission it is essential to be endlessly patient: the proper tone must be set in conversations with the ground and in a relationship with your comrade." (96)

-Educated: (365)(372)(456)

--The ability to react correctly

--Being able to find the correct solution to any situation in order to make it possible to continue working together successfully (456)

--"The inability to live together with someone else is, in my opinion, mainly a sign that the person is not very well educated. Up there we are guided not only by tact and tolerance in our relations towards one another, but also by an understanding of what we must accomplish." (365)

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4.2 Expected Attitudes

People on long missions worry about whether they will be able to get along with their fellow crew members:

Lebedev: "I am apprehensive about myself; whether I will be able to live and work so long with my colleague; whether I will always be able to keep my composure and self-control." (646)

4.3 GROUP MANAGEMENT SKILLS

"Our...problem is deeply human. We must now adjust to living together, away from the rest of the world." (338)

As space and modeling experience show, the effects of psychological compatibility arise after approximately one month of group isolation. The longer the flight, the stronger the given effect appears. (218)

A. Problems:

Problems include:

-The inability of group members to satisfy all the needs of other crew members (266)

-Conflict: (282)(417)

--"Whether these conflicts blossom or dampen depended to a great extent on us." (417)

-Competition:

--Grechko: "Competition within a crew is one of the most harmful things, especially if each starts trying to prove that he is the best one--to prove it to himself, to the Earth. In space, you have no psychological outlet. You can't go to the theatre or relax with an interesting book. It is much more dangerous there." (220)

-Compatibility:

--Trifles can be exaggerated into annoyances, annoyances into quarrels. Soviets were concerned about compatibility during flights even for crews who were going to be confined for only 18 days. (335)

SOVIET SPACE STATION ANALOGS, Ed. II
4.3 Group Management Skills

-Fatigue:

--Lebedev, 211-Day Mission: "With growing fatigue there is a danger of serious lapses. There are tense moments, but they cannot be allowed to explode. Otherwise a crack, once it appears, can widen." (45)

--Lyakhov, 150-Day Mission, two months into flight: "...against the background of increasing tiredness, the blunders in communication, in the work with Earth, ...there are tense moments between the crew, but no outburst can be permitted." (106)

-Lack of unity among crew members because of:

- The absence of proper contact
- The absence of mutual understanding
- Failures in flight operations (219)

CONTINUOUS MONOTONY

Studies have shown that during continuous monotony, the group will either:

-Consolidate:

- Tendencies toward leadership
- Following the leader
- Establishing contact with all members
- Enthusiasm for work

or

-Grow apart:

- Disorganization
- Inadequate attempts at self assertion
- Impatience with others
- Stagnation
- Aggressive actions
- Irritability
- Touchiness

At the end of one such study on monotony, subjects recalled the negatives and evaluated them as inappropriate.

It is assumed that the negative and positive both have adapted significance. The positive ones are aimed at the consolidation of the group for opposing the extreme conditions of the environment, while the negative ones are aimed at the destruction of the extreme environment, mediated by the fracture of the group. This adaptation may not be conscious. (179) (See also 4.3 Group Management Studies.)

B. Solutions:

Solutions to problems include:

- Use of group management experts: (266)(300)
 - Such as the use of Dr. Atkov during the 237-Day Mission
- Training in being sensitive to the feelings of others:
 - "We have to solve our [problems] together, taking into account the feelings of the other. ...we had prepared for this long and hard together, rehearsing every anticipated problem, but this was done in an environment of other people. Here we are totally alone. ...one must bear in mind--constantly--the other's good and bad sides, anticipate his thinking, [and] the ramifications of a wrong utterance blown out of proportion."
(338)
- Use of a personal diary to write down thoughts
- Recognizing the capabilities of one another
- Working together as a team (220)
- Group discussions:
 - To strengthen the unity of the group
- Training in tension-releasing and conflict management (346)
- Face-to-face communication (114)
- Training together over a long period of time: (96)(219)
Berezevoy, 211-Day Mission, said that he and Lebedev had a short and highly intensive preparation period. He noted that they did not have time to resolve some interrelationship problems while on Earth, and these problems went with them into space. He said that it would be better if other cosmonauts did not have to do this.
(405)
- Making a concerted effort to get along:
 - Prior to their flight, Lebedev and Berezevoy promised to one another that they would be "...temperate, good-willed [and] try to maintain good relations." (106)(213)

SOVIET SPACE STATION ANALOGS, Ed. II

4.3 Group Management Skills

--Berezevoy, 211-Day Mission, on working with Lebedev:

"...Everyone has his convictions and habits, his own style of work. And sometimes they do not coincide..We immediately agreed that in the work there should be complete frankness. By launch time we knew each other probably as well as each knew himself, and we could soberly assess our achievements and shortcomings."

--Berezevoy, 211-Day Mission: "My...flight experience convinced me that patience and a genuine striving to understand the person who is working and living alongside you often simplifies things.: (405)

C. Group Size:

A three-person crew is psychologically less stable, as a situation may arise where two are pitted against one. (This is a potential problem indicated by a cosmonaut.) (417)

However, there are some who disagree with this:

Blagov, Deputy Flight Director: "We have become convinced that a crew of three creates a more favorable psychological climate for work than a crew of two. Two crew men instead of one by your side make it more stable, are a better stimulus for work, and help you fight changes of mood." (632)

Blagov noted that there were some problems:

- A crew of three needs 1.5 times more of everything than a crew of two:
 - Food
 - Expendable materials
 - Water
- Difficulties with physical exercises because there is only one bicycle ergometer. (He noted that they are planning to add at least one more running tract.) (632)
- Overcrowding) (284)

Before the 237-Day Mission, space program officials were not concerned about possible psychological problems that could develop from a crew of three, such as the two-against-one dispute. Cosmonaut Atkov said that if a problem arose between two people "...we would not appeal to the third member and would work out the problem independently. The third member...would try to find a compromise solution. And everything always worked out in the interest of the matter." (Atkov was referring to problems that arose, stressing that the only problems that arose had to do with work.) (66)

4.4 SELECTION PROCEDURES

"With an increase in the duration of spaceflights, the significance of the psychological reliability of the cosmonauts is increasing." (383)

"... not everyone can cope satisfactorily with a space assignment. This needs to be established before a flight because the price of ignorance could be prohibitive." (587)

A. Requirements:

- Excellent health, both physically and psychologically (20)(83)(214)
- High technical skill
- Education:
 - Aleksandrov: "In cosmonaut selection, both a person's character and his special training are taken into account. But the chief thing is knowledge." (109)
- Extensive experience as pilots
- Creative potential
- High degree of intellect
- Inclination for research work
- Ability to organize cognitive activity when information is uncertain
- Intuition
- Ability to restructure stereotypes
- Flexibility
- Psychological adaptation to the enclosed environment (28)(261)(364)(513)
- Good memory
- A sharp wit
- Attention that can easily be switched from one subject to another
- Ability to make quick and coordinate movements (214)

During international flights, the selection of candidates takes into account the linguistic capacities of the individuals: (334)

THE INDIAN CREW

During the 237-Day Mission, a crew with one Indian member visited. The selection of this Indian cosmonaut over another who was in training at the same time was done because the selected crew member, Sharma, had a better command of the Russian language. (See 3.3.1.2 Outsiders: International/Visiting Crews.) (161)

SOVIET SPACE STATION ANALOGS, Ed. II
4.4 Selection Procedures

It is not known how a cosmonaut will react to weightlessness until launched, and yet this is important for the selection of candidates and in planning orbital activities. Some information indicates that in second and later flights a person adapts faster to weightlessness. (47)

The work of a cosmonaut is a type of operator work. However, it is different from Earth work:

- Due to the design of the spacecraft and flight dynamics:
 - G-forces
 - Weightlessness
 - Limitation of mobility
 - Change in sleep-wakefulness
 - Uniqueness of the climate
 - Nutrition
- The absence of reliability and safety of equipment:
 - Possibility of decompression, fire, and breakdown of individual components
- Sociopsychological factors:
 - The indeterminacy of a situation
 - Absence of complete solitude
 - Monotony
- The extensive scientific research

These characteristics make large demands on the personality of a cosmonaut.

To improve selection, investigations should thus include:

- The personality of the person
- His inclination
- The psychological structure of volitional and emotional processes
- Communicability (28)(513)
- Temperament
- Former mode of life
- Occupational orientation
- Physiological traits (546)

B. Age:

The average age of cosmonaut crews is 45. (126)

Some reports have said that the Soviets are training teenage cosmonauts and future scientists. These teenagers begin their training in cosmonautic space clubs. (548)

4.4.1 HEALTH

A. Examination:

The medical selection is done in three stages:

Preliminary Screening:

-This is performed on an outpatient basis by medical sub-specialists representing:

- Internal medicine
- Neurology
- Ophthalmology
- Ear, nose, throat
- Endocrinology
- Other medical specialties

Based on clinical and historical data, an evaluation board of these sub-specialists then recommend whether the candidate should continue in the selection.

Second Stage:

-Extensive clinical evaluations. This in-depth medical history reevaluation takes place in an attempt to exclude:

- Hereditary disorders
- Recurring pathological conditions (particularly of the circulatory, respiratory, urinary, intestinal tract, and skeletal systems)

Final Stage:

-Hands-on evaluation, as well as up-to-date technological processes:

- Roentgenography
- Endoscopy
- Electrocardiography
- Laboratory tests on blood and hematological evaluations
- Blood chemistry
- Neurological evaluation:
 - Motor coordination
 - Sensory and reflex functions of the nervous system
 - Skull roentgenography
 - Electroencephalography (548)

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4.4 Selection Procedures

B. Requirements:

Health requirements can now be less stringent because of:

- Improvements in space technology
- Development of comfortable conditions aboard space stations
- Improvements in medical monitoring
- Improvements in prophylactic measures
- Improvements in training

Much attention is now given to the functional possibility of a person's body and adaptability. Even those not possessed of clearly expressed indexes characterizing the functional status of a given system in the body may have the ability to adapt easily, and this is an important biological response. (603)

Spatial orientation and visual perception training requirements were lowered for science crew members, since the latter would not need to pilot the spacecraft. (548)

There should be a 24-hour noise stress test. This test can permit an evaluation of the negative effect on:

- Auditory analyzer
- Vegetative nervous system
- Work capacity
- Sleep
- Psychological functions

Use of this examination makes it possible to objectively judge individual resistance to noise. (See 1.13 Vibroacoustics.) (242)(390)

Cosmonaut candidates must be in good general health. They must also have great reserve capacities in the reactions of their physiological system to load. This is important, since one person may withstand a load (for example, ascent in a pressure chamber, overload on a centrifuge, etc.) to the limit of his physiological capabilities, while another person still has a reserve. In connection with this, special methods were developed during testing of cosmonaut candidates which make it possible to determine these reserves, as well as to clarify any unapparent illnesses:

HYPOXIC TESTS

The use of hypoxic tests (breathing an oxygen-poor gas mixture) aids in clarifying any hidden coronary insufficiency. These tests have been included in clinical practice in screening pilots. (114)

"A space crew's professional success is determined to a considerable degree by the quality of medical selection. Good health, with high functional physical and mental capabilities, are the prime medical requirements." (263)

Laying stress on the training of the vestibular organ, and physical exercises connected with the development of head hyperaemia has led to the early elimination of individuals with hypersensitive vestibular organs and labile motor reactions. (19)

An individual can be considered for training when judged cured of an infectious or non-infectious disease.

In general, individuals are judged unsuitable if disorders are found in:

- Psychic
- Nervous
- Anatomic
- Infectious parameters including:
 - Venereal
 - Cardiac
 - Ear, nose, throat
 - Ophthalmologic
 - Skin disorders (548)

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4.4 Selection Procedures

C. Progress in Health Issues:

The selection of Dr. Atkov for the 237-Day Mission was important for making progress in space medicine. There are still unresolved problems in connection with:

- Weightlessness (See 4.1.1 Weightlessness, 3.6 Motion Sickness.)
- Cosmic radiation (See 2.5.7 Radiation.)
- Nervous and emotional stress (See 4.1.3 Psychological Stability, 4.1 Alertness and Performance.)

Having a doctor onboard helped to test a number of hypotheses that had arisen concerning the reasons for motion sickness, the redistribution of blood during flight conditions, etc. (143)(279)

The doctor spent much time on the physiological and psychological health of crew members. Focuses of study:

- Reserve capacities of the body
- Stresses
- Metabolism (143)

4.4.2 PSYCHOLOGICAL SELECTION

"The Soviet's experience in orbital station operations has mandated the need for significant psychological testing."

All serious psychological illnesses are grounds for rejection. If in individual cases the candidate possesses certain technical attributes that are required for the mission, efforts are made to treat certain psychological abnormalities. (548)

Psychological criteria include:

- Low anxiety level
- Emotionally well-balanced
- Extrovertive personality
- A high level of intellectual and perceptive abilities
- High resistance to long-standing mental work
- Steady, voluntary attention
- Good attention separability and changeability
- Memory
- Capacity to control one's own reactions. (See 3.4.1.3 Ground Training, Psychological, regarding methods of self-control.) (266)

Psychological tests are done for establishing:

- Perception
- Intellectual abilities
- Psychomotor efficiency
- Personality traits
- Physiological indices of emotional reactivity (19)

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4.4 Selection Procedures

4.4.2.1 METHODS

Selected personality features are examined using the personality scale of Taylor (MAF)-Eysenck's personality inventory, and a 16 point questionnaire of personality proposed by R. B. Catell. (19)

Projective and non-projective methods of personality testing are used. There is an analysis of the basic social requirements of the future cosmonaut and motivation. (Analysis of motivation is difficult because there is no scientifically developed methodological approach.)

Projective methods (Rorschach test; TAT) are used, but these have known weaknesses. A complete understanding cannot be insured by using these methods, and these methods do not correspond to studying the specific motivation of each person in flight.

Tests should evaluate the psychological qualities of a person in their interrelationships. Tests should also evaluate the characteristics of individual psychological processes and functions, and the speed and accuracy of individual reactions. However, these short-term tests only provide the psychological qualities of a person at a given moment of time, and should be supplemented by other methods. They should be combined with prolonged investigation. (237)

Soviet scientists have been studying the problem of psychological compatibility for 20 years. However, many things are still unknown. They are still searching for methods of crew selection. Some progress has been achieved. (388)

4.4.2.2 GOALS

By using experimental psychology, people can be selected who not only fulfill all the tasks, but also maintain a normal psychological atmosphere and a friendly attitude toward each other throughout the flight. Without that, the crew's cooperation in emergency situations would be impossible. (388)

4.4.2.3 STABILITY IN SPACE

All candidates are subjected to solitary testing to determine:

- Psychoemotional stability to extreme conditions
- Individual specifics of reactions and behavior (114)

PSYCHOEMOTIONAL TESTING

Experiments are conducted to clarify a series of psycho-physiological mechanisms (for example, emotional instability), as well as the development of recommendations for preventing the development of unfavorable psychical conditions (work and rest regime, goal-oriented activity, pharmacological treatment).

A number of studies show that the most fragile emotiogenic factors are psychical functions such as attention and operative memory. This is particularly important to consider in cosmonaut selection and special training on various training mock-up devices. (114)

It is necessary to have a special medical and technical-psychological selection system to make it possible to choose candidates who are:

- Most suited for work under conditions of changing informational loads
- Capable of making proper decisions
- Capable of taking quick action in case of an emergency

In particular, the problem of psychological selection includes the clarification of psychical reserve capabilities for work under difficult conditions (for example, emotional stability in an emergency situation). (114)

Without psychological selection and coordination of the crew while still on Earth, it is impossible to insure good psychological compatibility on a long flight. However, as experience has shown, even these measures are insufficient. (218)

SOVIET SPACE STATION ANALOGS, Ed. II

4.4 Selection Procedures

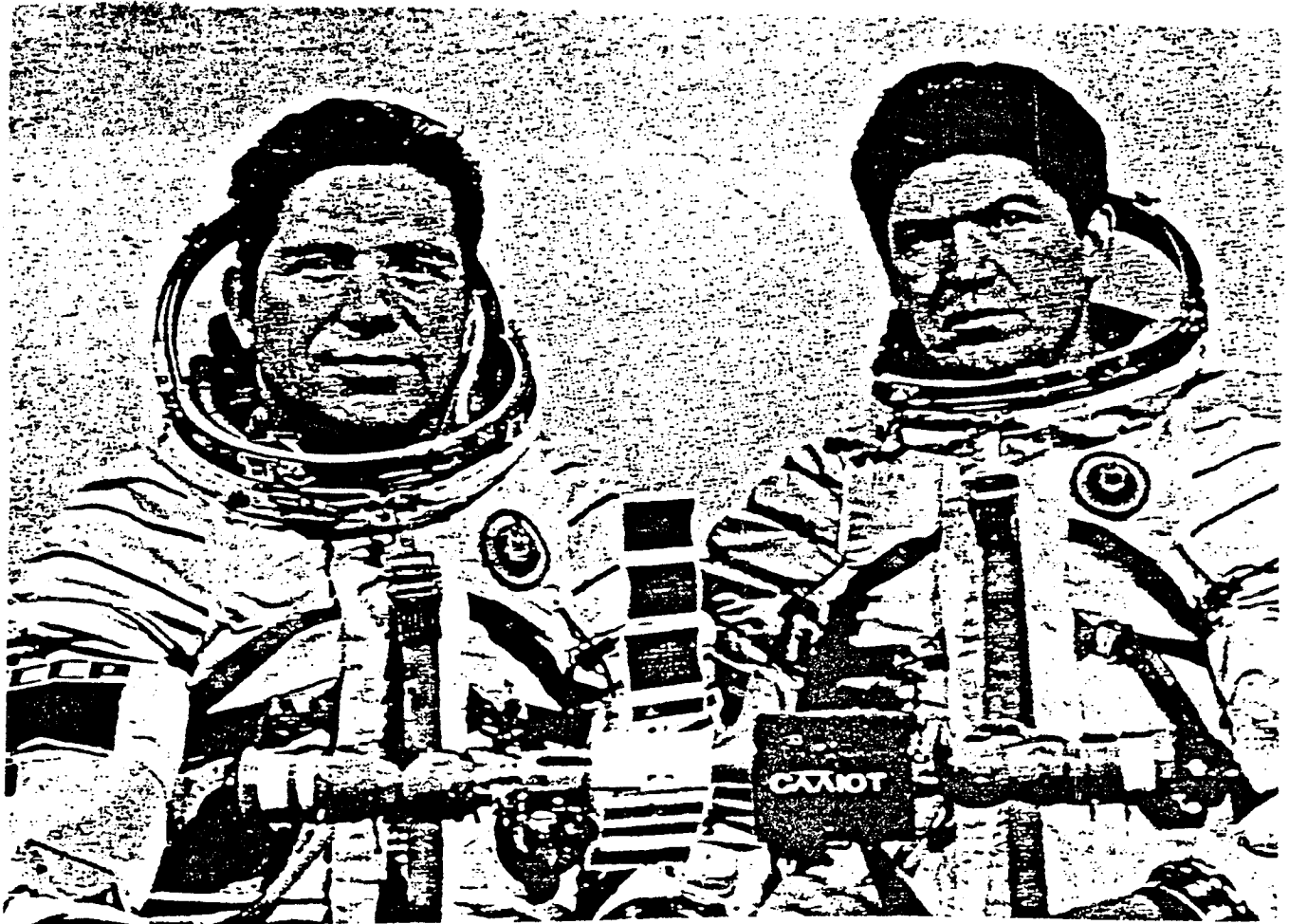
Psychological support can be used to prevent potential psychoemotional disorders. The support is directed primarily at satisfying the main requirements, tastes and habits of each person. The use of these measures on the Salyut 6 have shown their efficiency in terms of expansion of the "psychological living space" and the maintenance of a high emotional and working tone of the crew. (See 4.1.3 Psychological Stability.) (39)(256)

The Psychological Support Group constantly helps crews by organizing meetings with families, friends and artists. (39)(340)

4.4.3 COMPATIBILITY

Shatalov: "...This issue [of compatibility] arouses concern...knowing that over a period of two to three months it is not always easy to maintain mutual sympathy and to be able to work without arguing..." (456)

Grechko: "The problem of compatibility is alleviated when crew members concentrate onfulfilling their experimental program and subordinating all of their actions to this one thing, also." (587)



Ed. I

4.4 Selection Procedures

Compatible traits are taken into consideration during selection procedures. Factors include:

- Intellectual abilities
- Likes and dislikes
- Tact
- Tolerance
- Sense of duty
- Positive attitude toward each other
- Willingness to cooperate and conform in order to accomplish the mission:
 - Special tests have been developed to determine if crew members are psychologically compatible. For example, cosmonauts are asked to take part in various experiments especially developed to simulate a kind of mutually-dependent activity:
(122)(346)(366)(388)(548)

COMPATIBILITY TESTING

One test used is the Mutual Talking Test. As soon as the partners start helping each other, their pulses synchronize to some extent. The higher the pulse rate, the greater the compatibility of the crew members and the more successful their cooperation in orbit will be. For Lyakhov and Ryumin, this factor was 0.75. For Kovalenok and Ivanchenkov it was 0.78. It has also been noticed that opposites can be compatible: the reserved and silent introvert can be paired with an extrovert. The prerequisite for compatibility is based on mutual understanding on both the intellectual and emotional level. (388)

- The Soviets believe that biorhythms are somewhat individualistic. They therefore select cosmonauts with specific biorhythms for particular space missions (See 3.1.2.11 Biorhythms) (548)

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4.4 Selection Procedures

According to Gazenko, compatibility is also affected by the psychological climate onboard. This psychological climate is affected by:

- Crew selection
- Satisfactory work and living conditions
- Balanced schedule of work and leisure
- Psychological support (587)

Mutual sympathy, friendship and common viewpoints are important for a unified crew. (219)

"Despite the selection and training process, psychological tensions between crew members do develop." (548)

So far there is no completely reliable method for selecting people by compatibility of character. (20)

Prior to the flight, crew members should:

- Train, test, and relax together (219)(220)
- Have experience working with various personalities:
 - This increases the capability for understanding, coping and adapting to different individual characteristics. This leads to improved teamwork. (219)

Compatibility and mutual understanding must be achieved prior to the flight. (220)

The cosmonauts are reluctant to talk about hostility among crew members. According to Beregovoi (who is in charge of Cosmonaut Crew Training), after 30 days into long missions the crews begin to show signs of hostility and irritability in spite of the diligent testing to arrange personality compatibility. (See 4.4.3.1 Mission Highlights.) (34)(176)

Ryumin, Salyut 6 cosmonaut who spent 175 days and 185 days in space, said that it was important to be compatible and get along in flights or cosmonauts would feel very much alone. (400)

Even with a pleasant person, a long mission is a test in itself. (341)

SOVIET SPACE STATION ANALOGS, Ed. II

4.4 Selection Procedures

4.4.3.1 MISSION HIGHLIGHTS

96-Day Mission:

Grechko was reported as being even-tempered, while Romanenko's personality was described as volatile. (548)

Grechko: "...somewhat incompatible people can go into space on a flight of up to several weeks duration. On flights of a month, the factor [of compatibility] already starts to show up, and on longer flights it becomes essential. One must give the psychologists their due: Recently, in the course of preparation, they have learned to explain to us just who your partner is and you yourself, what our character traits are and how we must deal with them. In the case of Yurii Romanenko and me, we had been acquainted only a short time before the flight, but over a period of three months in orbit we never once quarreled." (421)

140-Day Mission:

Ivanchenkov: "...It's not such an easy thing to spend half a year eye-to-eye with someone in isolation [away] from other people. That's why on Earth the crews are picked...[for] psychological compatibility."

According to Ivanchenkov, he and Kovalyonok were completely different types. "He is the kind who plans things out, who reacts to things slowly. I am more reactive and more sure of my actions as a result of having been involved in downhill skiing for more than 20 years. You'd be surprised, but this difference of characters only helped us get along." (365)

211-Day Mission:

This crew was reported to have had some difficulty getting along. (34)(176)

Berezevoy: "[Lebedev] and I had a very short and very intensive period of training together...Our mutual relationship [was] simply not solved completely successfully. We had to deal with it in space...It is advisable to form crews in such a way that the merits of each member are complemented, while the defects are smoothed over. If this is done, a crew will be strong and capable of going further than we did." (96)

237-Day Mission:

According to Shatalov, this was the crew that, for the first time, worked together very calmly, very harmoniously, and well coordinated right up to the landing. This was credited to those who took part in the selection (See 4.4 Selection Procedures.), as well as the cosmonauts themselves and their expected attitudes. (See 4.2 Expected Attitudes.) (456)(591)

According to visiting crew member Dzhanibekov, the crew of the 237-Day Mission was very compatible "because they knew how to complement each other. Their sense of tact [was] amazing." (568)

Compatibility of the main crew is important not only for the main crew cosmonauts, but also for visiting crew members who work a very intensive pace in a short period of time. Dzhanibekov, visiting crew member: "...This favorable human climate helped us considerably in completing the entire program. They gave us the kind of assistance that is not included...in any program. If it had not been for this attitude, it might have been harder in some respects for us to work with Svetlana [Savitskaya]." (568)

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4.4 Selection Procedures

4.4.4 ROLES

The spaceship commander is usually a military pilot. Because of their prior flight experience, they already have many of the skills required:

- They can force themselves to work efficiently in dangerous situations at various physical and mental loads
- They know and understand what risk means and can act courageously and coolly (20)

Half of the cosmonaut trainees are military pilots or engineers. The other half are civilian engineers hired exclusively from within the ranks of manned spacecraft design bureaus or the flight control organization. (275)

Because there are so many different instruments onboard, a cosmonaut must have a good knowledge of all the technical equipment in the spacecraft, including the numerous engines and life support equipment. For these reasons, cosmonauts who have long years of experience or who have cooperated on the development of space satellites are highly considered. (126)

Even though the cosmonauts now need much training in many different fields, there is no way that the cosmonaut can be a professional in so many different areas. This means that there is only one way to conduct experiments: An experiment has to be divided into elementary parts so that a person who has very little preflight experience in dealing with the object of study can perform it successfully in orbit. (194)

The work of cosmonauts (scientific-research work, observations, analysis of obtained data, and the huge mass of information) is highly intellectual. It is not a role of just observation and control. It also requires that the person be an active participant in case of technical failure. Therefore, the following requirements are recommended:

- Attention stability and transfer
- Memory
- Logical thought
- Sense of time
- Decisiveness of action (114)

Candidates who have a desire for permanent activity and who find rest in periods of switching from one kind of activity to another are preferred. (266)

V. PHYSICAL CONDITION OF THE COSMONAUT

5.1 GENERAL STATE OF THE COSMONAUTS

"In-flight and post-flight medical examinations have demonstrated man's capacity not only to adapt to the half-year flight conditions, but also to work actively under them, to carry out complicated scientific and technological experiments, and to perform extravehicular operations. All in-flight and post-flight changes were of a reversible nature, and they disappeared completely after a relatively short period of readaptation. These changes seem to reflect a process of adaptation to the space flight condition and readaptation to 1-G environment. They did not endanger the cosmonauts' work capacity." (86)

Gazenko: "The general conclusion: that the blood, bones and muscle tissues do undergo changes during flight, but the changes are reversible....there is no insurmountable biological obstacles to prolonging the duration of man's journey in space." (587)

5.1.1 INFLIGHT

The following occurred during flight:

- The development of feelings of blood rushing to the head, stuffiness of the nose and edema of the face tissue
- Appearance of short-term spatial illusions:
 - Cosmonauts say that even when they keep their body and eyes immobilized, they still see a stationary object move (See 3.1.3 Experiments.) (626)
 - The form of this space movement disorder is complex. There are a few hypotheses, but scientists have been unable to recreate an adequate model
 - Development of the malady is influenced by flickering irritants. The phenomena can be compared with the feelings a person has when watching rapidly alternating objects on Earth (See 3.1.3 Experiments, Optokinesis.) (520)
 - Most probably caused by a lack of coordination between the vestibular apparatus and eye movement mechanisms (553)
- Appearance of vestibular discomfort that increases when moving the head and trunk
- Poor health (such as a cold)

SOVIET SPACE STATION ANALOGS, Ed. II
5.1 General State of Cosmonauts

- Headaches and unfavorable feelings in the region of the heart
(This occurred in the third month of one flight and involved
lack of sleep, according to specialists)
- Pain in the teeth
- Paronychia in finger
- Otitis of middle ear
- Bruises
- Decrease in appetite for certain foods
- Difficulty in sleeping (385) (587)
- Metabolism changes during long flights:
 - During a long flight sodium, potassium, calcium and magnesium
leave the bones but increase their concentration in the blood,
which may have an effect on the body's functional system
(143)(646)
- Loss of muscle mass
- Visible atrophy of arm and leg muscles
- Decrease in muscle tone (98)(548)
- Sensation of being filled with gas (646)

Numerous studies performed during these long-term flights and in the post-flight period indicate that cosmonauts develop polymorphic functional deviations, which cause problems when returning to Earth. (See 5.1.2 Post Flight.) (202)

Symptoms of these deviations:

- Motion sickness
- Changes in motor function and fluid-electrolyte metabolism

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5.1 General State of Cosmonauts

- Deconditioning of the cardiovascular system for exercise and orthostatic factors:
 - The human cardiovascular system appears to be the first to react to weightlessness. Soviets say that the system of a space-based blood circulation control system with a new method known as ballistic cardiography at Og has allowed doctors to judge the value and spatial distribution of systolic energy in any part of the cosmonaut's body. (553)
- Moderate increase in heart rate
- Transient increase in observed ejection time
- Increase during first 2-3 weeks of stroke volume and cardiac output
- Increased cerebral blood flow during first 3-4 months prior to stabilization
- Increase in jugular vein pressure
- A decrease in leg volume
- A decrease in venous blood pressure in legs
- A decrease in systolic arterial pressure
- Diminished mineralization of bone tissue
- Anemic syndrome
- Pain in the muscles and ligaments

Deviations probably arise because of:

- Hemodynamic disorders
- Disregulation of vascular toness
- Change in activity of the adrenosympathetic system
- Diminished functional reserve of the cardiorespiratory system (202)

An ecological approach to protecting cosmonaut health is important (monitoring, predicting and controlling the cosmonaut's condition by looking at all aspects of the environment). (40)

A. Onboard Physician:

The 237-Day Mission crew included, for the first time, a physician. He conducted more than 200 experiments. Among them:

- Genom experiment (This involved electrophoretic separation of heavy fragments of DNA.) This was successful.
- Membrana Experiment (This investigated the loss of calcium through cell membranes.) This experiment was conducted simultaneously in space and on Earth under similar temperature conditions

The advantages of having a space crew physician:

- Ability to take blood samples from the veins
- Possible to make a more complete decision on an efficient regime of physical exercise in preparation for readaptation to Earth's gravity:
- During the 237-Day Mission, the daily exercise period was cut back, while the level of exertion was increased. This was only possible with the presence of a physician to directly assess the cosmonauts' conditions. (46)

SOVIET SPACE STATION ANALOGS, Ed. II

5.1 General State of Cosmonauts

5.1.1.1 SPACESIGHT

Crew members from all flights have reported that after time in space they can see better:

- Increased acuity
- Enhanced perception
- Enhanced color differentiation (537)

Ground was a little skeptical at first, but during the 140-day mission a brightly colored ground cloth was laid out near the edge of a glacier and the cosmonauts were asked to estimate just how near it was. After several passes overhead, Kovalyonok reported that he thought the markers were about 700 feet from the edge. This was close enough to make believers out of the ground experts. (418)

On another flight, the crew was flying at a height of about 290km (180 miles), but were able to distinguish a 20-30m wide depression in a glacier. In another experiment, they reported that a glacier was 200m (219 yards) from a specified point. When scientists checked this, they found that the cosmonauts were correct within a few meters. (127)

5.1.1.2 MISSION HIGHLIGHTS

96-Day Mission:

One cosmonaut became ill with a cold. This was treated with the first aid kit. In the third month, both cosmonauts had headaches and unpleasant sensations in the region of the heart. Problems with teeth also arose. (Note: specialists ascertained that the heart problem was because of a lack of sleep.) (385)

140-Day Mission:

One cosmonaut developed paronychia of the finger after taking a blood sample. It was treated with antibiotics, sulsamides and syntazol ointment. Also reported: unpleasant sensation in the region of the heart, which disappeared independently. One cosmonaut reported an earache, which was treated with a warm alcohol compress.

SOVIET SPACE STATION ANALOGS, Ed. II
5.1 General State of Cosmonauts

Bruises also occurred, but treatment wasn't required. Cosmonauts thought headaches might be due to the increase in carbon dioxide above the 5mm mercury column (up to 6-7 mercury column). Due to this, in the future flights carbon dioxide above 5mm mercury column was not permitted. (385)

96-Day and 140-Day Missions: All the cosmonauts for the first few days noted statokinetic disorders in the form of instability in the Romberg position, and sweating when walking. Two people had vestibular vegetative disorders. They had dizziness, nausea, and a tendency to vomit, which particularly increased with head movement in a vertical position.

During adaptation, some cosmonauts vomited after eating. (385)

175-day Mission:

There was a change in the voice (nasality). (86)

"Active medical control...based on medical examinations of the crew and in combination with an efficient pattern of work and rest, full-value nutrition, sufficient water consumption and adequate sleep guaranteed the maintenance of the good state of health and sufficient performance capacity of the crew members on the...flight." (85)

Ryumin: "My worst fear during this stay in space has been over a possible appendicitis attack. And the other: that I may get a toothache requiring dental help. One night, aboard the station, I dreamed that I was having a toothache and I woke up in a cold sweat. And one tooth was indeed sensitive. But by morning the toothache was gone." (338)

211-Day Mission:

The first few days the crew had some physical discomforts: headaches and congestion. "Feelings throughout the day came in waves: in the morning you are a little dull; after breakfast things are better. The work is a good distraction, if you can do it." (106)

SOVIET SPACE STATION ANALOGS, Ed. II

5.1 General State of Cosmonauts

Berezovoy had difficulty sleeping (he talked in his sleep). (213)

The basic medical finding obtained during this flight was that increasing the time humans spend in space compared with flights of shorter duration did not lead to the appearance of any qualitatively new shifts in the cosmonauts' bodies. (32)

150-Day Mission:

Aleksandrov experienced discomfort from the rush of blood to his head during the first few days, as well as difficulty sleeping, loss of appetite, and thirst. By the end of the week he was feeling better. Lyakhov's adaptation went more smoothly. Both cosmonauts were permitted to begin exercising on the stationary bicycle by the end of the first week. (See 3.1.2.6 Exercise Time.) (150)(572)

Lyakhov gained weight during the beginning of both of his missions. Doctors have not discovered why.

At the beginning of the fourth month, the crew experienced a psychological decline. New experiments were included, as well as other ideas from the Psychological Support Group. (See 4.1.3 Psychological Stability.) (528)

Aleksandrov: "In the first two days of flight only the headache that came about after the docking, a hard day and a restless night in the crew compartment was unpleasant. It became easier later. But there is a feeling that something is different than on Earth. There is no playfulness and the usual train of thoughts and movements are constrained."

10th Mission Day, Aleksandrov: "We feel pretty good. The muscles ache a little. Again I noticed flashes with my eyes closed."

19th Mission Day, "My hands and fingers ache. I worked a lot with them yesterday. My fingers have many hangnails. The fingernails are weak and break."

25th Mission Day, "We get very tired by the end of the day and our nerves are no longer like in the morning...We awaken fresh, but with reluctance." (249)

237-Day Mission:

None of the crew members were reported to have suffered from any major physical ailments. None of the cosmonauts used any medicine. After 212 days, the weight of the cosmonauts had not changed much: one cosmonaut gained 1.5 kilograms, another lost some weight, and the third cosmonaut reported no weight change. Change in muscle mass remained within safe limits. (284)

By September 6, 1984, the volume of the tibia of all crew people had decreased by an average of 15%. This was deemed a normal reaction to prolonged stay in weightlessness, connected with the leaching of calcium from the bone tissue. (456)



Ed. I

"All people who have been in orbit experience certain difficulties, often significant ones...after returning to Earth." (88)

In general, cosmonauts noticed after landing:

- Weakness
- Fatigue
- A feeling of increased body and object weight
- A gravitational shift in the internal organs in the direction of the gravitation vector and vertigo
- Vestibular discomfort with sharp movements of the head
- Paleness of the skin
- Puffiness of the face
- Limitation in the locomotor function
- Decrease in orthostatic stability
- Increased perspiration
- Faintness
- Tachycardia
- Decrease in stroke volume and ejection time
- Discomfort sitting

The condition of crew members progressively improves the longer they're back on Earth. (4)(85)(90)(163)(385)(388)(548)

The increase in the duration of flights changes the physical condition of the cosmonauts, at least temporarily. Some of these changes may be attributed to weightlessness. Others may be attributed to:

- Stress
- Environment
- Inconvenience
- Work operation
- Feelings of responsibility for the optimal implementation of the flight program
- Insufficient rest and sleep
- Disruption in the eating regime (114)

A. Readaptation Difficulties:

The first long flight on the Salyut showed that people re-adapt with difficulty to Earth's gravity. Specialists developed methods for facilitating the return to Earth's gravity. (84)

The recuperation of the bodily structure and functions is successful, but it does take some time. (287)(305)

Psychological investigations do not terminate with the end of the flight. New problems arise in readaptation. (237)

The adaptation reactions to weightlessness make readaptation to Earth's gravitation more difficult.

Adaptation to weightlessness is easier and faster than readaptation to Earth's gravitation. (119)(127)

B. Successful Readaptation:

Quick readaptation after flight is evidence of intensive physical training on Earth and well thought out exercises in flight. Cosmonauts who were unable to carry out the full program of exercises have shown poorer readaptation to Earth. (20)(166)(168)

SOVIET SPACE STATION ANALOGS, Ed. II

5.1 General State of Cosmonauts

Three weeks prior to flight termination, the cosmonauts begin to use the Chibis vacuum suit, a lower body negative pressure suit. The negative pressure to the lower half of the body causes a redistribution of body fluids from the upper part of the body downward. This redistribution permits the reestablishment of vascular tone for subsequent postflight orthostatic stability. The application of negative pressure is performed every fourth day for a 20-minute interval at negative pressures ranging from -10 to -45 mm of mercury. During the last two days of flight, the negative pressure exposure is extended to a total of 50 minutes at a negative pressure ranging from 25-40 mm of mercury. (175)(284)(548)

Ryumin: "The individual physical and psychological makeup of a cosmonaut certainly plays an important role in one's successful adaptation to weightlessness and then readaptation upon return to Earth. ...We very strictly observed...that the body should be constantly reminded of the Earth, and that its systems, especially the cardiovascular system, should be able to endure extreme changes in environment." (50)

5.1.2.1 RESTORATIVE MEASURES

In order to accelerate normalization of these changes, restorative measures taken are:

- Regulation of motor activity
- Use and gradual expansion of physical exercises
- Massaging muscles
- Athletic games
- Swimming (Cosmonauts swim for short periods, in the hopes that this will enable them to "relieve" the condition of weightlessness.)
- Showering
- Walks (wearing special prophylactic spacesuits and/or training trousers. These help leg vessels gradually become accustomed to the full weight of blood flow on Earth)
- Sauna
- Psycho-emotional influence (40)(85)(86)(87)(172)(484)(624)

The presence of changes in the cardiovascular, nervous, muscular, adrenosympathetic and cardiorespiratory system make it necessary to use a strictly regulated exercise regimen in the early readaptation period.

The three regimens:

- Sparing (For the adaptation and conditioning of the erect position and the prevention of muscular and ligament pain. Includes light exercise.)
- Sparing and conditioning (Aimed at adapting the body to moderate exercise and creating favorable conditions to increase the reserve of the cardiorespiratory and other systems)
- Conditioning (To obtain as complete as possible a recovery of impaired function)

Used are:

- Morning toning exercise
- Massage
- Therapeutic exercise in pool
- Drug therapy (used when appropriate at the early phase of recovery)

To reduce axial loads and hydrostatic pressures that aid in the prevention of orthostatic disturbances and normalization of circulation and muscle tone:

- Therapeutic exercise in pool (at temperatures of 31-32° C)
- Therapeutic massage of leg and back muscles (prescribed from the first day of the recovery period) (202)

Graded walking: This has a universal conditioning effect on the cardiorespiratory system, coordination and statokinetic functions. It is probably the most-used rehabilitation measure. At first, the subjects walk at a strolling pace, then the speed and duration are increased and the routes begin to include ascents and descents. The cosmonauts walk up to 1 km at the Sparing stage and 10-14 km/day at the Conditioning stage. (202)

SOVIET SPACE STATION ANALOGS, Ed. II

5.1 General State of Cosmonauts

A. Sparing Regimen:

Exercises for the small and medium muscle group, with limited amplitude and intensity of motion.

B. Sparing-Conditioning Regimen:

Adding special conditioning exercises aimed at:

- Restoring muscle tone
- Coordination and statokinetic function
- Speed and force qualities

Increase in pulse rate not exceeding 120/minute and 3 minute plateau on the tolerance level. (202)

C. Conditioning:

All forms of exercise are increased. Walking, bike riding and sports are added. (202)

Exercises are tailored for each person with regard to individual physical structure. (For example, Solovyev is tall and more prone to orthostatic changes.) (501)(545)

"The early phase is the most important period of rehabilitation therapy, and proper implementation thereof determines subsequent dynamics of recovery of function." (202)

SOVIET SPACE STATION ANALOGS, Ed. II
5.1 General State of Cosmonauts

For the first four days of readaptation, it is important to wear a preventive post-flight suit, which maintains circulating blood volume when body position is changed.

These first days of rehabilitation and therapeutic measures are to prevent orthostatic disturbances and so the person can gradually adapt to light exercise. (202)

SOVIET SPACE STATION ANALOGS, Ed. II

5.1 General State of Cosmonauts

5.1.2.1.1 FOOD

The cosmonauts eat small meals regularly. (172)

To accelerate rehabilitation, the cosmonaut is provided with food and fluids consisting of:

- Fruit
- Berry juices
- Fresh vegetables
- Stewed and dried apricots
- Meat:
 - Liver
 - Kidneys
- Dairy products
- Eggs

The caloric value of the diet during the first three days after returning to Earth is increased gradually to preflight levels (approximately 3,300 calories). (548)

5.1.2.1.2 SLEEP

Returning cosmonauts have said that they sleep soundly without recalling any dreams. However, some have complained of discomfort: their light blankets felt heavy and their soft beds feel as hard as bare boards. (172)

5.1.2.2 MISSION HIGHLIGHTS

96-Day Mission:

- Readjustment was gradual.
- During their first few days back, the cosmonauts were tired and had muscular pain. It required effort to stand.
- The cosmonauts felt better laying down.
- Soviet doctors said that these two crew members were physically and mentally still in space. This was indicated by their attempting to swim out of their beds in the mornings, as they had done for the past three months.
- Their motions were not always precise.
- Each cosmonaut weighed 5 kg less.

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5.1 General State of Cosmonauts

Physical exercises and strolls were daily events, but even a week after his return to Earth Grechko said that he was still shaky and felt heavy. It took about two weeks before the crew members returned to normal. This has been attributed to the fact that the crew did not follow their scheduled exercise program and use of other prophylactic measures. (114)(154)(410)(548)

Even the relatively mild effects of the current long missions should not be underestimated, according to Cosmonaut Gretchko:

"Even after half a year's space travel, walking and standing gets difficult. You sleep badly and even eating is unpleasant to start with."

"Your heart and entire organism would have become so accustomed to living in space [after, for example, a trip to Mars that would take about three years] that you would never be able to stand on Earth again." (359)

140-Day Mission:

- This crew had reactions to readaptation that were less pronounced than during previous, shorter flights. A disproportion in movement and difficulties with coordination were observed only on the day when the flight ended. They were able to take a walk the second morning, wearing special trousers that assist walking:
 - They took a total of 140 steps while accompanied by their doctors. Their pulse rates rose only 15-20 beats.
 - Later on, the cosmonauts did not experience any kind of subjective difficulties or problems.
- Kovalyonok lost 2.3 kg and Ivanchenkov 3.9 kg.
- Stability with regard to orthostatic tolerance and to physical stresses diminished, but to a smaller degree than the shorter flights.
- Electrocardiographs did not reveal any pathological changes.
- There were symptoms of atrophy and atonicity.
- There was a heightened reflex response to irritation of the muscles.
- A severe period of readaptation took 3-4 days, but the major body systems returned to normal in 6-10 days. Some muscular systems did not regain their preflight abilities until 25 days after return. (87)(154)(484)(600)(624)

SOVIET SPACE STATION ANALOGS, Ed. II

5.1 General State of Cosmonauts

- They were the first people to return with erythrocytes born in space. Erythrocytes, which carry oxygen to tissues, have a life of 120 days. Those which were space-born were somewhat smaller than normal, but appeared to function adequately.
- By November 11, Ivanchenkov was playing a limited amount of tennis, although his coordination was still suffering and he was tired at the end of the day. (548)

This flight shows how important it is to adhere to the daily schedule, particularly to the physical exercises. Their post flight condition was better than that of Romanenko and Grechko. (114)

175-Day Mission:

- This crew was in the best condition (as compared to other long mission crews.)
- Cosmonauts complained of fatigue, and reported that their bodies felt heavy, as did different objects they manipulated. These feelings disappeared on the third post-flight day. (86)(154)(170)
- Ryumin returned weighing the same as when he left. Lyakhov lost a total of 5.5 kg.
- Both showed a decrease in shin size.
- Heart rate and arterial pressure were the same as preflight.
- There were some reports that Ryumin initially had trouble articulating words upon return.
- The readaptation took 2-3 days less than had been anticipated, although it was different for both:
 - Ryumin wanted permission to walk immediately. He walked 800 meters the first day.
 - On the third day, Ryumin was jogging and Lyakhov was doing gymnastics, both for 10 minutes each. (548)(552)
 - They went swimming in a net-equipped pool. (552)

Ryumin: "...my first cigarette! I inhale the smoke with intense pleasure. How I missed that." (338)

185-Day Mission:

- Less than 24 hours after landing, the crew went for a 30-minute walk and their pulse rate quickened by 15-20 beats.
- Both crew members had gained weight (Ryumin about 10 lbs, Popov about 7 lbs) and had grown (temporarily) about 3 cm.

- Two days after landing the two men participated in a press conference that had been scheduled. The conference was only to have lasted minutes, but it lasted over an hour.
- Four days after landing both were playing tennis. (548)
- Both cosmonauts had slight difficulty in speaking. (90)(172)
- With Popov and Ryumin, no reduction was observed in the strength of their shin posterior muscle group:
 - This fact is accounted for by the adequate and correctly organized physical training in space.
- Posture, coordination, walking and other movements also improved quickly.
- Overall, this crew readapted faster than any crew before them. (20)(400)

Ryumin made this flight six months after his 175-day mission. His returning health status was essentially identical in both cases. The Soviets were encouraged by this, maintaining that it showed that six months between flights was long enough to recover. (90)

Ryumin: "The individual physical and psychological makeup of a cosmonaut certainly plays an important role in one's successful adaptation to weightlessness and then re-adaptation upon return to Earth." (400)

211-Day Mission:

- Headaches and post-flight postural dysequilibrium were reported.
- Both cosmonauts lost 8-10% of their preflight weight. (176)(361)
- Berezovoy and Lebedev had pinched faces and had grown thin and pale.
- Their muscle volume had altered and their density had changed.
- They were in the hospital and ate solitary meals in their rooms until after the third day, when they came to the dining hall.
- They bathed each day in the pool, which has an elevated oxygen content. It was difficult for them to sit because their muscles had become unaccustomed to sitting: (187)
 - Berezevoy noted that after their return it was difficult for him to walk and to even sit. He had to lie down and rest before standing up and starting to move about. He noted that the swimming pool helped him to stand. (96)

SOVIET SPACE STATION ANALOGS, Ed. II

5.1 General State of Cosmonauts

- This crew landed at night in the midst of a snowstorm. Due to their physical deconditioning, they were unable to get out of the Soyuz:
- The first rescue helicopter sent to assist them crashed on landing. The second rescue helicopter, which carried medical teams aboard, managed to reach the Soyuz. However, it could not take off. Motor vehicles were then dispatched and the cosmonauts spent the night in this vehicle. (548)

150-Day Mission:

- Aleksandrov's weight had increased 1.2 kg and Lyakhov had added 1 kg of weight. (481)
- Four days after landing the cosmonauts were allowed to take their first walk. It was noted that there was a slight lack of sureness in their steps. (446)
- Lyakhov: "After leaving the descent module, we felt a great heaviness in the body, and disturbance in the coordination of movements and walking was observed." (482)

237-Day Mission:

- Atkov had gained 5-6 cm in height. (456)(464)
- Solovyev (a tall man) was more prone to orthostatic changes than the other two crew members:
 - This was taken into consideration during readaptation, with individualized exercise designed specifically for him (449)
- All shin bones reduced by an average of 15%. (545)(632)
- The crew was said to be in good humor.
- The cosmonauts looked weak. Their flatfootedness and spells of occasional dizziness disappeared soon. (545)
- One week after landing the cosmonauts were returning to their former norms. Readaptation was proceeding ahead of schedule. The specialists were not sure of the reason why. (456)
- This crew had a great deal of trouble walking, but were completely recovered from these motor disturbances eleven days after landing. The difficulties in movement suffered by the cosmonauts were due primarily to anomalies in the balance apparatus in the inner ear. (456)
- Dr. Atkov, who participated in the Salyut 7, 237-Day Mission, said that about three weeks after the flight the crew was back to normal. (408)

APPENDIX I
SALYUT 6 & SALYUT 7 PRIME MISSIONS

APPENDIX II
PROGRESS FLIGHT CALENDARS

APPENDIX III
EVA MISSION CALENDARS

APPENDIX IV
SALYUT EVOLUTION

APPENDIX V
CHARACTERISTICS AND PERFORMANCE RATINGS
OF SOVIET ORBITAL SPACECRAFT

APPENDIX VI
SOVIET LAUNCH VEHICLES

APPENDIX VII
SALYUT STATION LAUNCHES AND RETRO DATES

APPENDIX VIII
MEDICAL TABLES

APPENDIX IX
INTER KOSMOS PROGRAM

APPENDIX I

MAIN SALYUT 6 AND SALYUT 7 MISSIONS

* * * SALYUT 6 AND SALYUT 7 PRIME MISSIONS * * *

Salyut 6 Prime Missions

Launched: September 29, 1977
Deorbited: July 1982

The first mission was aborted due to faulty Soyuz docking mechanisms in October, 1977. Crew: Kovalyonok & Ryumin.

<u>Total Days</u>	<u>Crew</u>	<u>Launch & Return Dates</u>
96 days	Romanenko & Grechko	12/10/77 - 03/16/78
140 days	Kovalyonok & Ivanchenkov	06/15/78 - 11/02/78
175 days	Ryumin & Lyakhov	02/25/79 - 08/19/79
185 days	Ryumin & Popov	04/09/80 - 10/11/80

1192 Man Days / 28,608 Man Hours

Salyut 7 Prime Missions

The Salyut 7 was launched on
April 19, 1982

<u>Total Days</u>	<u>Crew</u>	<u>Launch & Return Dates</u>
211 days	Lebedev & Berezovoy	05/13/82 - 12/10/82
150 days	Lyakhov & Aleksandrov	06/27/83 - 11/23/83
237 days	Kizim, Solovyev & Atkov	02/08/84 - 10/02/84
102 days	Savinykh & Dzhaniibekov*	06/09/85 - 09/27/85
*52 days	Savinkkh, Vasyutin, Volkov**	09/27/85 - 11/21/85

1805 Man Days / 43,320 Man Hours

* Dzhaniibekov left the station with visiting cosmonaut Gretchko. Savinykh stayed onboard with the two crew members who had arrived with Gretchko.

** This mission was aborted on November 21, 1985 due to the illness of Vasyutin. The entire crew returned to the ground.

APPENDIX II

PROGRESS FLIGHT CALENDARS

ORIGINAL PAGE IS
OF POOR QUALITY

PROGRESS FLIGHTS

96- and 140-Day Missions

1978

JANUARY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

FEBRUARY

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28				

MARCH

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

APRIL

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

MAY

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

JUNE

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

JULY

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

AUGUST

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

SEPTEMBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

OCTOBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

NOVEMBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

DECEMBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

PROGRESS FLIGHTS

175-Day Mission

1979

JANUARY							FEBRUARY							MARCH							APRIL							
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
	①	2	3	4	5	6					1	2	3						1	2	3	①	2	3	4	5	6	7
7	8	9	10	11	12	13	4	5	6	7	8	9	10	4	5	6	7	8	9	10	8	9	10	⑪	12	13	14	
14	15	16	17	18	19	20	11	12	13	14	15	16	17	11	12	13	14	15	16	17	⑮	16	17	18	19	20	21	
21	22	23	24	25	26	27	18	⑲	20	21	22	23	24	⑮	18	19	20	21	22	23	24	22	23	24	25	26	27	28
28	29	30	31	25	26	27	28	25	26	27	28	29	30	31	29	30												

MAY							JUNE							JULY							AUGUST							
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
						1						1	2	①	2	3	④	5	6	7					1	2	3	4
6	7	8	9	10	11	12	3	4	5	6	7	8	9	8	9	10	11	12	13	14	5	6	7	8	9	10	11	
13	14	15	16	17	18	19	10	11	12	13	14	15	16	15	16	17	18	19	20	21	12	13	14	15	16	17	18	
20	21	22	23	24	25	26	17	18	19	20	21	22	23	22	23	24	25	26	27	28	19	20	21	22	23	24	25	
27	⑲	29	30	31	24	25	26	27	28	29	30	29	30	31	26	27	28	29	30	31								

SEPTEMBER							OCTOBER							NOVEMBER							DECEMBER						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
						1	①	2	3	4	5	6						1	2	3							1
2	③	4	5	6	7	8	7	⑧	9	10	11	12	13	4	5	⑥	7	8	9	10	2	3	4	5	6	7	8
9	10	11	12	13	14	15	14	15	16	17	18	19	20	11	12	13	14	15	16	17	9	10	11	12	13	14	15
16	17	18	19	20	21	22	21	22	23	24	25	26	27	18	19	20	21	⑳	23	24	16	17	18	19	20	21	22
23	24	25	26	27	28	29	28	29	30	31	25	26	27	28	29	30	23	24	㉓	26	27	28	29				
30																					30	31					

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PROGRESS FLIGHTS

211- and 150-Day Missions

1982

JANUARY							FEBRUARY							MARCH							APRIL						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
					1	2	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	7		
3	4	5	6	7	8	9	7	8	9	10	11	12	13	7	8	9	10	11	12	13	4	5	6	7	8	9	10
10	11	12	13	14	15	16	14	15	16	17	18	19	20	14	15	16	17	18	19	20	11	12	13	14	15	16	17
17	18	19	20	21	22	23	21	22	23	24	25	26	27	21	22	23	24	25	26	27	18	19	20	21	22	23	24
24	25	26	27	28	29	30	28							28	29	30	31				25	26	27	28	29	30	
31																											

MAY							JUNE							JULY							AUGUST						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
						1	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	7		
2	3	4	5	6	7	8	6	7	8	9	10	11	12	4	5	6	7	8	9	10	8	9	10	11	12	13	14
9	10	11	12	13	14	15	13	14	15	16	17	18	19	11	12	13	14	15	16	17	15	16	17	18	19	20	21
16	17	18	19	20	21	22	20	21	22	23	24	25	26	18	19	20	21	22	23	24	22	23	24	25	26	27	28
23	24	25	26	27	28	29	27	28	29	30				25	26	27	28	29	30	31	29	30	31				
30	31																										

SEPTEMBER							OCTOBER							NOVEMBER							DECEMBER						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
						1						1	2	1	2	3	4	5	6	1	2	3	4	5	6	7	
5	6	7	8	9	10	11	3	4	5	6	7	8	9	7	8	9	10	11	12	13	5	6	7	8	9	10	11
12	13	14	15	16	17	18	10	11	12	13	14	15	16	14	15	16	17	18	19	20	12	13	14	15	16	17	18
19	20	21	22	23	24	25	17	18	19	20	21	22	23	21	22	23	24	25	26	27	19	20	21	22	23	24	25
26	27	28	29	30			24	25	26	27	28	29	30	28	29	30					26	27	28	29	30	31	

PROGRESS FLIGHTS

ORIGINAL PAGE IS
OF POOR QUALITY

237-Day Mission

1984

JANUARY							FEBRUARY							MARCH							APRIL						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
1	2	3	4	5	6	7			1	2	3	4	1	2	3					1	2	3	4	5	6	7	
8	9	10	11	12	13	14	5	6	7	8	9	10	11	4	5	6	7	8	9	10	8	9	10	11	12	13	14
15	16	17	18	19	20	21	12	13	14	15	16	17	18	11	12	13	14	15	16	17	15	16	17	18	19	20	21
22	23	24	25	26	27	28	19	20	21	22	23	24	25	18	19	20	21	22	23	24	22	23	24	25	26	27	28
29	30	31	26	27	28	29	25	26	27	28	29	30	31	29	30												

MAY							JUNE							JULY							AUGUST								
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S		
			1	2	3	4	5						1	2	1	2	3	4	5	6	7					1	2	3	4
6	7	8	9	10	11	12	3	4	5	6	7	8	9	8	9	10	11	12	13	14	5	6	7	8	9	10	11		
13	14	15	16	17	18	19	10	11	12	13	14	15	16	15	16	17	18	19	20	21	12	13	14	15	16	17	18		
20	21	22	23	24	25	26	17	18	19	20	21	22	23	22	23	24	25	26	27	28	19	20	21	22	23	24	25		
27	28	29	30	31	24	25	26	27	28	29	30	29	30	31	26	27	28	29	30	31									

SEPTEMBER							OCTOBER							NOVEMBER							DECEMBER											
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S					
						1							1	2	3								1	2	3							1
2	3	4	5	6	7	8	7	8	9	10	11	12	13	4	5	6	7	8	9	10	2	3	4	5	6	7	8					
9	10	11	12	13	14	15	14	15	16	17	18	19	20	11	12	13	14	15	16	17	9	10	11	12	13	14	15					
16	17	18	19	20	21	22	21	22	23	24	25	26	27	18	19	20	21	22	23	24	16	17	18	19	20	21	22					
23	24	25	26	27	28	29	28	29	30	31	25	26	27	28	29	30	23	24	25	26	27	28	29									

APPENDIX III

EVA CALENDARS

EVA

ORIGINAL PAGE IS
OF POOR QUALITY

96-Day Mission

1977

JANUARY

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

FEBRUARY

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28					

MARCH

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

APRIL

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

MAY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

JUNE

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

JULY

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

AUGUST

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

SEPTEMBER

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

OCTOBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

NOVEMBER

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

DECEMBER

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

1978

JANUARY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

FEBRUARY

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

MARCH

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

APRIL

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

MAY

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

JUNE

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

JULY

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

AUGUST

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

SEPTEMBER

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

OCTOBER

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

NOVEMBER

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

DECEMBER

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

ORIGINAL PAGE IS
OF POOR QUALITY

EVA

140-Day Mission

1978

JANUARY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

FEBRUARY

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28				

MARCH

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

APRIL

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

MAY

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

JUNE

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

JULY

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

AUGUST

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

SEPTEMBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

OCTOBER

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

NOVEMBER

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

DECEMBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

ORIGINAL PAGE IS
OF POOR QUALITY

EVA

175-Day Mission

1979

JANUARY							FEBRUARY							MARCH							APRIL							
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
1	2	3	4	5	6						1	2	3						1	2	3	1	2	3	4	5	6	7
7	8	9	10	11	12	13	4	5	6	7	8	9	10	4	5	6	7	8	9	10	8	9	10	11	12	13	14	
14	15	16	17	18	19	20	11	12	13	14	15	16	17	11	12	13	14	15	16	17	15	16	17	18	19	20	21	
21	22	23	24	25	26	27	18	19	20	21	22	23	24	18	19	20	21	22	23	24	22	23	24	25	26	27	28	
28	29	30	31				25	26	27	28				25	26	27	28	29	30	31	29	30						

MAY							JUNE							JULY							AUGUST							
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
			1	2	3	4	5					1	2	1	2	3	4	5	6	7					1	2	3	4
6	7	8	9	10	11	12	3	4	5	6	7	8	9	8	9	10	11	12	13	14	5	6	7	8	9	10	11	
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20	21	22	23	24	25	26	17	18	19	20	21	22	23	22	23	24	25	26	27	28	19	20	21	22	23	24	25	
27	28	29	30	31			24	25	26	27	28	29	30	29	30	31				26	27	28	29	30	31			

SEPTEMBER							OCTOBER							NOVEMBER							DECEMBER									
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
						1						1	2	3							1	2	3							1
2	3	4	5	6	7	8	7	8	9	10	11	12	13	4	5	6	7	8	9	10	2	3	4	5	6	7	8			
9	10	11	12	13	14	15	14	15	16	17	18	19	20	11	12	13	14	15	16	17	9	10	11	12	13	14	15			
16	17	18	19	20	21	22	21	22	23	24	25	26	27	18	19	20	21	22	23	24	16	17	18	19	20	21	22			
23	24	25	26	27	28	29	28	29	30	31				25	26	27	28	29	30	23	24	25	26	27	28	29				
30																				30	31									

NO EVAs

185-Day Mission

EVA

211-Day Mission

1982

JANUARY							FEBRUARY							MARCH							APRIL						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
					①	2	1	2	3	4	5	6	1	2	3	4	5	6						1	2	3	
3	4	5	6	7	8	9	7	8	9	10	11	12	13	7	8	9	10	11	12	13	4	5	6	7	⑧	9	10
10	11	12	13	14	15	16	14	⑤	16	17	18	19	20	14	15	16	17	18	19	20	⑪	12	13	14	15	16	17
17	18	19	20	21	22	23	21	22	23	24	25	26	27	21	22	23	24	25	26	27	18	19	20	21	22	23	24
24	25	26	27	28	29	30	28	28	29	30	31	25	26	27	28	29	30										
31																											

MAY							JUNE							JULY							AUGUST								
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S		
						1				1	2	3	4	5						1	2	3	1	2	3	4	5	6	7
2	3	4	5	6	7	8	6	7	8	9	10	11	12	6	7	8	9	10	11	12	8	9	10	11	12	13	14		
9	10	11	12	13	14	15	13	14	15	16	17	18	19	13	12	13	14	15	16	17	15	16	17	18	19	20	21		
16	17	18	19	20	21	22	20	21	22	23	24	25	26	18	19	20	21	22	23	24	22	23	24	25	26	27	28		
23	24	25	26	27	28	29	27	28	29	30	25	26	27	28	29	30	31	29	30	31									
30	⑩																												

SEPTEMBER							OCTOBER							NOVEMBER							DECEMBER							
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
			1	2	3	4					1	2				1	②	3	4	5	6	1	2	3	4			
5	⑥	7	8	9	10	11	3	4	5	6	7	8	9	7	8	9	10	11	12	13	5	6	7	8	9	10	11	
12	13	14	15	16	17	18	10	⑪	12	13	14	15	16	14	15	16	17	18	19	20	12	13	14	15	16	17	18	
19	20	21	22	23	24	25	17	18	19	20	21	22	23	21	22	23	24	25	26	27	19	20	21	22	23	24	⑬	
26	⑭	28	29	30	24	25	26	27	28	29	30	28	29	30	26	27	28	29	30	31								
							31																					

EVA's

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237-Day Mission

1984

JANUARY							FEBRUARY							MARCH							APRIL						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
1	2	3	4	5	6	7		1	2	3	4			1	2	3					1	2	3	4	5	6	7
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22	23	24	25	26	27	28	19	20	21	22	23	24	25	18	19	20	21	22	23	24	17	18	19	20	21	22	23
29	30	31					26	27	28	29				25	26	27	28	29	30	31	22	23	24	25	26	27	28

MAY							JUNE							JULY							AUGUST						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
			1	2	3	4					1	2		1	2	3	4	5	6	7				1	2	3	4
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27	28	29	30	31			24	25	26	27	28	29	30	26	27	28	29	30	31		26	27	28	29	30	31	

SEPTEMBER							OCTOBER							NOVEMBER							DECEMBER						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
						1					1	2	3	4	5	6				1	2	3					1
2	3	4	5	6	7	8	7	8	9	10	11	12	13	4	5	6	7	8	9	10	2	3	4	5	6	7	8
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16	17	18	19	20	21	22	21	22	23	24	25	26	27	18	19	20	21	22	23	24	16	17	18	19	20	21	22
23	24	25	26	27	28	29	28	29	30	31				25	26	27	28	29	30		25	26	27	28	29	30	31

Note: July EVA was conducted by two visiting crew members.

EVA

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1985 Mission(s)

1985

JANUARY							FEBRUARY							MARCH							APRIL																	
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S											
		①	2	3	4	5				6	7	8	9							1	2											1	2	3	4	5	⑥	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	
13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	②	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	
20	21	22	23	24	25	26	27	28	29	30	31			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
27	28	29	30	31			24	25	26	27	28			25	26	27	28	29	30								28	29	30									

MAY							JUNE							JULY							AUGUST																		
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S												
														①	2	3	4	5	6																				
5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11		
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31							12	13	14	15	16	17	18	19	20	21	22	23		
19	20	21	22	23	24	25	26	27	28	29	30	31			28	29	30	31									24	25	26	27	28	29	30	31					
26	②	28	29	30	31		24	25	26	27	28	29			28	29	30	31									25	26	27	28	29	30	31						

SEPTEMBER							OCTOBER							NOVEMBER							DECEMBER																		
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S												
③	3	4	5	6	7		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31									
8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31			1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31										15	16	17	18	19	20	21	22	23	24	25	26	27	28
22	23	24	④	26	27	28	29	30	31					17	18	19	20	21	22	23	24	25	26	27	28	29	30	31											
29	30						28	29	30	31				24	25	26	27	28	29	30						29	30	31											

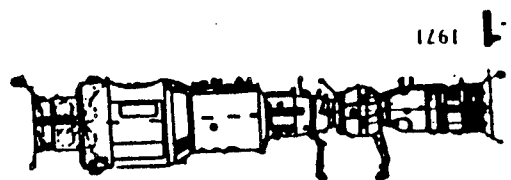
Note: September 28 was the first day of work for the rotating crew. This crew had to abort their mission on November 21, 1985, when the crew commander became ill.

APPENDIX IV

SALYUT EVOLUTION

SALYUT EVOLUTION

1971 - 1987

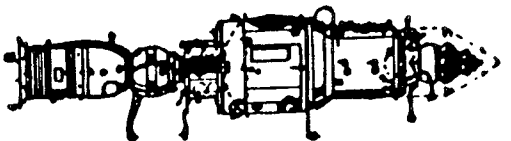


1 1971

2 1973 FAILED

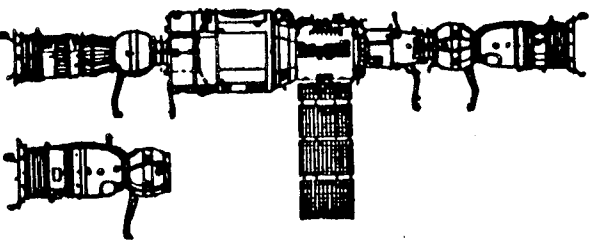


3 1974



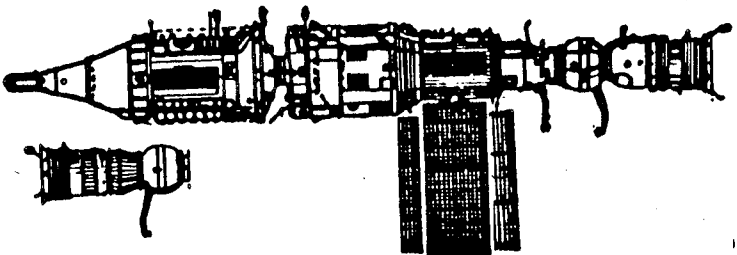
4 1974

5 1976

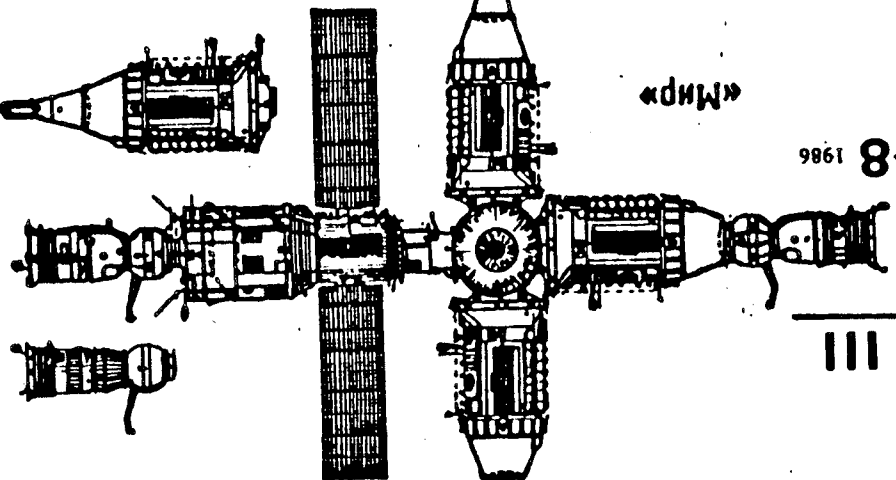


6 1977

II



7 1982



8 1986

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III

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"SALYUT"

APPENDIX V

CHARACTERISTICS AND PERFORMANCE

RATINGS OF SOVIET ORBITAL SPACECRAFT

CHARACTERISTICS AND PERFORMANCE RATINGS
OF SOVIET ORBITAL SPACECRAFT

ITEM	SOYUZ T	PROGRESS	SALYUT 7	COSMOS	ORBITAL COMPLEX*
Total Weight	6.85 t	7.02 t	19.6 t	20 t	47 t
Payload Only	0.7 t	2.3 t	2 t	4 t	---
Maximum Diameter	2.72 m	2.2 m	4.15 m	4 m	---
Maximum Length	7.94 m	7.94 m	15 m	13 m	36 m
Span	12.8 m	---	17 m	16 m	---
Solar Generator: Surface Area	12 m ²	---	60 m ²	40 m ²	100 m ²
Power	---	---	4 kW	3 kW	7 kW
Total Usable Space	10 m ³	6.6 m ³	90 m ³	50 m ³	150 m ³
Crew	2 to 3	0	2 to 6	0	2 to 6
Endurance	4-90 days	3-30 days	5 years	1 yr. plus	---
Accessible orbits					
Altitude	200-350 km	200-350km	300-400km	400km plus	---
Inclination	51.6°	51.6°	51.6°	51.6°	---
Launcher	Soyuz	Soyuz	Proton	Proton	---

* Editor's note: Orbital complex made up of Salyut 7, Cosmos 1443 and Soyuz 9

APPENDIX VI

SOVIET LAUNCH VEHICLES

OPERATIONAL SOVIET LAUNCH VEHICLES

CLASS	ANTECEDENT	VARIANT	SL.NO.	LAUNCH SITES	YEAR OF DEBUT	NUMBER LAUNCHED IN 1985 ^c	PROGRAMS CURRENTLY SUPPORTED
A	SS-6 (ICBM)	A-1 a	SL-3	TT, PL	1959	1	KOSMOS (NATURAL RESOURCES)
		A-2	SL-4	TT, PL	1961	40	SOYUZ T, PROGRESS KOSMOS (PHOTO RECON, SCIENTIFIC, RESUPPLY)
		A-2-e	SL-6	TT, PL	1961	16	MOLNIYA, PROGNOZ KOSMOS (EARLY WARNING)
C	SS-5 (LRBM)	C-1	SL-8	PL, KY	1964	11	INTERKOSMOS, KOSMOS (ELINT, COMMUNICATION NAVIGATION, ASAT TARGET, MINOR MILITAR EXPERIMENTAL)
D	NONE	D-1-e	SL-12	TT	1967	11b	RADUGA, GORIZONT, EKTRAN, VENERA, ASTRON KOSMOS (COMMUNICATION NAVIGATION, ELINT)
		D-1-h	SL-13	TT	1970	1	SALYUT, KOSMOS (SPACE STATION RELATED)
F	SS-9 (ICBM)	F-1-m	SL-11	TT	1966	5	KOSMOS (OCEAN SURVEILLANCE, ASAT)
		F-2	SL-14	PL	1977	12	METEOR, KOSMOS, (NATURAL RESOURCES COMMUNICATIONS, ELINT GEODETIC)

JOHNSON, NICHOLS L. The Sov
Year in Space. Teledyne Br
Engineering, Colorado

- a BEING PHASED OUT; OCCASIONAL LAUNCHES STILL POSSIBLE
- b THREE FLIGHTS APPEAR TO BE D-1-e VARIANTS
- c ONE LAUNCH (1985-53) USED AN NKNOWN BOOSTER

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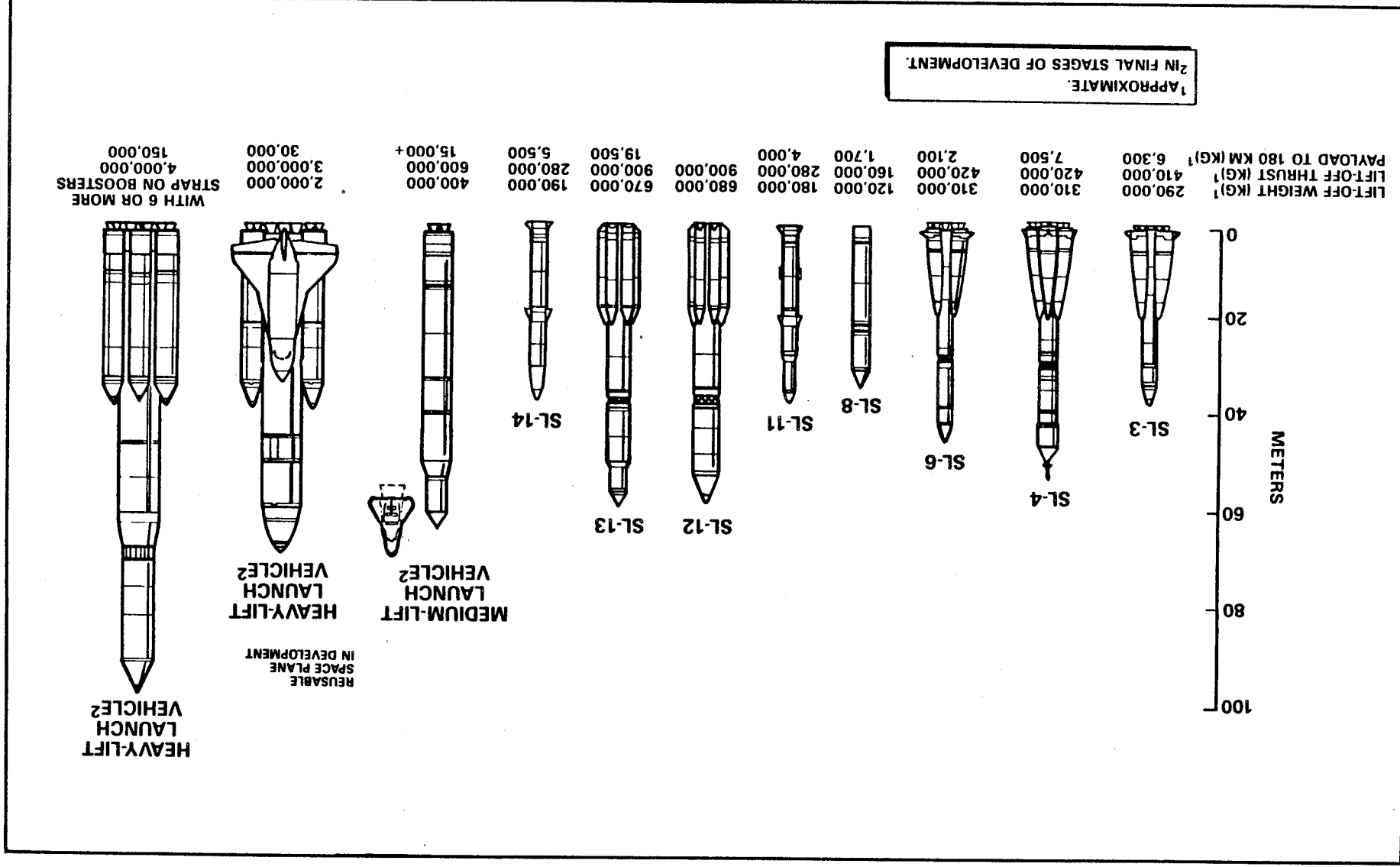


FIGURE 8. The U.S. Department of Defense released these statistics for the Soviet launch vehicle (SL-X-16) as the booster for the Soviet operational space plane. arsenal in 1985, confirming the anticipated use of the forthcoming medium-lift vehicle

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APPENDIX VII

SALYUT STATION LAUNCHES AND RETRO DATES

SALYUT STATIONS

<u>FLIGHT</u>	<u>LAUNCHED</u>	<u>RETRO DATE</u>	<u>CREWS</u>
SALYUT 1	04/22/71	10/11/71	- First crew that attempted to dock was unable to due to faulty docking equipment on the Soyuz. The next 3-person crew docked and resided for 23 days.
SALYUT 2	04/03/73	05/28/73	- This Salyut did not achieve stability in orbit.
SALYUT 3	06/24/74	01/02/75	- Thought to be the first military space station. - First crew resided for 14 days. - Second crew was unable to dock.
SALYUT 4	12/26/74	02/02/77	- First crew resided for 20 days - Second crew, mission was aborted. - Third crew resided for 62 days - Unmanned Soyuz docked with the station for 89 days.
SALYUT 5	06/22/76	08/08/77	- First 2-person crew resided for 49 days. - Second crew failed to dock. - Third crew resided for 16 days.
SALYUT 6	09/29/77	07/29/82	See Appendix IV
SALYUT 7	04/19/82	--	See Appendix IV

APPENDIX VIII
MEDICAL TABLES

MEDICAL

RESULTS OF PRE- AND POST-FLIGHT ABSORPTIOMETRIC MEASUREMENTS
OF THE CALACANEUS IN SALYUT 6 COSMONAUTS

CREWMEMBER	FLIGHT DURATION DAYS	CHANGE IN MINERAL CONTENT PERCENT
A	140	-3.0
B	140	-19.8
C	175	-9.8
D*	175	-3.0
E	185	-9.6
D*	185	-4.1
G	75	-0.9
H	75	-3.2

* Same crewmember with eight months intervening between missions

APPENDIX IX
INTER KOSMOS PROGRAM

SALYUT Y

VISITING CREWS - INTERKOSMOS PROGRAM

<u>CREW MEMBERS</u>	<u>DOCKED</u>	<u>UNDOCKED</u>	<u>NO. OF DAYS</u>	<u>MISSION</u>
Gubarev Remek (Czechoslovakia)	03/03/78	03/10/78	7	96-Day
Klimuk Germashevskiy (Poland)	06/27/78	07/05/78	8	140-Day
Bykovskiy Jen (GDR)	08/26/78	09/03/78	8	140-Day
Kubasov Farkash (Hungary)	05/27/80-	06/03/80	7	185-Day
Gorbatko Fam Tuan (Vietnam)	07/23/80	08/31/80	39	185-Day
Romanenko Mendes (Cuba)	09/18/80	09/26/80	8	185-Day
Dzhanibekov Gurragcha (Mongolia)	03/22/81	03/30/81	8	75-Day
Popov Prunario (Romania)	05/14/81	05/22/81	8	75-Day

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