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Selection and Training of Soviet Cosmonauts

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Project Officer
[redacted]

PRÉCIS

The Soviets appear to have extensive cosmonaut selection and training programs. The size of the cosmonaut corps was increased a few years ago to an estimated 75-80, and new facilities and equipment have been added in recent years at the Star City Cosmonaut Training Center. Despite improvements in these programs, Soviet cosmonauts are still not as well qualified as US astronauts in many respects. As a consequence of their inhibitions in taking independent action, the Soviet cosmonauts are generally not as resourceful in handling unusual or emergency situations. If the Soviets continue to rely on automatic systems rather than man to control their spacecraft, the supply of suitably trained cosmonauts for the space missions anticipated in the next few years should be adequate. If the cosmonauts are to assume a larger role in the future as pilots and controllers/decisionmakers, however, wholesale changes will be needed in the cosmonaut selection and training programs.

SELECTION AND TRAINING OF SOVIET COSMONAUTS

Project Officer

[redacted]

SI 76-10003
January 1976

CENTRAL INTELLIGENCE AGENCY
DIRECTORATE OF SCIENCE AND TECHNOLOGY
OFFICE OF SCIENTIFIC INTELLIGENCE

PREFACE

Publicity related to the joint US-USSR space flight, the Apollo Soyuz Test Project (ASTP), gives a distorted or fragmentary view of the adequacy of cosmonaut preparation to carry out manned space activity. Joint ASTP training exercises and visits by US sources to Soviet cosmonaut training facilities, on the other hand, provided a unique opportunity to gain information and insight for evaluating the Soviet effort. [redacted]

This report examines available information, [redacted] unclassified sources, on the Soviet cosmonaut selection and training programs. The paper considers the methods and equipment used by the USSR in selecting and training cosmonauts and examines the size and composition of the cosmonaut detachment. Emphasis is given to significant differences between the US and Soviet programs and an assessment is made of the capabilities and limitations of the cosmonauts to carry out current and future space missions.

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PROBLEM

To describe and assess the adequacy of the Soviet cosmonaut selection and training programs.

SUMMARY AND CONCLUSIONS

The USSR appears to have a large-scale effort to select and train cosmonauts for space missions as measured by the size of the cosmonaut corps. The Soviets are expanding their training facilities and acquiring new training equipment including highly sophisticated centrifuges. The Soviet selection and training programs have been modified from time to time in response to changing mission requirements in order to insure healthy, technically oriented cosmonauts for more complex, longer duration missions. These programs seem capable of assuring an adequate supply of trained cosmonauts for the anticipated Soviet space missions within the next few years.

While Soviet cosmonaut training always has emphasized physical conditioning, changes have been made which include the use of a battery of training procedures designed to overcome disorientation during flight, decreased use of the isolation chamber and parachute training, and increased attention to group psychology. Recently, the Soviets also have reduced their admitted overemphasis on psychological and physiological stress testing for selecting cosmonauts.

Major differences exist in the US and Soviet training programs, aside from the Soviet emphasis on physical conditioning and disorientation procedures. Soviet cosmonauts ordinarily are not trained as rigorously in operational matters as US astronauts, which in part reflects Soviet reliance on automatic systems rather than on man. The influence on and participation of cosmonauts in spacecraft and subsystems design and development are far less than that which is considered standard for US astronauts. Until the ASTP, extensive training and check-out of the crew with mission controllers were not carried out by the Soviets despite their reliance on these controllers during a flight. The Soviets also have not felt that the scientist-engineer cosmonauts needed to be cross-trained as pilots but appear to be more interested in the technical contribution they can make to the onboard program and mission objectives.

From an initial group of about 15 cosmonauts, who were military fighter pilots, the Soviets have increased the number of cosmonauts to an estimated 75-80. The current cosmonaut group probably is composed of around 50 military pilots (a few are test pilots) with advanced technical training and some 25-30 scientist/engineers, many of whom have graduate degrees. In addition to high physical and educational standards, a prerequisite for inclusion in the cosmonaut detachment now appears to be "political reliability." All recent additions have been members of the Communist Party.

Even with the increased technical qualifications, the inflight competence of the cosmonauts has varied considerably. Cosmonaut performance may be a function in part of the selection process. A kind of preselection occurs since the majority of cosmonaut candidates have a background as military pilots who were in good standing with their superiors. These candidates already have been trained to adhere strictly to flight rules and regulations. Hence, as a group it may not be unusual that the cosmonauts suffer overall from an inability to innovate or handle unusual situations. They appear almost afraid or unable to deviate at times from the preplanned program. The Soviets appear to recognize deficiencies in cosmonaut selection, however, and have tasked the Institute of Psychology to develop methods for selecting individuals who will be more effective during actual space missions.

The simulators and equipment used by the Soviets in cosmonaut training have been relatively simple in comparison to those of the United States. This relationship may reflect more on the differences in spacecraft design and philosophy concerning the inflight role of man than on the inability of the Soviets to provide such equipment.

Within the past 3-4 years, however, the Soviets have expanded significantly the facilities and equipment for cosmonaut training, particularly at the Star City Cosmonaut Training Center near Moscow. Upgraded simulators have been added along with laboratory space for familiarization with certain mission procedures and experiments. Some of the most sophisticated centrifuge capability in the world will become available at Star City within a year or so with the addition of two advanced centrifuges. Likely uses for these centrifuges are to test and train a large group of cosmonauts for earth orbital missions, as well as to expose them to the expected higher G forces during reentry from lunar missions.* Several advanced simulators for a large earth orbital space station and for lunar missions have been noted at several R&D facilities, but there is no direct evidence that they have been used for cosmonaut training.

On the basis of the training they receive, Soviet cosmonaut crews would not be expected to be as responsive or resourceful as US crews in abnormal situations. On the other hand, their effectiveness as onboard experimenters and observors, already demonstrated by some cosmonauts, can be expected to increase. Any expanded role for the cosmonaut as pilot and controller would require wholesale changes in the present training program.

DISCUSSION

SELECTION OF SOVIET COSMONAUTS

Introduction

In late 1959 the Soviets initiated a program to select a group of cosmonauts for space flight.[1] A special cosmonaut selection commission, established under the Scientific Research Institute of the Soviet Air Force (NIIVVS), was responsible for defining Soviet selection criteria that would meet the needs of the Vostok series of flights.[2] Since the US astronauts had just begun their training program, the Soviets were able to evaluate the US selection standards prior to the start of their own program.

The Soviet selection criteria generally were similiar to those of the United States in that Soviet officials selected only pilots in top physical condition who were believed to have the ability to function effectively in an isolated environment.[3-5] Unlike the United States the Soviets traded maturity, education, and flight experience for a younger, more athletic type of individual. The average age for the first group of cosmonauts selected was 28 years compared to 35 years for US astronauts. The Soviet candidates were selected largely from Soviet air force fighter squadrons with varying hours of flight experience. None of the original cosmonauts were test pilots as frequently is the case with US astronauts.

The Soviet selection program for the first group of cosmonauts generally consisted of three phases: (1) initial selection based largely on recommendation of others and documentation of family medical history; (2) a thorough medical examination; and (3) physical and psychological stress testing.[6] The latter phase included tests on the centrifuge and vibration platforms along with simulated ascents in a low-pressure or altitude chamber and tests for tolerance to decompression. The cosmonaut candidate group then was subjected to a series of special exercises oriented toward improving physical conditioning and coordination, developing the cosmonaut's ability to move in the weightless state, and augmenting his ability to withstand the various environmental stresses such as acceleration, high heat load, and hypoxia.

*Apart from cosmonaut training, these facilities are likely to be used to train pilots to withstand the high gravitational forces expected with new advanced aircraft. Swedish pilots flying high performance aircraft are undergoing such centrifuge training as are pilots in Japan and West Germany. The Soviet centrifuge, however, will be capable of more closely simulating actual flight conditions and providing more accurate data than any other centrifuge in the world.

Selection out of personnel could be accomplished at any time if lack of physical capability or psychological incompatibility became apparent. Psychological testing measured: emotional stability (during a 2-week stay in an isolation chamber), suggestibility (from symptoms of imagined hypoxia following a mock ascent in a pressure chamber), operational memory (on continuous sequential tasks while subjected to interference), and the ability to react under stress (in selecting signal from noise under the pressure of limited time).[7] A final selection of cosmonaut candidates was made early in 1960, nearly 1 year before the first Soviet manned space flight.

Early in the program (after Gherman Titov's 1961 flight in Vostok 2), the selection procedures were modified significantly to include a battery of vestibular tests designed to eliminate the individual who was susceptible to vestibular disorientation during space flight (figure 1).

Figure 1. Cosmonaut Komarov Undergoes Vestibular Tolerance Testing

Current Selection Criteria and Procedures

The current criteria for selecting cosmonaut candidates, although generally similar to those used for the selection of Soviet pilots, also incorporate several major changes from those used to select the initial cosmonauts. The changes largely reflect the current operational requirements of more complex and longer duration missions. The most important change has been an attempt to upgrade the technical background of cosmonaut candidates. The Soviets also appear to have adopted a more flexible attitude toward the once stringent physical requirements for selection of cosmonauts which were designed to test the cosmonaut's abilities to withstand the physical and psychological demands of space flight. The Soviets have openly admitted that they originally overdid the stress testing and now say it is not necessary to prepare a cosmonaut for all extremes during flight.[8]

A psychomotor testing program has been incorporated into the selection process and appears to include valid, objective measures to aid in the selection of cosmonaut candidates. The Soviets have computerized the data in at least one psychomotor test which permits nearly real-time readout of the test results of a rather sophisticated reaction time test in a simulated control system environment. This test involves tracking a dot which moves on a TV screen in an identifiable pattern. A computer keeps track of the errors in real time and prints out the results.[9]

During selection and training, the cosmonaut is said to undergo continual evaluation for what is often referred to as his psychological readiness to undertake a mission. This flight readiness state appears to include his psychological compatability with other potential crew members, an analysis of an individual's personality, the kind of role he plays in his interaction with others, familiarization with psychological reactions during flight, and his emotional stability in stressful situations. Lastly, he undergoes so-called moral or political education in Communist ideology. Thus, the Soviets say their program provides the necessary moral and psychological training which is important in shaping the personalities of cosmonauts to undertake complex tasks in space.[8]

The Soviets, however, do not appear completely satisfied with the entire selection process since Dr. B. V. Lomov's Institute of Psychology in Moscow has been assigned the task of devising better methods of selecting cosmonauts (and pilots).[10] In late 1973 Lomov indicated that the selection techniques used in the USSR had to be reexamined, apparently due to some dissatisfaction with cosmonaut performance during flight. Dr. Lomov reportedly is developing an integrated assessment of the individual (a profile) which is to include physiological, psychological, and social factors. Dr. Lomov's goal appears to be to develop a valid method for forecasting an individual's effectiveness and reliability during flight. On several occasions, Lomov reportedly has expressed the view that the Soviets have a real problem with crew selection. Although the Soviets believe they choose the best candidates initially for the training program, these individuals do not always live up to expectations by the time the mission is ready.[11] Lomov may well be referring to the seeming preoccupation of the Soviets to select individuals with high tolerance to physical and psychological stresses for their training program while neglecting the skills necessary for their mission performance, e.g. piloting and technical skills.

The present cosmonaut selection process is carried out in several phases.[12] The initial phase is directed by a special mandate commission which is responsible for the screening of both civilian and military cosmonaut candidates and reportedly also for reexamination of the cosmonauts during their training and after their return from space. The initial phase, as described by a Soviet physician who helped to develop the procedures, is based on certain documentation such as personal history statements and of recommendations of a candidate's immediate superiors and of Communist Party officials.[13] The criteria for initial recruitment of the Soviet candidate differ somewhat from US practice in that the potential candidate ordinarily does not volunteer but is selected by his superiors. The selection for inclusion in the cosmonaut reserve group is similar to US practices, however, in that excellent physical condition and professional experience are prerequisites. Since all recent cosmonauts have been members of the Communist Party for a number of years prior to their selection, membership in the Party now may be a requirement in becoming a cosmonaut candidate.

During the second phase, the potential candidate is given a medical examination, the objective of which is to detect latent abnormalities.[14] The functional capability of the whole body and individual systems, such as the cardiovascular, respiratory, and central nervous systems are investigated. Detailed examinations include neurological, otorhinolaryngological and ophthalmological along with X-ray and various biochemical and hematological tests. Physiological tests include those for gas exchange, external respiration, basal metabolism, and electrolytes. Electroencephalographs are evaluated and the vestibular function checked. This phase is conducted in a hospital, and if the candidate is judged clinically healthy, he undergoes the final phase, consisting of stress tests. For example, tolerance to hypoxia is examined in low-pressure chamber ascents, as well as by exposure to gas mixtures with reduced oxygen content. Centrifuge tests are conducted to determine the individual's tolerance to radial acceleration. In addition, a rigorous series of tests is given to examine vestibular stress tolerance.

After completion of all the above phases, the special mandate commission decides whether to admit the candidate to training. If selected, the individuals are considered to be in the cosmonaut reserve group.[15]

According to an assessment made of several publications of Soviet medical and scientific personnel, only about 15-25 percent of those undergoing the selection procedures become cosmonaut candidates. About 50 percent are rejected in the initial phase, about 25-50 percent are eliminated during the medical examination, and another 10 percent are rejected during the first month of training probably largely because of failure to pass the stress tests.[16]

SOVIET COSMONAUT DETACHMENT

Recent (1974) US visitors to the Star City Cosmonaut Training Center (Zvezdny Gorodok), the Soviet cosmonaut training center 12 nautical miles northeast of Moscow, have estimated that there are between 75-80 cosmonauts in the detachment. About 50 members of this group are military personnel.[17] Earlier (1969) [redacted] indicated that a smaller group of 52 was in training which probably included those in the reserve and those in active training for a specific mission.[18] Recent enlargement of the cosmonaut detachment is inferred from several Soviet reports of individuals who entered the cosmonaut detachment at Star City during 1970 and 1972. Although the size of the cosmonaut detachment is not known with certainty, the estimated large number of Soviet cosmonauts appears to demonstrate that the Soviets have a continuing and active commitment to manned space flight.

An analysis [redacted] publications indicates that the original group of cosmonauts probably numbered 15.[19] Of this group 11 have carried out at least one space flight (table 1). Three of these veterans have died or have been killed and six may still remain on active flying status. Some of the original group who never were selected for a flight probably were replaced in 1963 by military pilots who had to meet the higher selection standards that were imposed after Titov's disorientation during his flight. A year earlier the cosmonaut group had been augmented by the addition of probably four to five women including cosmonaut Valentina Tereshkova. In 1964 the cosmonaut group was modified again by the addition of the first engineer-scientist cosmonauts. At least two out of the three known additional cosmonauts added then probably were selected specifically to carry out the Voskhod 1 three-man flight.

Until 1966 the cosmonaut detachment was relatively small, but after that year a large number of cosmonauts appears to have been added to the cosmonaut group. The candidates included after 1966 do not appear to have been added as a single group but probably were selected periodically during the past several years. [redacted] has stated that candidates came through the Institute of Biomedical Problems (IMBP) in Moscow for their examination in the selection process individually or in twos but never in a group or in large numbers.[13]

The enlargement of the group in 1966-67 probably was necessitated by the need for additional cosmonauts for the Soyuz and Salyut programs and by the requirement for higher educational standards related to an expanded on-board program during earth orbital space station missions. All of the known cosmonauts in the 1966-67 group are civilians. Almost all are engineers with a background in aviation and spacecraft design and about two-thirds of this group have advanced degrees. There is no evidence from background data on the known cosmonauts that any military cosmonauts were added to the corps until 1970. From 1966 onward all additions appear to be related to an expansion of the technical capabilities of the cosmonauts.

All of the original cosmonauts subsequently acquired degrees in space engineering at the Military Air Engineering Academy imeni N. K. Zhukovskiy. In spite of this upgrading of Soviet cosmonauts' technical abilities, certain Soviet scientists from time to time have appeared almost envious of the caliber of US astronauts. Under space flight conditions the demonstrated competence of the cosmonauts in general has varied considerably. Their performance still suffers frequently from a lack of technical expertise and judgment. As recently as August 1974 the Soyuz 15 crew apparently exercised extremely poor judgment as a result of their technical limitations and seeming reluctance to incorporate changes to the flight plan in order to handle unexpected situations.[20-21] On the other hand, the crew onboard the Soyuz 18-Salyut 4 mission performed rather well on the whole and appeared to exercise some ability and judgment in handling the on-board experimental program and mission requirements.[22]

In addition to the military cosmonauts, the current composition of the cosmonaut group probably includes several physicians from IMBP and engineers and scientists from other facilities including possibly astronomers and geologists. According to General V. Shatalov who is in charge of cosmonaut training, no women at present are preparing for space missions, although they will be used sometime in the future for long space flight. He justified the latter statement by the fact that in the USSR many women specialize in meteorology and medicine which are professions that will be needed on orbital space stations. Other reports also indicate no Soviet plans to use women cosmonauts, at least in the immediate future.[23]

The largest portion of the cosmonaut detachment probably consists of military pilots and those with engineering backgrounds. Some 20 of the 34 cosmonauts who have flown on space missions previously are considered still on active flight status. The reasons the cosmonauts have left the cosmonaut detachment include death, sickness during flight, and assignment to administrative functions, research, and design responsibilities. Six cosmonauts died including four killed during space flights.

COSMONAUT TRAINING

Overall Training Program

The cosmonaut training program is divided into two phases, general and specific. After his selection, the

Table 1

Identified Members of Soviet Cosmonaut Detachment

Original Group (1960)

- ★ Gagarin (Vostok 1-1961)
- ★ Titov (Vostok 2-1961)
- Nik[illegible]v (Vostok 3-1962) (Soyuz 9-1970)
- Popovich (Vostok 4-1962) (Soyuz 14-1974)
- ★ Bykovsky (Vostok 5-1963)
- ☆ Komarov (Voskhod 1-1964) (Soyuz 1-1967)
- ☆ Belyayev (Voskhod 2-1965)
- Leonov (Voskhod 2-1965) ASTP-1975)
- Volynov (Soyuz 5-1969)
- Khrunov (Soyuz 4/5-1969)
- Shonin (Soyuz 6-1969)

Women Cosmonauts (1962)

- ★● Tereshkova (Vostok 6-1963)

Additions to Original Group (1963)

- ★ Shatalov (Soyuz 4-1969) (Soyuz 8-1969) (Soyuz 10-1971)
- Gorbatko (Soyuz 7-1969)
- Filipchenko (Soyuz 7-1969) (Soyuz 16-1974)
- ☆ Dobrovolskiy (Soyuz 11-1971)
- Artyukhin (Soyuz 14-1974)
- Demin (Soyuz 15-1974)
- Gubarev (Soyuz 17-1975)

Additions for Voshod Program (1964)

- ★● Feoktistov (Voskhod 1-1964)
- ★● Yegorov (Voskhod 1-1964)
- ★ Beregovoy (Soyuz 3-1968)

Additions (1965)

- Klimuk (Soyuz 13-1973) (Soyuz 18-1975)
- Sarafanov (Soyuz 15-1974)

Second Major Group (1966-67)

- ★● Yeliseyev (Soyuz 4/5-1969) (Soyuz 8-1969) (Soyuz 10-1971)
- ☆● Volkov (Soyuz 7-1969) (Soyuz 11-1971)
- ● Kubasov (Soyuz 6-1969) (ASTP-1975)
- ● Sevastyanov (Soyuz 9-1970) (Soyuz 18-1975)
- ● Rukavishnikov (Soyuz 10-1971) (Soyuz 16-1974)
- ☆● Patsayev (Soyuz 11-1971)
- ● Makarov (Soyuz 12-1973) (abort-1975)
- ● Lazarev (Soyuz 12-1973) (abort-1975)
- ● Grechko (Soyuz 17-1975)

Group Added (1970)

- Zhanibekov
- ● Andreyev
- Romanenko
- ● Ivanchenkov

Addition (1972) ● Lebedev (Soyuz 13-1973)

★ not on active flight
☆ deceased
● civilian

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cosmonaut-candidate is given general training, which involves preparation for activities which are common to all missions. This general phase is concerned largely with physical conditioning and technical preparation. The latter is said to include acquisition of at least a minimum level of knowledge in subjects such as space science and technology including space medicine and astronomy. During the general phase, the candidate also undergoes centrifuge training and testing under weightless conditions, i.e., in aircraft flying parabolic orbits. Both military and civilian candidates are said to undergo the same level of physical training but differ in the theoretical and technical preparation needed. Military and civilian cosmonauts do not train together until they have been selected for a specific mission.

After their initial period of training is completed the civilian cosmonauts as a rule return to their usual work environment but are required to maintain their physical conditioning.[15] At least one design bureau has a small training facility for such purposes.[24] The military cosmonauts ordinarily are detached to the Star City Cosmonaut Training Center, although some candidates reportedly remain in reserve with their military unit awaiting entry into the advanced, specific training program.[25]

Specific training is provided when the crew has been selected for a particular flight. The duration of the specific phase of training probably varies with the complexity of the mission, although as late as 1970 one [redacted] estimated it lasted only up to 5 months.[24] A primary crew and at least one backup crew are selected for this phase.[13]

At the conclusion of the specific preflight training, the cosmonauts are required to take and pass an examination relating to their training program and the upcoming space flight. Reportedly, the cosmonaut or crew with the highest marks then is selected for the actual flight.[15]

Differences Between US and Soviet Training Practices

With the exception of one physician cosmonaut who also is a pilot, the civilian cosmonauts have not, to date, been cross-trained as jet pilots. They receive some training on propeller aircraft, however. The reason for this minimal pilot training for civilians is that the Soviets seem to feel that there is no need to choose a civilian for piloting duties as the military cosmonauts already have considerable flight experience. This lack of pilot training for civilians is in contrast to the US-requirement in the Apollo and Skylab programs that all scientist-astronauts be fully qualified jet pilots.* The Soviets appear more interested in the technical expertise that the civilian cosmonaut can contribute to the on-board experimental program than in his piloting abilities. Piloting duties on board Soviet spacecraft, however, have not been extensive and are to a large degree handled by automatic systems.

One of the most significant disparities between the US and Soviet space crews is the extent of familiarity with their spacecraft and its subsystems. The Soviets say that during their training the cosmonauts visit the facility which develops the spacecraft. But it is apparent that there is little direct input or extensive familiarity with the development of the spacecraft by the cosmonauts.[15] Even when the engineer-cosmonauts are collocated at the facility which develops the spacecraft, compartmentalization probably prevents their interaction and influence in the development process, at least to the extent which has become standard for US astronauts. In the United States the astronauts have an important role in recommending improvements/modifications of the spacecraft from the early design stage. As a consequence the astronaut benefits from an in-depth knowledge of his spacecraft's systems. In addition, utilization of the astronauts' experience in the early stages of development results in an improved spacecraft since suggested changes can be readily incorporated into the design. The limited cosmonaut participation in spacecraft design is an example of Soviet compartmentalization of space systems development which hinders not only the efficacy of the final product but also limits the depth of training provided Soviet cosmonauts.

Another difference between US and USSR training practices is that Soviet cosmonauts do not as a rule undergo extensive simulation of the entire mission with their mission control center and down-range communications facilities.[26] This could have been a factor in problems with mission control during unplanned situations on certain earlier missions and in a lack of extensive practice and planning by the Soviets for contingency situations. In the Apollo-Soyuz

*The previous US requirement for cross training scientists as pilots now have been changed. Scientists-technicians-experimenters on the Space Shuttle will not be required to be pilots. Only the three flight crew members must be astronauts with pilot training and experience.

Test Project (ASTP), however, the cosmonauts underwent more extensive mission simulation than ever before.

From its beginning the Soviet training program for cosmonauts has emphasized physical conditioning to a significantly greater degree than has the US program, which has considered physical conditioning a minimal and largely voluntary effort.[23] The original cosmonaut group underwent a rigorous program of stress adaptation and testing including 8-10-day stay in an isolation chamber and extensive parachute training. At the present time, however, neither exhaustive parachute training nor confinement in an isolation chamber is required of the cosmonauts.[27] Apparently, the reasoning behind the prolonged confinement was to test emotional stability and to give the cosmonauts an idea of the psychological consequences if communication with others were lost. Isolation and confinement were relevant test parameters for 1-man missions but were questioned by Soviet investigators concerning their applicability to multiman crews. Studies in group dynamics and the interactions and compatibility between crew members have now assumed increased importance in space flight as they have in the US program. The Institute of Psychology under Dr. Lomov, for example, has been given responsibility for applying research in these areas to the space environment.[28] Since the cosmonaut now lands inside his spacecraft instead of ejecting, as was the standard recovery option on the Vostok flights, parachute training also has little direct application to present cosmonaut training. Only minimal parachute training now is provided for cosmonauts and this appears to be largely for experience in handling stressful situations.

A major difference in training practices between the US and USSR is in the area involving the vestibular system.[29] Unlike the United States, the Soviets have a very extensive vestibular training program. The effects of weightlessness and the space environment on the vestibular system is thought to be the root of disorientation problems encountered by the cosmonaut during flight as well as of certain undesirable autonomic nervous system responses largely described under the term motion sickness. To counteract these problems, which were first noted on Titov's Vostok 2 flight in 1961, the Soviets have an exhaustive vestibular testing and training program largely geared toward conditioning the cosmonaut's vestibular system to be less sensitive to irritants. The need for this type of training is particularly relevant for the Soviets since the Soyuz spacecraft must rotate in orbit to maintain the proper orientation of its solar panels.

The Soviets believe that individual sensitivity to disorientation and motion sickness can be changed. Once an optimal (but unspecified) level of conditioning is reached and training ceases, it apparently takes about 6 months before the individual becomes deconditioned again.[29] It is believed that the Soviets will continue to emphasize this type of training particularly as missions become longer and more complex to insure optimum cosmonaut physiological ability to perform onboard tasks.

Training Equipment and Facilities at Star City

US sources have evaluated Soviet cosmonaut training simulators in general as adequate equipment but far less sophisticated than similar US equipment.[32] This lack of sophistication may be due to several factors: the Soviet philosophy of giving the cosmonaut only a minor role in the control of his spacecraft, a major reliance on automatic systems, a lack of appreciation of the need for rigorous training of the cosmonaut, and the traditional Soviet philosophy of using the simplest device to accomplish the desired end.

With the increasing complexity and duration of space flights the Soviets, within the past 3-4 years, have expanded significantly their manned space training facilities.[33-34] Until the construction of Star City such facilities were centralized in the general Moscow area. Even so, the cosmonauts had to travel to various other sites for some of their training, particularly with certain equipment such as centrifuges and on occasion for tests in pressure chambers. These kinds of equipment either are now available or very shortly will be at Star City. Additional facilities include those for the physical conditioning of the cosmonauts, research laboratories (including those for practicing mission procedures and experiments), and a number of upgraded spacecraft simulators and mockups. A living area is collocated at Star City and houses the cosmonauts and their families as well as a large number of support personnel.[35]

The available training equipment (figures 2-5) at Star City includes:

(1) A centrifuge, built by a Swedish company for the Soviets, and scheduled for operation by 1976. Another advanced centrifuge also may be installed at Star City at a later date.

(2) Full scale mock-up of the Salyut space station.

(3) Soyuz-Soyuz docking simulator.

(4) Soyuz-Salyut docking simulator.

(5) Soyuz mission simulator.

(6) Low-pressure chamber large enough to test Soyuz spacecraft.

The Soviets apparently make extensive use of the centrifuge in their cosmonaut training program. This is contrary to US practice where astronaut training on the centrifuge has been significantly decreased. Soviet use of the centrifuge probably has three general purposes:

(1) To familiarize the cosmonaut with accelerations which differ in duration and intensity.

(2) To determine individual tolerances to G-forces according to levels expected during mission launch and reentry phases.

(3) To adapt the individual to withstand acceleration.[18]

The centrifuge, which contains the largest direct-current motors ever built (185 tons), has a 100-ton rotor arm, 18 meters long, and is one of the most advanced centrifuges in the world. Two interchangeable gondolas, seating one and two persons, can be driven at 30 rpm with 3 degrees of freedom. The gondola, configured to hold two persons, is capable of being evacuated to simulate an altitude environment. In this manner, the subject can be exposed not only to increased gravitational forces but also to a decreased pressure or variety of breathing gas mixtures. In addition, the gondolas can be further modified or controlled to both increased and decreased temperatures and relative humidities.

The Soyuz mission simulator, i.e., a task simulator, appears to have the capability of simulating all mission phases except docking. It includes a complex computer-driven view screen which duplicates the scene outside with simulated realtime changes, including the expected stellar and earth views as various control commands are executed.[33] The Soyuz mission simulator also includes the capability for simulating orbital corrections, emergency procedures, and reentry.[32]

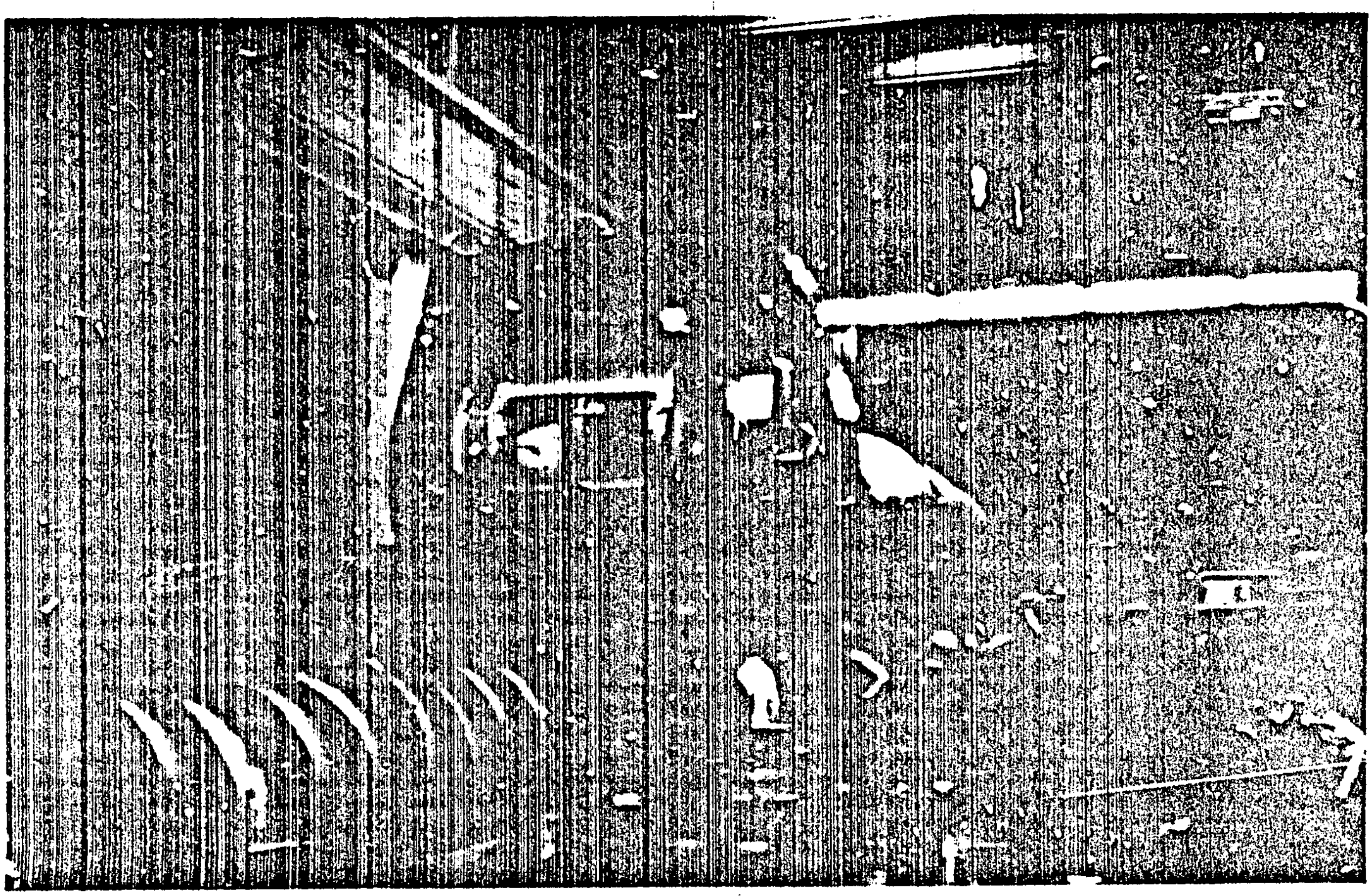

Figure 2. Centrifuge Destined for Star City Under Construction at ASEA Plant in Sweden, March 1975

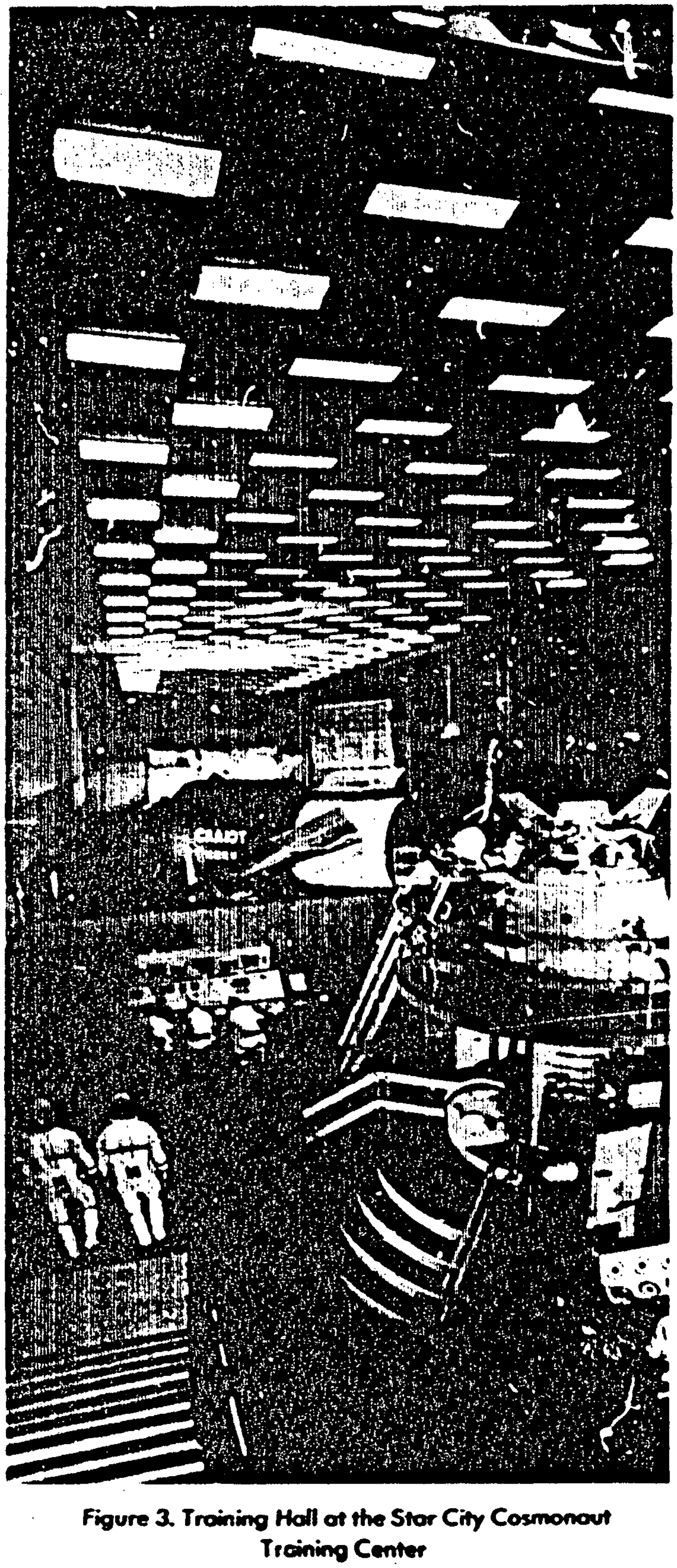

Figure 3. Training Hall at the Star City Cosmonaut Training Center

A docking simulator is devoted solely to training in docking. While the controls operate differently and are not as precise as US controls for this type of simulator, the simulated docking technique has been estimated by one US source as quite good.[36] In the docking procedure training, the Soviets use full-scale models that are fully automatic and have the ability to rotate and turn. They use a combination of direct vision through a periscope and three television cameras in the simulation. The scale models are worked on a feedback servo-loop system where the trainees are flying in a stationary simulator while the other training device (or Soyuz spacecraft) does all the maneuvering.[29]

In addition to the mission-oriented simulators at Star City, the Soviets were known to have (in early 1970) a full-scale metal mock-up of a space station at the Institute of Medical and Biological Problems in Moscow.[37] This simulator is primarily an R&D tool and is suitable for evaluating various space station system design configurations in terms of equipment and human performance, i.e., man-machine systems. It could be used, however, for familiarizing and training cosmonauts for possible space stations planned as follow-on for the Salyut space station. The simulator, along with available computer facilities, provides a great deal of power in terms of the operations which it can perform on human responses and the feedback it supplies to the human operator.

The Soviets use a large number of devices for this vestibular training including the Khilov swing,* Barany chair,** and the MVK-1 revolving chair. One idea behind using this equipment is that the degree of excitability of the vestibular apparatus depends on visual stimuli and on the character of muscular contractions, primarily the muscles of the neck and trunk. In theory, the sensitivity of the vestibular apparatus increases with the flickering of objects in the field of vision when a man is balancing himself on an unstable support and when there are no stable muscular strains. The following method has been used by the Soviets to increase vestibular tolerance: (i) rotation followed by transfer to an unstable platform, (ii) rocking, (iii) rotation with active tilting of the head

*The Khilov swing is a four-support swing in which the supports move with the gear, maintaining the cosmonaut parallel to the ground while swinging back and forth.

**The Barany chair is a kind of chair named after the Swedish physician Robert Barany in which a person is revolved to test his susceptibility to vertigo.

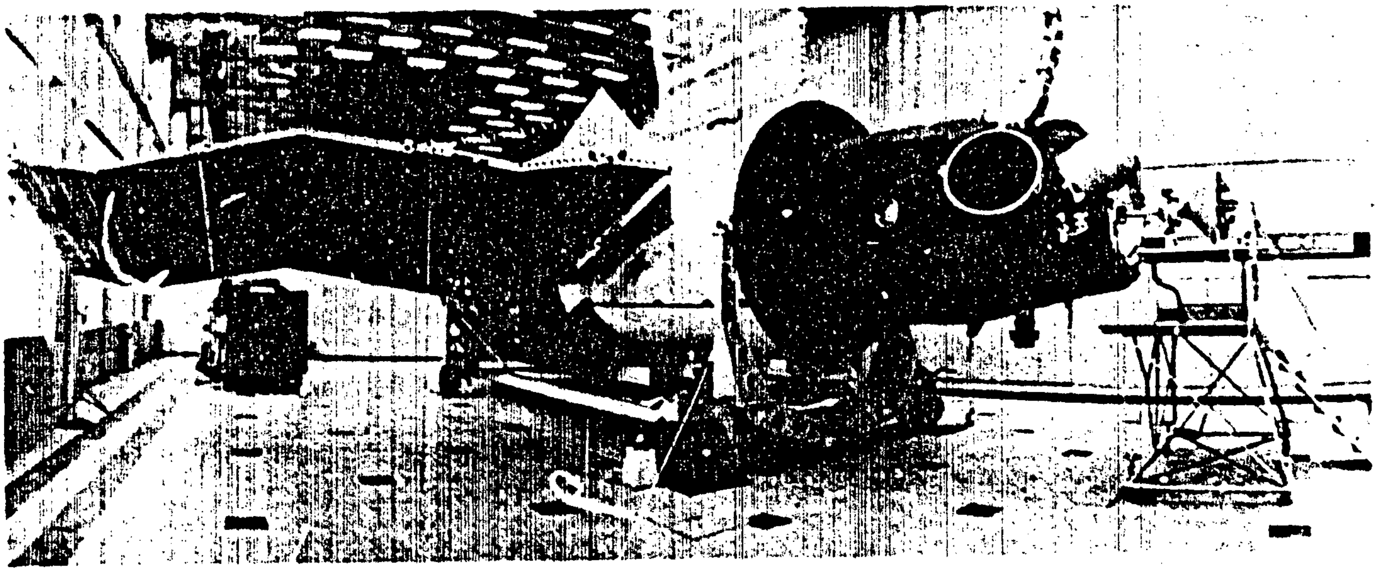

Figure 4. Training Mock-up of Salyut Space Station at the Star City Cosmonaut Training Center

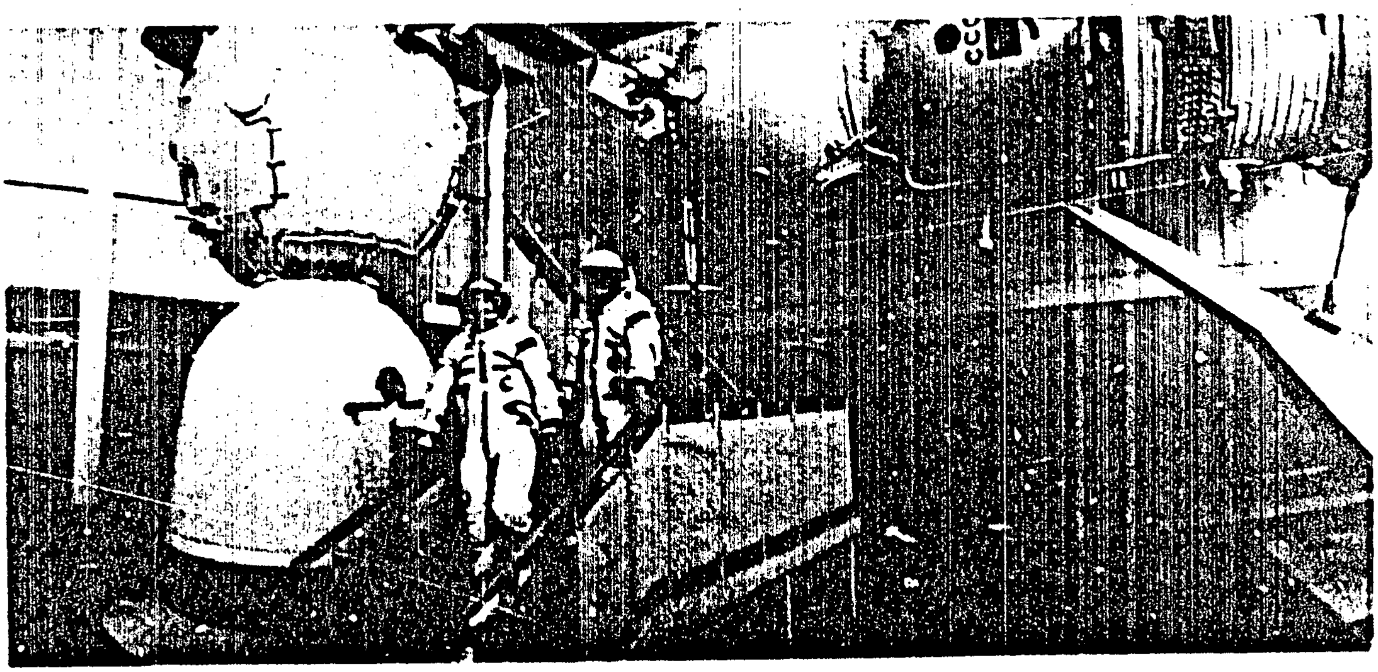

Figure 5. Soyuz Spacecraft Simulator at Star City

and body, (iv) balancing, and (v) complex vestibular and visual stimuli. The methodology includes rotation in a special chair with transition to an unstable support (probably the MVK-1), rocking in a special four-beam Khilov rocking device (swing), training in a rolling device with optokinetic stimulation (the optokinetic drum*), rotation in a chair with simultaneous sequential inclinations and straightenings of the body and head, and balancing in a chair with an unstable support. Available equipment allows investigation of the vestibular, visual, and proprioceptive systems individually or in combination.[16]

In all of the above investigations which involve Coriolis** accelerations, vestibular studies predominate. The Soviets appear to have an increased interest in cerebral or intracranial circulation and have identified what they consider to be major, qualitative categories of hemodynamic responses to Coriolis stress, which can be used as selection criteria for cosmonauts.[23 31]

Another training device is described as a standard rotating room. Little is known concerning the details of this room except that during the late 1960s one such room was said to exist at an unknown location in Zhukovskiy which may be the Central Aerohydrodynamics Institute or ne · TsAGI.[30] This room was described by one Soviet source as having a diameter of 3.5 meters and was attached to the end of a centrifuge about 6-7 meters in diameter. The research was said to involve study of human behavior as affected by the vestibular system when a subject is in continuous rotation for several days. At that time and at that location it was only considered an experimental device and was not used for cosmonaut training.

Joint Training for ASTP

The 2-year period of joint US-Soviet training for ASTP provided further insight into the Soviet philosophy, methods, and equipment used in preparing cosmonauts for space flight. The ASTP training was the most extensive ever carried out by Soviet cosmonauts as they followed US training philosophy which is characteristically rigorous (table 2).[38]

Early in the ASTP training sessions, it became apparent that the cosmonauts ordinarily did not act as diagnosticians and problem solvers as US astronauts do.[39] Despite contrary views noted in the Soviet press expressing the need to function creatively while constantly doubting and criticizing existing concepts, norms, regulations, and instructions, the Soviets appear to have little confidence in the cosmonaut as an innovator, controller, and decisionmaker. During practice sessions between the crews and mission control in simulating nonnominal situations, for example, it became apparent that the Soviet crew had been given the questions and answers ahead of time seemingly in an effort to give evidence of their excellent performance capabilities.[26]

A US visitor to the Star City Cosmonaut Training Center during the joint training sessions commented that the cosmonauts were rarely critical of each other or anything else.[40] He said they appeared to live affluently and perhaps were concerned about losing their hero status should their behavior depart from some prescribed norm. While these comments may be a bit overdrawn, they do reflect a personality characteristic of some cosmonauts noted during flight which can perhaps be described as fear-of-failure. Some cosmonauts seemingly are reluctant to incorporate change in order to handle unexpected situations. It is almost as if they are afraid to risk a change in approach, because it would be outside the accepted or established program and hence lead to assumed punishment.

The cosmonauts were not used to the intensity or depth of training provided US astronauts, and it was clear that any training sessions in the past between the cosmonaut crew and mission controllers had been minimal. The joint training program called for many hours of briefings, training sessions with their own and the other country's spacecrafts and subsystems, along with extensive simulations of the entire mission and communications checkout between the crew and ground controllers.[26] These mission simulations were by far the most extensive ever carried out by the cosmonauts. One US source relates that during the training sessions, the cosmonauts were more than ready to quit just as soon as the scheduled working day was over rather than put in extra time to study the flight plan or spacecraft subsystems as is commonly done by US astronauts.[41]

*The optokinetic drum is a rotating drum with the inside painted with a pattern of black and white stripes. The cosmonaut is seated inside on an unsteady mount. With the rotation of the drum, the stripes move to provide the illusion of movement.

**The resulting Coriolis effects are physiological effects (nausea, dizziness, vertigo, etc.) felt by a person moving radically in a rotating system, e.g., vertigo occurs when a pilot moves his head up and down while in a spin.

Table 2
Type of Training Accomplished During Joint ASTP Training Visits

Training	July 1973	Nov 1973	June 1974	Sept 1974	Feb 1975	Apr 1975
Apollo Systems Briefings	●					
Apollo Rendezvous Briefings				●		
Experiment Briefings					●	
Contingency Briefings					●	
Command Module Simulator	●			●	●	
Docking Module Simulator					●	
Command Module Mockup	●			●	●	
Docking Module Mockup	●			●	●	
Communications Training		●	●	●	●	●
TV Camera Briefing				●		
16mm Camera Briefing				●		
Onboard Documentation	●	●	●			
Joint Activity Walkthroughs					●	
Joint Activity Simulations					●	●
Soyuz Systems Briefings		●	●			●
Soyuz Simulator		●	●			●
Docking Simulator		●	●			
Soyuz Mockup		●	●			
Soyuz Spacecraft Briefings						●
Inspection Soyuz Spacecraft at Launch Site						●

● US ● USSR

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Training for Future or Advanced Manned Space Flights

With the addition of the new centrifuges at Star City, the Soviets will have some of the most sophisticated centrifuge capability in the world for testing and training humans under acceleration stress.[34] This capability appears to be far in excess of current Soviet requirements for manned space missions. The most likely explanations for their use at Star City appear to be:

(1) Routine testing and training of a large group of cosmonauts for earth orbital stations

(2) Cosmonaut training for expected higher G forces during lunar reentry

(3) Training of pilots for an advanced aircraft design incorporating a tilt back seat to enable the pilot to withstand the high G conditions experienced during combat maneuvers. (Star City reportedly also is used for pilot training.) The centrifuge also can be used to test pilots in inflated pressure suits or under conditions of reduced pressure, i.e., high altitude.

Other than the simulator at the Institute for Medical and Biological Problems (IMBP) for studying the design options for more advanced earth orbital stations, little is known about possible Soviet training devices related to more advanced Soviet manned space missions. [redacted] from time to time have reported that the Soviets possess lunar simulators.[13, 42] The simulators which have been described all appear to be located at R&D facilities in the USSR and have not, per se, been designated as cosmonaut training devices. One Soviet scientist stated that about 1970 while at the spacesuit and life support development facility at Tomilino, he had seen a special simulator for testing subjects in a lunar spacesuit under simulated one-sixth gravity.[13] The lunar gravity conditions were achieved by suspending the subject at the appropriate angle over a treadmill along which the trainee walked. A more sophisticated device for simulating lunar gravity conditions* probably is located at the no. 2 site of IMBP just northwest of Moscow. This IMBP site is a major Soviet bioastronautic R&D facility.[43] The lunar device appears to be part of a multipurpose facility for simulating conditions in outer space and on the lunar surface. It probably will become operational early in 1977.

The Soviets also appear to be interested in training cosmonauts onboard their spacecraft during a long duration flight.[14] They feel that when there is a long duration between launch and landing of a spacecraft training must be reinforced monthly during the flight. They have stated that the longer a flight is, the greater the need for an update of landing skills and ability prior to landing. Therefore, they reportedly intend to do more onboard, prelanding training in the future.