
L5 NEWS
January 1979

L-5 NEWS

A PUBLICATION OF THE L-5 SOCIETY

VOL. 4 NUMBER 1 JANUARY 1979

In this issue:

Cover: The view that you will have when returning to your space colony in cislunar space after a vacation on Earth.

Publication office: the L-5 Society, 1060 E. Elm, Tucson, Arizona 85719. Published monthly. Subscription: $12.00 per year, included in dues ($20.00 per year, students $15.00 per year). Second class postage paid at Tucson, Arizona and additional offices.

Membership Services: L-5 Society, 1620 N. Park Avenue, Tucson, Arizona 85719. Telephone: 602/622-6351.

Change of address notices, undeliverable copies, orders for subscriptions, and other mail items are to be sent to:
L-5 Society
Membership Services
1620 N. Park
Tucson, AZ 85719

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Soviets In Space

Fanciful Soviet cartoon of future space gardens.

EDITOR'S NOTE: 1978 has been a significant year for the Russian space program. With the operations of the Salyut 6, the Russians have moved into their "second generation" of space stations: they have had more launches, more visits, more activity in this one year than in the previous six; they now hold the records for the longest space flight, greatest number of total man hours in space, and have broken previous Salyut altitude records. And the Russians have been thinking of the future, as well, although these news items are not very well publicized in the West. **L-5 News,** *therefore, is dedicating a large portion of this issue to the Russian space effort and to the significant and far-reaching research that the Russians have done in exploring the habitability of space.*

Soviets Overcome O-g Problems

Nov. 2, 1978, Cosmonauts Vladimir "Volodiya" Kovalenok and Aleksandr "Sasha" Ivanchenkov returned from their record-breaking (139 days, 14 hrs., 48 min.) Salyut-6/Soyuz flight. After 2 weeks of intensive study of medical data gathered during and after their marathon flight, Academician Oleg Gazenko, in a speech at Moscow State University, gave this report:

During the preparatory period, in the course of this 140-day flight, and now after its completion, both the cosmonauts and the specialists who worked on the medical safeguarding of this flight must carry out very serious analysis of the very voluminous and very important scientific material which, it can already be said, will significantly expand our ideas of space and the people who conquer it. Naturally, this data still requires more analysis, more serious study and evaluation, so today I can present only the very first observations and some of the first results of this material.

It must be noted that during this prolonged flight, the crew not only completely fulfilled the mission's scientific program but, in many important areas of that program, overfulfilled it, especially in the area of medical and biological research. The scientific program, as you know, was exceptionally broad, variegated and intense. It included: many scientific and technical experiments, the fulfillment of various technical tests on the numerous systems on board the orbital complex, work connected with servicing the station itself, the repair of equipment, and, finally, constant communication with the flight control center. But I should like to point out the remarkable fact that as time went on, the crew's work capacity actually increased in comparison with the initial flight period.

We are gaining the impression that there were several circumstances contributing to this fact. First, there was the punctual fulfillment by the crew of the work and rest regimen which they helped to draw up. There was wider crew participation than has previously been the case in the planning of future operations. And there was the quite successful adaptation by the members of the crew to the specific, unusual conditions of living and working in weightlessness.

It would perhaps be relevant to note here that, as distinct from certain previous observations, the initial adaptation to weightlessness was free of unpleasant sensations except for one, the sensing of a certain flow of blood to the head. And this adaptation was completed in the first 2, or apparently no more than 3, days. It is quite possible that this may be explained first of all, by certain individual physiological features of the men and, secondly, by all the training exercises which they carried out during the preflight period.

Periodically, throughout the flight, detailed medical research was carried out on specially allocated days. This research was carried out both when the cosmonauts were in a state of rest and when various stressing tests were being carried out. The cosmonauts were exceptionally sensible and creative in fulfilling that great and not always pleasant work, involving such tasks as taking samples of their own blood and carrying out biochemical research. Also, the medical research program was complemented by certain new aspects which were not in previous flights. Thus, for example, they carried out so-called dynamic electrocardiography, that is continuous recording of an electrocardiogram for 24 hours, which has considerably broadened our ideas of the reactions of the human body and the cardiovascular system to the effect of flight factors at different periods of flight. A great deal of other research was also carried out, in particular, research into such parameters as gustatory sensitivity, hearing thresholds and many others.

As they became accustomed to weightlessness, a new coordination of motion... became established.

We knew that the prolonged effect of weightlessness could have an adverse effect on a whole series of systems of the human body: primarily the cardiovascular system, the bone joints, the metabolism and the state of the blood.

Electrocardiograph research, conducted in detail during the flight, did not show any deviations from the norm throughout the flight. Functional tests at dosed physical stresses and also with the application of negative pressure to the lower part of the body also showed that these reactions were adequate and, most important, showed that no negative dynamic was noted. With the passage of time, the responses to these tests did not worsen.

The objective signs of redistribution of the blood, revealed by rheography, were observed with particular acuity during the initial phase of the flight. It was possible to register the refilling of the vessels in the head and in the upper part of the body, and the depletion of the blood in the lower part of the body, particularly the legs. These readings leveled out somewhat in the middle part of the flight, but, all the same, continued to the end, although, as the cosmonauts will relate, this did not cause them any unpleasant subjective sensations.

As they became accustomed to weightlessness, a new coordination of motion naturally became established. This provided enough efficiency for the fulfillment of all necessary working operations. An analysis of the television images obtained on Earth was conducted, and indicated that comparatively soon, at least by the end of the first month, these movements were being carried out rapidly, precisely and with confidence.

With the passage of time, a reduction in the volume of the lower limbs was registered, in particular the crus which, as is known, indicates the loss of a certain part of the fluid, components of the lower limbs and part of the muscle tissue.

Thanks to the use of the measurement mass of the body (inasmuch as weight in weightlessness can be measured), it was possible to obtain an impression of the dynamics of the weight of the cosmonauts and, in a certain way, to regulate this parameter by alterations in the quantity of food and water intake.

Naturally, the study of the state of the blood was particularly intriguing for us. The point here is that the average duration of life of the erythrocytes, i.e. the red cells in human blood, is 120 days. In the course of 120 days, our red blood corpuscles are completely changed.

From experiments conducted previously during space flights, it was also known that in the course of a space flight of shorter duration, there was a reduction in the number of these cells, which are very important to us. They are the carriers of oxygen in our organism, and in the tissues. Therefore, research into the blood system was of great interest and great importance. I can report that the control samples which the cosmonauts took by themselves during the flight and which were delivered to Earth and subjected to appropriate analysis here, showed only a very moderate reduction in the number of erythrocytes and hemoglobin—considerably less than the values which we had obtained earlier even in shorter flights.

The specialists who have analyzed this data believe that this obviously positive result can be connected with the fact that the cosmonauts did, apparently, lose less of their circulatory blood than those who had flown earlier. This was partially made possible by the fact that they maintained the consumption of water at a sufficiently satisfactory level and fulfilled an adequate volume of physical stresses, which assisted in the preservation of the volume of the erythrocytic mass of the blood.

The complex of physical exercises was carried out by them practically every day during the whole of this prolonged flight, for approximately 2 hours each day. To give you an idea of the volume of work carried out during this time, I might say that they were running at a speed of eight to nine kilometers per hour. If we were to transpose this into useful work, so to speak, then the energy spent would be equal to climbing a skyscraper over 200 stories high. For you and I, who have never gone into space, it is difficult to imagine the efforts which one has to expand in order to execute such intense work in a weightless environment. However, the crew brilliantly fulfilled this task.

The cosmonauts displayed a great sense of observation. They have collected a great deal of interesting and important data, the further analysis of which, together with the proposals they have made, will undoubtedly serve to improve the methods of maintaining physiological well-being in future prolonged space flights.

In general, I would say that it was precisely this scrupulous adherence of the crew to the daily schedule prevailing on board, with a sufficiently elastic, variable planning of extensive and intense work, together with very meticulous and competent fulfillment of the corresponding prophylactic and sanitary-hygienic measures, which helped the crew preserve good health, a high working ability and an even mood during the whole marathon flight.

The cosmonauts themselves have, in the main, evaluated their feelings and general state as good. Let us note that the personnel at ground control and the psychologists were attaching great importance to the optimization of communications between the ground and the space station, and to the carrying-out of measures which were termed as "psychological support." Special issues of newspapers and videotapes with family chronicles of events, concerts and the like were taken on board. Periodic radio conversations with family members, friends, interesting interlocutors and various performers were organized. All this undoubtedly contributed to maintaining the high spirits of the crew.

Finally, as there are unavoidable difficulties with provisions, a certain variety was provided by various new kinds of produce, fresh vegetables and fruit, which were brought by visiting expeditions and transport craft.

...from the medical point of view, the principal results of this flight are that the cosmonauts underwent it well.

After touchdown the cosmonauts' reactions connected with the changeover to life in Earthly conditions, to life in conditions of gravity, were less pronounced than was the case during previous, less prolonged flights. Thus, with the apparent increase in the weight of their own bodies and all the objects they were faced with when back on earth, subsequent disproportion of movement and difficulties with coordination were observed only on the day when the flight had ended. Later on, the cosmonauts did not experience any kind of subjective difficulties or problems. On the first day after the flight, loss of weight was 2.3 kilograms in the commander of the crew, and 3.9 kilograms in the flight engineer. Restitution of weight in the commander was completed on the third day, but the weight of the flight engineer took longer to be restored, 12 days.

Blood changes were manifested only in a very insignificant lowering of the number of erythrocytes and hemoglobin, with an inclination toward the diminution of the size of these cells; but the changes which took place were without any practical significance. The number of white corpuscles or leucocytes increased somewhat. The content and level of discharge of steroid hormones rose somewhat, which is an indication of a tension reaction, quite natural in a situation of this kind. Stability with regard to orthostatic tolerance and to physical stresses diminished, but to a relatively smaller degree than could be registered after flights of shorter duration.

Research carried out with the help of ultrasonic electrocardiographs did not reveal any pathological changes in the condition of the heart, even though the quantity of blood which the heart pumps out with every beat had diminished, but to a lower degree than we had previously recorded.

The greatest attention, against the background of such a favorable condition of the cosmonauts, was drawn to changes in the sphere of motion. They manifested themselves, first of all, in symptoms of atrophy and atonicity, and also in a heightened reflex response to irritation of the muscles. The perimeter of the hip of the commander of the crew diminished by about 1.5 centimeters and the hip of the flight engineer by 4 centimeters. These changes, we suppose, were the result of adapting to conditions of weightlessness.

From the first day since the completion of the flight, the cosmonauts have been active. Their locomotive regimen has gradually increased, and I think that the chief problem is to somewhat restrain that motor activity. In order to ease their adaptation to conditions of life in Earth's gravity, we have been carrying out the appropriate measures: healing massage, walks of variable length, swimming in the pool, and so on. And the cosmonauts did not need any medicines. The so-called "severe period" of adaptation to Earth's conditions, or "readaptation", seems to have taken no more than 3 to 4 days which, from our point of view, is an extremely good result.

Briefly, one can say that from the medical point of view, the principal results of this flight are that the cosmonauts underwent it well, maintained a good working capacity, successfully fulfilled their whole program, and underwent their return to Earth conditions well.

UNEXPECTED PSYCHOLOGICAL BENEFIT ON SALYUT 6

The cosmonauts, isolated from normal life on Earth and surrounded by lifeless space, manifested a particular attachment to any organisms that grew aboard the station. This was confirmed by cosmonauts from previous missions, who lovingly tended onion stems, and fish in the aquarium, claiming that biological experiments were a pleasure rather than a work assignment. In fact it offered them a kind of emotional relaxation, and they were always ready to return to the care of their nurslings even during their "free time." On Salyut 4, Grechko especially enjoyed watching the green petals of peas growing in the "Oazis" device.

On Salyut 6, Romanenko and Grechko experimented with tadpole raising and derived much pleasure from watching the tadpoles pirouette around air bubbles in the containers. They, like the other cosmonauts of previous flights, stressed the psychological advantage of having living creatures around them.

LIFE FOR THE MOON

How the Moon can be made habitable is the subject of a brief, unattributed article in the Russian magazine, *Aviatsiya i Kosmonavtika*. Soviet scientists do not know all the answers, but certain ideas of how a normal biosphere can be implanted on the surface of the Moon are already looming.

The presence of a magnetic field is a must for any life on any planet. Radiation conditions must be created that would not harm any living organisms, hence the atmosphere must possess certain protective characteristics, above all it must have a higher molecular weight, since the gravitational potential of the Moon is six times smaller than that on Earth. A heavy atmosphere will not easily dissipate into surrounding space, and its "refilling" would become technologically feasible. It is not sure that such an atmosphere can be created, i.e., that people would be able to move around without spacesuits. Nevertheless, even if people had to wear some light-weight breathing apparatus, the atmosphere would offer protection from galactic radiation and solar flares.

Some specific lunar flora eventually would contribute to the formation of a biosphere and thus allow humankind to make the Moon the first step toward populating the universe.

POSSIBILITY OF UTILIZING HIGHER PLANTS IN A LIFE-SUPPORT SYSTEM ON THE MOON

The possibility is examined for the repeated interruption of plant vegetation by long-term darkness corresponding to the "night" on the Moon in the Russian journal, *Kosmicheskaya Biologiya*. This may prove useful for incorporating a unit of higher plants into a life-support system on lunar bases in the event of using the sun as an illumination source. To this end, cultures of vegetables (Bordeaux beets, Petrovskaya turnips, Chantanet carrots, dill, and Virovskiy white radish) and wheat (Sonora variety) were cultivated during a "lunar" photoperiod, i.e., the light and dark periods equal 15 terrestrial days. The tests convincingly showed the basic possibility of obtaining traditional plant products under conditions of the "lunar" photoperiod. It was also proven possible to use grain from wheat grown during the "lunar" photoperiod as seed material for further cultivation of these plants during this photoperiod.

"OAZIS" EXPERIMENT WITH PROTEIN-PRODUCING HYDROGEN BACTERIA

The Oazis biological system is described by Vadim Vital'yevich Kotelev, Doctor of biological sciences, Chief of the Microbiology Dept., Moldavian AS, in charge of the Oazis project, in an interview by T. I. Malinovskiy.

The system was devised to study the processes of regeneration in an enclosed limited environment, which is important for long-term spaceflights. The second model, the Oazis-2, was aboard Soyuz-13 (18-26 December 1973; Klimuk and Lebedev).

Oazis was designed for the cultivation of certain types of microorganisms. It consists of two cylinders serving as fermentors filled with liquid and gas. One cylinder contains hydrogen-oxidizing bacteria, which uses mainly hydrogen obtained from water electrolysis for their growth. The second cylinder carries bacteria capable of decomposing urea; they absorb oxygen from the first cylinder and give off carbon dioxide, which is used by hydrogen-oxidizing bacteria for protein synthesis. Hence, the Oazis system regenerates air and water and produces biomass.

The most promising method of protein synthesis is the use of microorganisms. Microbes increase their mass 500 times faster than plants and 1500-2000 times faster than animals. One 100-m^3 cultivator with microorganisms can produce in three days as much protein as two hectares of wheat, irrespective of the weather. Among microorganisms, the most promising are hydrogen-oxidizing bacteria. They feed exclusively on inorganic products and can directly convert hydrogen energy into proteins.

Studies of the behavior and properties of hydrogen-oxidizing bacteria, i.e., their biochemistry, physiology and cultivation methods, have been conducted for several years. The greatest achievement has been the production of a new strain of hydrogen-

oxidizing bacteria, the thermophylic variety, growing at 50-55° C: they produce two and one half times more protein than other strains.

The property of hydrogen bacteria to capture carbon dioxide could also be used for air purification. In contrast to other, e.g. chemical, CO_2 scrubbers, microbes can operate endlessly and still produce protein.

Triple Growth in 0g

Experiments with hydrogen bacteria in space has opened additional vistas; in space, they grow three times faster than on Earth, probably due to weightlessness.

The thermophylic strain of hydrogen bacteria was obtained after long experiments of their cultivation on Moldavian mud soils. For many months, in a hydrogen medium at 55° C containing oxygen and CO_2 as well, the microorganism-rich soils had been studied. Expectations proved correct, and the thermophylic strain was finally obtained.

EGGS IN SPACE

A Soviet spacecraft, scheduled for launching in early 1980, will carry an experiment in which Japanese quail eggs will be incubated in O-g conditions. The spacecraft will return to Earth just before the eggs hatch. In discussing the experiment with a correspondent from *Literaturnaya Gazeta*, Professor Nikolay Gurovskiy noted that the Japanese quail may be used in complete, closed ecological systems for future spacecraft. Gurovskiy denied reports that Soviet scientists were also planning the birth of a child in outer space.

LIFE SUPPORT SYSTEMS ABOARD SALYUT 6:

WATER REGENERATION

In a recent report, design engineer Ye. Dunin discusses some methods of water regeneration under spaceflight conditions and describes the Salyut-6 water-regeneration system.

The refrigerating-drying units collect the condensate of atmospheric moisture and feed it into receiver-separators of moisture from the gaseous phase. The gaseous products are returned, and the moisture is pumped into columns with sorbents (ion-exchange resins) and filters (activated carbon), where it is purified of foreign matter and solid particles. Further, the water is passed through mineral filters of dolomite crumbs, artificial silicates, and salt pellets. Concentrated salt solutions are introduced according to the individual tastes of the cosmonauts.

The water, now potable, is pumped into a tank with two cavities—for water and air—separated by a special diaphragm, which bends and forces the air out as the water is pumped in. The water can be served by increasing the pressure in the air cavity and, if desirable, can be heated. To avoid accidents, special sensors produce a warning signal if the water is not fit to drink. In that case, it can be removed automatically into special tanks.

Salyut-6 as Soyuz-27 approaches.

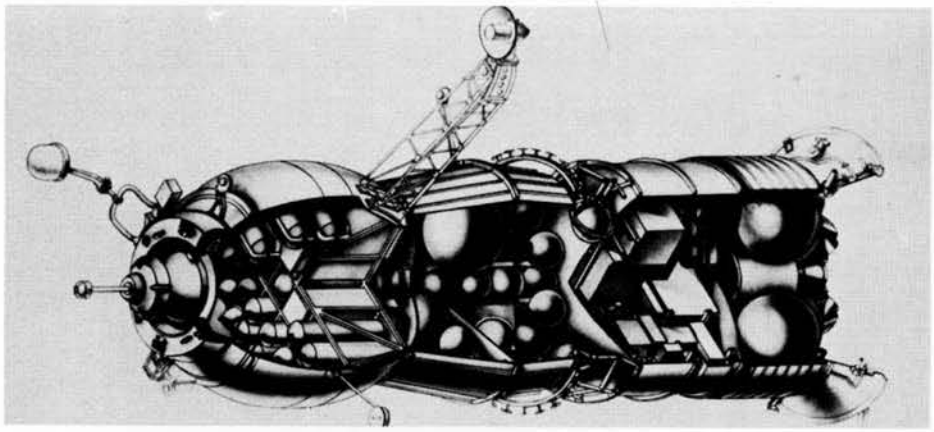
CIRCADIAN RHYTHMS ON SALYUT-6

It has already been determined that the human body cannot adapt itself to any other sleep/wakefulness regimen but the usual 24-hour rhythm. The experimental regimen of "migrating" hours, when every day the rhythm was shifted by one-half hour, as was tried aboard Salyut-4 on Klimuk and Sevast'yanov, proved to be an obstacle in the normal performance of the two cosmonauts; Sevast'yanov said this regimen was a real scourge during their mission. The regimen was also tried experimentally for 30 and 50 days on Earth, aboard a Salyut mockup, but without success.

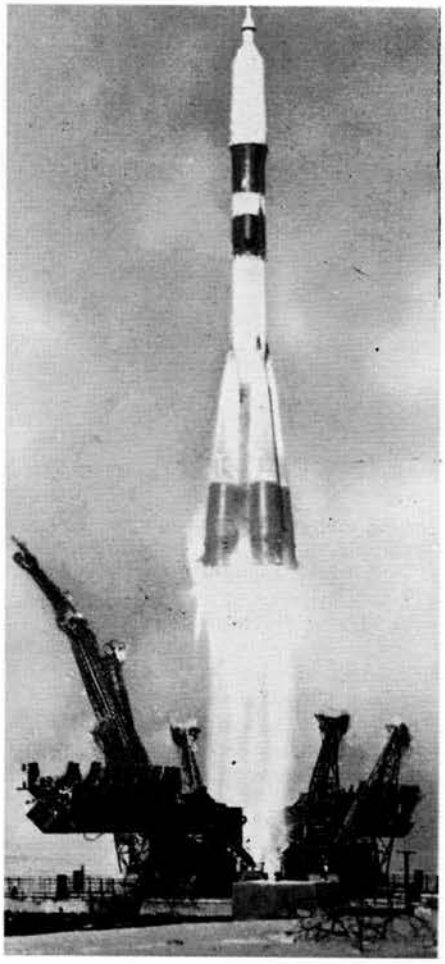
B.S. Alyakrinskiy, a biorhythmologist, noticed that desynchronization of the circadian rhythm was an inherent component of stress states observed in test subjects. Grechko, who had been subjected to adverse effects of desynchronization and "migrating" hours during his flight aboard Salyut-4 in Jan.-Feb. 1975, praised the advantages of the normal circadian-rhythm regimen introduced aboard Salyut-6. During his and Romanenko's mission, the rest period was set at nine hours, to last from 2300 to 0800 hours, Moscow time. Romanenko and Grechko slept well, usually for 7½-8 hours; 1½-2 hours before sleep, they did not engage in any strenuous activities.

The program of daily routines worked out for the Salyut-6 crews envisaged an alternation of mental and physical work and of monotonous and emotionally creative assignments. All these activities were designed to intermingle further with physical exercises, personal hygiene, and meal times.

As a rule, the daily time quota for personal hygiene was set at 30-40 minutes; for physical exercises, 90 minutes twice a day, in the morning and in the evening, either on the bicycle ergometer or on the complex trainer, depending on the individual preference. The week was divided into six workdays and one rest day. During the rest hours, Romanenko and Grechko, to remain in high spirits, listened to the voices of their relatives, song recitals, and various debates.



Above: Internal detail of the Progress tanker/transport used to refuel and resupply Salyut-6. The forward orbital module contains bulk cargo storage cylinders, while the earlier Soyuz descent module has been replaced totally with a unit containing propellant for refueling operations.



Above right: The Progress-1 at takeoff last January.

Below: A Soviet cartoon shows freight from Progress-1 being loaded onto Salyut-6. (Actual spacecraft docked at opposite ends!)

SOVIET SPACE STATION ACTIVITIES, 1979

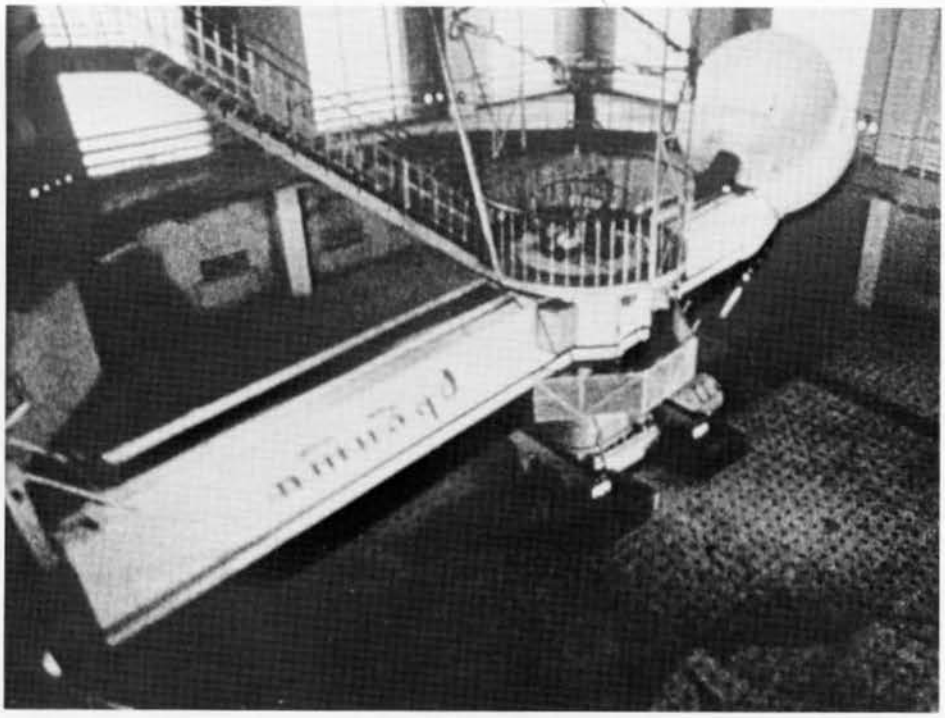
Western observers expect the USSR to resume cosmonaut visits to the Salyut-6 space station in February, with long expeditions of at least seven months duration. At the end of that time, one or both of the cosmonauts may be rotated home and replaced by fresh crew members. In parallel with the marathon expeditions and periodic "Progress" freighter resupply missions, short visits by additional non-Soviet 'guest cosmonauts' and by Soviet specialists (such as doctors, geologists, and astronomers) are anticipated. Since March 1978, cosmonauts from Bulgaria, Cuba, Hungary, Mongolia, and Romania have been in training; they were assigned to specific flight crews in November and the first should fly as early as April.

Improved versions of the Soyuz spacecraft, perhaps carrying four or five cosmonauts, may also appear, but immediate flights of the much rumored "Soviet space shuttle" are no longer expected by most observers.

Two features of the Salyut-6 which are irreplaceable and seem to have the shortest lifetime are the orbital adjustment rocket engines and the solar panels. This problem may be alleviated by the launching of another Salyut to dock at the aft end of Salyut-6, forming a permanent double station capable of hosting four to six cosmonauts. The new module would have its own orbital adjustment rockets and several solar panels to supplement the degrading panels on the original module.

Unpiloted Soyuz ships with their "orbital modules" specially outfitted with unique laboratory or observatory equipment will also be launched, according to Soviet sources. Following a month-long program, the unpiloted Soyuz would return to Earth with special samples. Two possible candidates for such missions are the Orion UV telescope and the "Oazis" biological laboratory.

In addition to Salyut-6, other Salyuts may be launched on specialized missions such as military reconnaissance. In other words, the USSR may have two (or more) independent space stations in operation this year.



Three test engineers lived in the capsule at the end of the centrifuge arm for several weeks to study the effects of coriolis forces on the crew in spinning space stations. Project was called "Orbit."

RUSSIAN PLANS FOR SPACE STATIONS IN THE NEXT 10 YEARS

Academician B. N. Petrov reports on the future development of Russian orbital station.

Next Generation of Long-term, Large-crew Stations

Scientists are already busy designing larger stations, for a crew of 12-20, with a lifespan of up to 10 years, which would replace the present small stations. This will happen as soon as it is clear that the present stations have exhausted all their possibilities. There is no answer to the question of how often such larger stations would exchange crews. Improved methods of training and prophylaxis have already extended the period of time in space to many weeks, without any harm to health.

Rotating Stations

It is to be expected that crews will be exchanged rather frequently, until such stations have artificial gravity. This problem, however, remains unsolved: artificial gravity can be created only by rotating the station; any rapid rotation would incapacitate the crew, while slow rotation would require a much larger station (since with a slower rotation gravity can be created only far away from the axis of rotation). This seems to be one possible form of the future orbital station: large size and slow rotation, thus forming an artificial gravity where, in principle, people could live and work for many months. Rotation, even a slow one, would interfere with observation programs and would be a handicap in docking. Hence, such stations would have to be made with a nonrotating module. Under such conditions, it could be more economical to exchange the crew more often.

COSMONAUT FEOKTISTOV ON FUTURE OF ORBITAL STATIONS

Orbital stations will be developed above all as multipurpose scientific laboratories. Medical and biological experiments, making it possible to ascertain how long humans can live and work in space without harming their health, will continue on board the stations. As before, great significance will also be attached to inhabited stations for the study of natural resources—the highly effective nature of this work has already been proven by practice. It is no accident that in the past 2 years the number of organizations using space information in the interests of the national economy has doubled.

The orbital stations' unique potential will also be used for extra-atmospheric astronomical observations and for technological experiments, making it possible to obtain materials that under Earth conditions cannot be obtained at all or cost too much. In a word, in fulfilling national economic tasks, the orbital stations will also serve to seek out the most effective systems for developing methods for research and the design of scientific instruments and equipment.

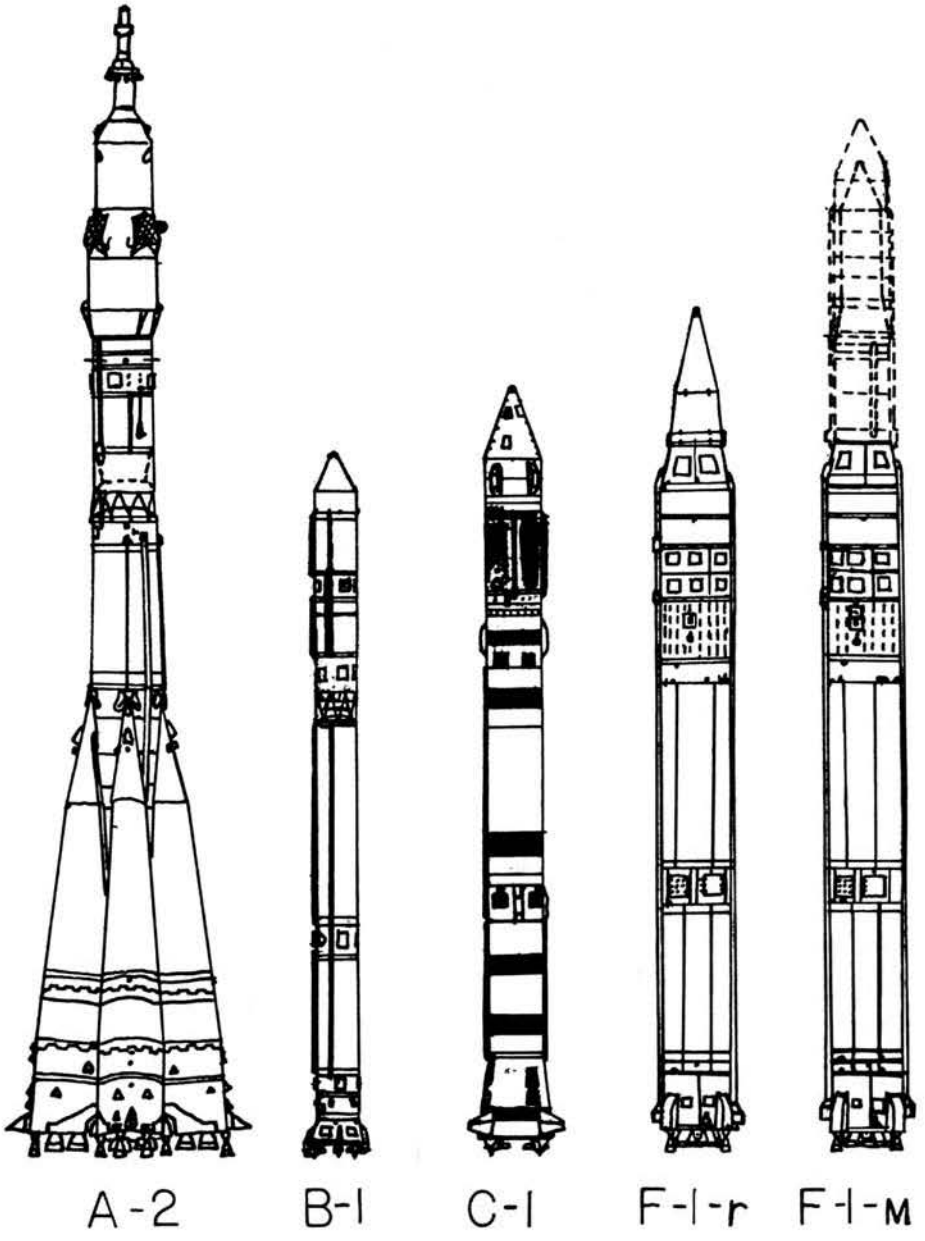
The problem of the optimal distribution of duties between human and machine is becoming increasingly topical with the increase in the duration of space flights. There is much that is controversial here. Some specialists believe that space is above all a sphere for the operation of machines. There is reason in their arguments; for instance, astrophysical observations, even in the immediate future, could be carried out with the aid of preprogrammed apparatus. Research into natural resources is also perfectly within the powers of modern radio or program controlled television equipment. But it is still people who have to elaborate the methods for this research and correlate the degree to which the information obtained by machine corresponds with the real picture.

In my view, very broad prospects are opened up for inhabited stations if they are examined above all as the basis for industrial construction in space. Not everyone shares this view, but I personally believe that within the next few decades the development of technology will make it possible to actually set the task of creating powerplants in space. These installations, gigantic by present standards and covering tens of square kilometers, will trap solar energy and convey it in transformed form for use on Earth. With time, technological experiments will lead to the creation of real industrial enterprises in orbit.

And this means that millions of tons of diverse equipment will have to be put into space and enormous and complex structures will have to be assembled there. Such work can scarcely be fully automated. Large collectives of people will control the equipment and carry out installation work. Of course, this will not happen rapidly and many people may relegate such forecasts to the realm of fantasy. But after all, 17 years ago Yuriy Gagarin's flight also seemed a fantastic achievement.

SPACE POWER STATIONS

Commenting on the projects of tapping the resources of space for the production of electricity, cosmonaut



Soviet space launch booster family which placed 1000 tons of payload and hardware into orbit in 1977 in 100 successful launches.

U.S. label	*Derivation*	*Launch #*	*Payload*
A-2	*Sapwood (SS-6) ICBM*	*54*	*7000 Kg.*
B	*Sandel (SS-4) IRBM*	*2*	*450 Kg.*
C	*Skean (SS-5) IRBM*	*28*	*1000 Kg.*
F	*Scarp (SS-9) ICBM*	*11*	*4500 Kg.*

(ICBM=Intercontinental Ballistic Missile; IRBM=Intermediate Range Ballistic Missile)

Feoktistov believes that the concept of space power stations is not unrealistic and may become a reality within several decades. The idea of transforming solar energy into a form that can be transmitted to Earth would require millions of tons of materials and equipment to be moved into space and hundreds of people to maintain such a system, since it cannot be fully automated.

DEVELOPMENT PROSPECTS OF SPACE INDUSTRIAL FACILITIES, NUCLEAR AND SOLAR POWER SOURCES SURVEYED

Professor O. M. Belotserkovski, director of the Moscow Physical and Technical Institute, corresponding member of the USSR Academy of Sciences, Lenin Prize laureate, was quoted in the Oct. 21 issue of *Evening Leningrad* as follows:

"What will be the next step into space? In the first place, basic research leading to the appearance of new, still unknown and unexpected practical applications of cosmonautics will be further developed. Whereas flights to the Moon and planets somewhat overshadowed other aspects of space research during the first decade of the space era, problems of studying the distant cosmos by such methods as satellite astronomy are now coming to the fore. These prospects are connected primarily with putting large telescopes in orbit.

"Trends in the development of contemporary cosmonautics indicate that scientific-and-production complexes will be built in orbit and that metallurgical, machine-building and chemical plants may be created beyond the limits of the Earth soon, possibly within the next decade. Production facilities, whose organization in Earth conditions is altogether impossible, will be the first to appear in space, of course.

"The future of space flights depends also on the creation of new rocket engines utilizing nuclear energy. The search for still other sources of energy is in progress. It is known, for example, that energy gradients on the order of several thousand volts exist in the Earth's magnetosphere. The "solar wind" contains still greater reserves of energy. Its power could impart a speed to a spacecraft on the same order as the speed of the "solar wind" itself. Then the problem of the duration of a flight also would become considerably less acute than it is at present."

Heading For Unknown Worlds

An Interview with Konstantin Feoktistov by TASS, the Soviet News Agency

Q: *What do you think a twenty-first century spaceship designed for passenger transport within the solar system will look like?*

A: I think it will be an electrical jet craft with a powerful nuclear plant that will contain a reactor and converters of heat into electrical energy—turbine generators or thermal converters. The electrical jet engines will be of either the ion or plasma type, in which a stream of electrically charged particles accelerated in the propelling device provides the necessary thrust. To keep the capacity of the on-board power unit within the limits of our technological possibilities, the engine thrust must be very small, with the result that the spaceship will accelerate very slowly, taking several months to get away from the Earth and the same time to decelerate near the planet it is headed for.

Another distinguishing feature of this spaceship will be gigantic surfaces for the dissipation of the excessive heat developed by the nuclear unit. Hence, the ship will look like a sharp-pointed triangle. At its apex will be the reactor, the radiator will be the wedge, and a considerable distance away will be the living quarters housing the instruments, control panels and crew cabins. In front of the radiator will be a shield to guard against radiation. And, finally, somewhere nearby will be a descent module for landing on the planet of destination, since the craft I am talking about will serve only for transport between planets. For landing, we need other devices of the Soyuz or Apollo type.

This spaceship is also capable of carrying research probes, putting them into planetary orbit and also landing them. You might ask why this has to be done with probes. Because it is still hard to imagine a person landing on, say, Venus.

Q: *So people and machines will participate on an equal basis in further space exploration?*

A: I would say so. For carrying out regular routine tasks—for example, collecting meteorological data, retransmitting it, taking pictures of the Earth's surface—it is simpler to use automatic devices. They can also easily land on a distant planet and do research on, say, Venus or Saturn. These tasks are easily algorithmed and programmed. People should be sent only on particularly complicated missions, for instance, laboratory research, observation of stars or the Earth in line with a selected program and to create laboratories and workshops in orbit. I think those types of projects will require the presence of human beings.

...it is simpler to use automatic devices...People should be sent only on particularly complicated missions...

Q: *What aspect of cosmonautics are you interested in today?*

A: I've been thinking more and more about whether space research can be justified economically. Many people believe that there are too many unsolved problems here on Earth to spend huge sums on space research that, they claim, does not pay off. Well, on reflection, I've come to the conclusion that we can already prove that our activity does pay off.

First, some aspects of space research work are already economically profitable. I mean the economic value of meteorological satellites, retransmission devices, TV and telegraph communication via sputniks.

Secondly, apparatus for observing the Earth from space in the interest of the economy makes better economic operation possible. For example, the two expeditions to our orbital station Salyut 4, according to the estimate of experts, saved us the economic equivalent of 50 to 70 million rubles.

Thirdly, space facilities make it possible to acquire fundamental knowledge—I mean information which cannot be obtained from the Earth—namely, about lunar soil, the appearance of Venus, characteristics of planets, electromagnetic radiation that does not penetrate the Earth's atmosphere. Thanks to space engineering, contemporary astrophysics and planetology are making considerable headway. All this helps to accumulate fundamental knowledge. And, as history shows, a purely quantitative accumulation brings about, in the long run, a qualitative explosion, a revolution in one or another field of our knowledge which, without question, will eventually turn out to be economically valuable.

And finally, we are preparing a kind of reserve for the future. Let me take two concrete examples: the creation of economically rational orbital production and preparation for the gradual habitation of outer space.

What do we need orbiting plants for? Modern pharmaceutical and metallurgical industries need superpure compounds, metals, crystals, vaccines, and the like. Here on Earth the production of some of these substances is technologically infeasible because of the Earth's gravity; in outer space the conditions for it are ideal. For instance, it is possible to purify medical preparations with the most insignificant electrostatic forces. I think that by the mid-eighties we'll be able to provide profitable and regular production facilities in the Earth's orbit.

As far as cosmic settlements are

concerned, I think these will probably be built in the future, but I do not regard outer space as an escape from the problems that humanity has not yet solved. I believe these must be solved here on Earth, although I do not rule out the possibility that in time the cosmos may become the second home of human beings. There are even a number of ideas on how to do it. One of them comes from an American physicist, Professor Gerard O'Neill of Princeton University, who is not an expert in the field of space but, as a physicist, has ideas that are both serious and imaginative about the creation of space settlements.

Gerard O'Neill suggests that artificial gravity be used in these space settlements and I, as an engineer, know that this can be done with modern technology. But it would be very expensive at the present time. Current studies and experiments are aimed at making these projects substantially cheaper and more feasible.

Another example. Academician Nikolai Semenov proposes to saturate the Martian atmosphere with sufficient oxygen so that people can freely settle on this planet. Of course, this project sounds fantastic now, but only a while ago the thought of a person walking in space seemed just as absurd.

Q: *Can we already create artificial gravity in spaceships?*

A: This is quite feasible, although I, personally, hope that people will adapt to weightlessness without injury to their health. But this is as yet only an unsubstantiated hope. Therefore, we now have to deal with a spacecraft provided with artificial gravity. I think additional difficulties are likely to occur in solving this problem. A very unpleasant phenomenon will probably be the so-called coriolis acceleration. For the near future the dimensions of spacecraft will remain comparatively small, and their rotation radius negligible. To achieve an artificial force of gravity equal to that of terrestrial gravity, a comparatively great rotational speed is needed. This acceleration has its bad effect. A person moving inside the ship will have the sensation of staggering. Similar experiments have been done here on Earth, and they tell us that people adjust to such conditions much less readily than to weightlessness. Thus, adaptation to living conditions in a rotary environment will pose its own specific problems, but it is quite realistic to assume that we can solve them technically.

Spaceflight monument in Starry Town, home of the cosmonaut detachment.

COSMONAUT FEOKTISTOV COMMENTS ON G. O'NEILL'S "SPACE COLONIZATION"

Contrary to Dr. O'Neill's belief that space settlements will settle the territorial controversy and each settlement could become completely independent and even isolated if it wished to do so, Dr. Feoktistov says that the structure's mass may become a problem and cause for animosity. Technical difficulties and economic cost are underestimated, and Dr. O'Neill's time estimation is too optimistic. Equipment delivery from Earth would be 2-3 times costlier than delivery from the Moon. In the case of material delivery from the Moon, the development of a metallurgical plant, building material industry, et al. on the Moon would be necessary. Methods of material delivery from the Moon are either doubtful from a technical viewpoint or too costly. Humanity must solve problems of nutrition, energy, and population growth on Earth before it has a chance to build space settlements. The creation of space settlements is a realistic and feasible project, but it will take a longer time. Probably, it is more expedient to start with shorter distances such as building a permanent station in a twenty-four hour geostationary orbit or even closer.

THE COSMOS 954 INCIDENT AND INTERNATIONAL SPACE LAW

by ALCESTIS OBERG

Last January, the Russian nuclear-powered spacecraft, Cosmos 954, crashed into the arctic terrain of northern Canada. The incident raised serious legal and diplomatic questions in the international community. Although the fragments of this craft fell on isolated territory and there was no loss of human life, there was potentially dangerous radioactive debris scattered over a large area. In an article entitled "The Cosmos 954 Incident and the Operation of International Space Law" in the January 1979 issue of the *American Bar Association Journal*, two international law experts, the Hon. Edward R. Finch, Jr. and Dr. Amanda Moore concluded that the countries involved—Canada, the U.S. and the U.S.S.R.—handled the incident in a calm and cooperative manner which will serve as a kind of precedent for any future incidents of this nature. Finch is currently chairman of the Aerospace Law Committee, International Law Section of the American Bar Association. Moore is chairman of the Subcommittee on Treaty Interpretation of the Aerospace Law Committee. Their views are, of course, their own and do not necessarily represent the views of the U.S. government, the American Bar Association or any official organization.

In an *L-5 News* interview on Dec. 11, these two law experts stressed the good will involved in the resolution of the difficulties caused by the crash of the Cosmos 954. Prior to the crash, the U.S.S.R. cooperated in efforts to track and to predict the fall of the spacecraft, but predictions of this nature are very difficult.

After the demise of Cosmos 954, the Soviet Union agreed to their liability in this case. Since Canada has a year to fix the exact amount of liability—damage to the land on which the satellite fell, cost of search and recovery missions, etc.—the final amount is not yet known, but is estimated at 12 million dollars, not including the 2.7 million dollars the U.S. contributed by way of nuclear safety teams, sensing equipment and the like. The claim at this time, of course, remains to be settled.

The only area in which the Soviet Union did not cooperate was in giving clear information on the nature of the nuclear reactor aboard the spacecraft.

Also, the U.S.S.R. has not requested the return of the Cosmos 954 fragments, which are still in storage in Canada.

There were two international agreements cited as legal documents in this case. One was the 1972 *Convention on International Liability for Damage Caused by Space Objects*, which states that the country which launched a vehicle would be liable for damage caused by the vehicle's debris; the Convention also makes provisions by which a formal request for damages can be made and so forth. The other legal document is the 1968 *Rescue and Return Agreement*, which states that the launching nation must offer assistance in helping to eliminate possible consequences from the falling fragments of a satellite (in this case, radioactive fragments), and help in evacuation of these fragments. The Soviets offered to assist in the recovery of the Cosmos fragments, but the Canadians declined the offer of help.

...the U.S....would be required to notify a foreign power if Skylab is expected to fall within the boundaries of that country,...would be required to assist in recovery operations,... and would be liable for damage caused by the crashing spacecraft.

Because the device aboard the Cosmos 954 was nuclear, however, serious questions were raised regarding the adequacy of current notification and registration requirements under the 1975 *Convention on the Registration of Objects Launched into Outer Space*. Canada supports a more stringent notification requirement in spacecraft carrying nuclear power devices, but such a suggestion has not been welcomed by the Russians. A Scientific and Technical Subcommittee of the COPUOS (Committee on the Peaceful Use of Outer Space) at the U.N. is studying this and other questions. Should reactors be allowed on spacecraft in low Earth orbit? Should notification be made of impending launches of nuclear-powered spacecraft to the international community? Should radioisotope thermoelectric generators (used by the U.S.) be treated and regulated in a different manner than other nuclear reactors? Should the launching country be required to notify the U.N. of malfunctions on a nuclear-powered spacecraft?

The problems related to nuclear power are being investigated by this Scientific and Technical Subcommittee, which is made up of a working group of experts, including one Soviet representative. The Legal Subcommittee of the COPUOS may consider the legal aspects of this problem under its agenda item "Other Matters". But more concrete measures in the legal area are not expected until 1980.

To date, the need for formal treaty obligations, or for "mandating" cooperation, remains to be seen. The U.S. expressed satisfaction at Soviet cooperation in the Cosmos 954 incident, and the Soviet Union and Canada seem to be making progress toward an amicable settlement in the area of liabilities.

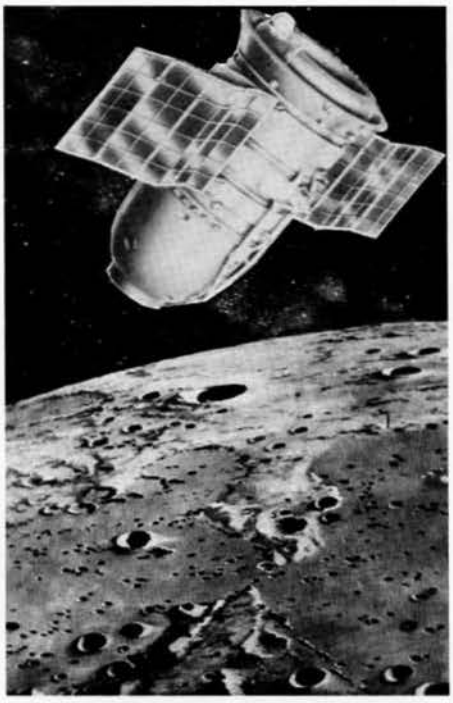
The upshot of the Cosmos 954 incident is that, first of all, it established more fully those procedures by which the problem of debris falling from space onto foreign soil will be handled in the future; and secondly, it may lead to wider reporting requirements of the activities of spacecraft, especially those with nuclear power.

The Cosmos 954 incident may also serve as a precedent for procedures in handling the impending demise of Skylab. The U.S., like the Soviet Union, would be required to notify a foreign power if Skylab is expected to fall within the boundries of that country; the U.S. would be required to assist in recovery operations; and the U.S. would be liable for damage caused by the crashing spacecraft. There are some differences between Skylab and the Cosmos craft: for one, Skylab is not nuclear powered, and secondly, Skylab is about 30 times larger than Cosmos 954.

All in all, Finch and Moore summed up the spirit in which this potentially touchy situation was handled as one of good will and cooperation. So far, the countries involved worked very well on an informal basis, and the upcoming liability settlement will go further in proving or disproving the continued efficacy of international space law.

Thoughts On The Tenth Anniversary Of The First Moon Flight

by JAMES OBERG



Moon flyby by Zond-Soyuz spacecraft, 1968. Several unpiloted tests were made, but Apollo-8 prompted the USSR to cancel a piloted Moon shot.

Ten years ago, Apollo-8 circled the Moon while astronauts sent greetings to Earth and read from the Book of Genesis. Now that the American lunar triumphs have become enshrined in our memories and petrified in our history books, a sense of inevitability and unavoidability clings to these events. They were **bound** to happen, it **had** to turn out that way - or so it looks, now, in hindsight.

A nagging doubt also remains to gnaw at our recollections: what happend, after all, to the Russians? Throughout the 1960s, the thrill of the Moscow-Washington "space race" added spice to our lives. Then we reached the Moon, while from Moscow came only assertions that the Soviets had never really wanted to compete (if they had wanted to, surely they would have won). While a few cynics saw this as a sour grapes reflex, by and large the world accepted the Soviet disclaimers, and in consequence endorsed the theory that greedy politicians and self-serving NASA officials had "tricked" the U.S.A. into a multi-billion dollar one-sided non-race moondoggle.

Thus it was that Walter Cronkite told the nation on the fifth anniversary of the Apollo-11 landing that "it turned out that there had never been a race to the Moon", a judgment that was echoed and re-echoed throughout the West. Few knew that Cronkite's research assistants had concluded that actually there was still dispute over this judgment, and that those specialists most well informed with the Soviet program did indeed feel that the race had been real...but Cronkite or his writers evidently needed to simplify the issue.

Among conservative spokesmen, the happy conclusion that the Russians were incompetent was reinforced by lurid revelations of defectors who claimed that the whole Soviet space program was a "bluff", a Potemkin village in orbit. Lloyd Mallan and other writers in the 1960s tried to prove that Russian space shots were fakes, since everyone knew that Soviet technology was backward if it wasn't pirated from the West.

So Western experts familiar with the intricacies and politics of the Soviet space program have thus observed in dumbfounded amazement how Moscow, unable to write new pages of space history, has successfully set about rewriting some old pages. In the past, the contents of history books have reflected the opinions of winners in wars, crusades, purges, and other struggles—but not this time. We won the Moon race, and now Moscow's propagandists have written the history!

Let there be no doubt about the facts. To set the record straight, the "Moon race" was totally real. Soviet engineers planned to send cosmonauts to the Moon ahead of American astronauts. Moscow wanted desperately to win the "Moon race" and, with top Kremlin approval and endorsement, poured precious resources of manpower, money, and material into that drive.

The effort faltered and failed, and rather than admit inferiority (which a second place finish would most certainly have done), Moscow cancelled the entire program and swept the abortion under a rug. The program was then publicly repudiated, a propaganda posture which synchronized closely with what many Western critics of the right and the left had been mouthing for years. Apollo was a useless stunt, a wasteful detour, an obscene diversion of resources and attention, a psychotic manifestation of infantile fantasies....

The detailed evidence for this reality has been catalogued elsewhere, in the Library of Congress's *Soviet Space Programs* reports, in *Spaceflight* magazine (particularly the May 1975 issue; published by the British Interplanetary Society in London), in *Space World* magazine (EG, the July 1977 special issue of "Soyuz"), in *La Lutte pour L'espace* (Alain Dupas, Editions du Seuil, Paris, 1977), and elsewhere. That evidence has not been disputed or challenged, but simply ignored.

To summarize it briefly, the Soviets built a one-man translunar variant of the Soyuz spaceship and tested it unpiloted under cover of the "Zond" program in 1967-1968. Cosmonaut Pavel Belyayev privately confided to American astronauts that he had been elected to fly the first mission, scheduled for November 1968 (then, when the first Apollo Moon missions were not expected until mid-1969). Other cosmonauts were in training for an actual Moon landing, anticipated in the 1971 time period. Soviet intelligence reports forecast an American schedule slip of at least two years from 1969. Hardware unique to a piloted lunar landing program was also flight tested, including a Saturn-V sized booster and probably a lunar module (some of the tests remain clouded in secrecy).

The faster-than-expected (by anyone!) Apollo flight sequence, combined with a new NASA administrator's uncharacteristically bold gamble on

Cosmonaut Pavel Belyayer (1926- 1970). With a little bit of luck, he might have been the first person to the Moon.

Apollo-8, scrapped the Zond program which had already been encountering a series of unrelated technical difficulties (but the month of December 1968 was the climax, since a pilot-rated Zond with booster and cosmonaut crew was ready for flight but was delayed for an additional month in anticipation of an Apollo-8 slip). Later, Soviet space shortcomings were underscored by the failure of the booster development program (these problems were accentuated by management difficulties caused by the unexpected death at age 59 of chief Soviet space designer Sergey Korolyov; he was irreplaceable, as the ensuing string of space setbacks showed).

Together with the 1971-1973 Salyut disasters punctuated by the American Skylab triumph, these psychologically devastating events constituted a "sputnik-in-reverse" humiliation in Moscow, only partially alleviated by phony propaganda campaigns. Moscow's reaction (like Washington's to the original sputnik "goosing") was an energetic rebuilding, and we see the results today in 1978.

Meanwhile, the Moon mocks our gullibility in falling for the attempted coverup of Russia's space failure, and for accepting the political neutralization of the implications of the Apollo victory. How can we view our future with any perspective if our past has been counterfeited? Critics have quashed the quintessence of the Apollo triumphs and now sharpen their knives against our new generation of dreams.

INDUSTRY LEERY OF PRODUCTION IN OUTER SPACE

by DAVE DOOLING

A major stumbling block in the way of using space as a resource for producing new materials is getting companies to believe there is potential profit for them, according to a Marshall Space Flight Center engineer.

"Most of the companies we've talked with have very little knowledge of space activities in materials processing," said Richard Brown, director of Marshall's commercial space processing development task team. "The typical comment is 'I can't imagine anything you do in space that relates to my business.' "

And among those who are aware of the space program, the feeling is that it is "an expensive, interesting national hobby."

The processing of materials in space holds the potential, many supporters believe, of becoming a multi-billion dollar industry by the end of the century. Preliminary tests aboard the Skylab space station and Apollo-Soyuz flight indicate that the absence of gravity will make it possible to produce better materials than those made on Earth, or to produce materials that will not form under gravity.

Brown's team is charged with explaining to industries outside the usual aerospace circle what they might be able produce in space, such as new electronics, lenses and drugs.

To date, he said, his team has briefed companies representing 25 percent of the gross national product.

"What we're up to is trying to translate the technology of materials processing into public benefits," he said.

"We make a particular point that materials processing in space is not space colonization, mining of the Moon, mining asteroids or large space factories.

"We are trying to drive the program into a transition phase," with government and industry sharing the risks and rewards, he said.

Such an arrangement, involving money from both sides but no exchange

of cash, is not unlike the land grants that made railroad expansion possible in the last century, or subsidies which gave birth to commercial aviation earlier in this century.

"We're not talking about a Sugar-Daddy deal," he said. "We want to negotiate good, sound business."

But before industry accepts that, Brown admitted, there is a need for products that can be made and will sell.

"The number one problem in selling to the industrial community is we do not have identified anything on how to use space that can really stand an economical analysis," he said.

Taking into account all costs, including riding the reusable Space Shuttle, materials produced in space early in the program will cost around $500 per gram, so they must be of very high value.

"The agency does not want to go into space (to process materials) unless it can only be done in space, or done better in space," he said.

Even if he had processing equipment ready to fly, Brown said he could not sell it to anyone until financial, legal and marketing questions are answered.

The task team at Marshall was established to help work those problems out.

"One of the models we studied before doing this is the county agent system," he said, "the most successful technology exchange in this country."

Like county agents, he explained, Marshall acts as an intermediary between two specialized areas of industry, interpreting needs and problems into words the other understands.

Part of the problem the space agency deals with is patent rights.

Under the Space Act of 1958, if a company spends $5 million of its own money developing a new idea, then scores the breakthrough with a $100,000 contract from the government, the federal government owns the whole thing.

Brown said that leasing equipment—as well as a patent-waiver clause—may help eliminate that large block to industrial participation.

Other problems include regulation, which the space agency does not want to do; data protection and Freedom of Information Act; reimbursements; liabilities and antitrust actions.

NEWS BRIEFS

LATEST SHUTTLE SCHEDULES

Latest Space Shuttle Orbiter 102 schedules, as planned by NASA in early December, called for "roll out" of the first real orbital flight model of the Shuttle from the Palmdale, California plant the last week in February. It will be transported overland to Edwards AFB and then mounted on the back of the 747 carrier aircraft for transportation to Cape Canaveral the first week in March.

Present launch plans are for the first orbital flight to occur September 28-30, 1979. The second flight, formerly assigned to the Skylab re-boost mission, would be launched January 29, 1980.

Originally designated "SS-1" and "SS-2" (for "Space Shuttle"), the flights have been renamed "STS-1" and "STS-2" for "Space Transportation System", avoiding any possible unpleasant connotations associated with the initials "SS". The missions have also been referred to as "OFT-1" and "OFT-2", for "Orbital Flight Test", since six flights are planned before the Space Shuttle enters the "operational" phase of its program. However, the OFT missions as planned and numbered may not be flown in sequential order, so an independent designation was needed.

The final four flights in the test series are slated for May 15, August 1, October 8, and December 1, all in 1980, and the first 'operational' mission, to be used to launch the "Tracking and Data Relay Satellite System", will be "STS-7" on February 27, 1981. The first Spacelab flight is now assigned to STS-10 on July 22, 1981.

CHINESE SPACE STATION BY 1986

*BY DAVE DOOLING **

The head of the space agency of the People's Republic of China has said that the Chinese will have a space station in orbit in a few years.

Dr. Edward Ezell, a contract aerospace historian in Woodbridge, Va., wrote recently that Jen Hsin-Min gave him a glimpse of China's plans in March. Ezell also has written the official histories of the Apollo-Soyuz mission and the Viking Mars mission.

According to Ezell, Jen said that China will have a space station by 1986. "They're talking about more than a spacecraft," Ezell said, "but less than a Skylab." Skylab is the U.S. space station used during 1973-74. Ezell said Jen would give no further details.

Jen's promise, though, implies that China soon must start piloted space flight in order to gain experience for such an undertaking.

China already has orbited eight satellites and recovered three. Adding a pilot to a spacecraft should not be too difficult.

It took the United States about a decade to go from the start of project Mercury, a one-person space capsule, to most of the technology that built Skylab. One advantage the Chinese have is free access—through open literature—to much of that technology.

FRENCH SPACE SHUTTLE

by Dave Dooling *

The Centre National d'Etudes Spatiales in France reportedly is studying a piloted hypersonic glider that would be launched by Ariane, a throwaway rocket now under development.

The craft would have a crew of three and would carry a payload of "a few tons." The U.S. shuttle will carry up to 32½ tons, and will also act as a hypersonic glider when it returns from space.

A lobbyist for the European aerospace industry has said that Europe needs an astronaut launch capability independent of the United States.

Ariane is being developed by the European Space Agency—mostly with French funds—to compete against the U.S. for communications satellite launches. A high-energy upper stage would be needed to boost a piloted glider into orbit.

Ariane's payload capacity is also being upgraded from four to six tons to enable it to launch automated laboratories. These would compete with some of the science programs planned for Spacelab, a European-built science workshop that will fly inside the U.S. shuttle.

Of Interest:

Institute For The Social Science Study Of Space

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OBJECTIVES

In recent years, technological concepts have emerged that suggest utilization of the space environment on an unprecedented scale. Numerous scholars and thoughtful citizens have suggested that the rise of the large scale industrialization of space should be accompanied by ongoing assessments of current and projected societal impacts. Spontaneous activity in this area has already occurred, but a serious need is emerging to establish a vehicle to coordinate this research and scholarship.

Consonant with this need, the Institute for the Social Science Study of Space, a non-profit educational and research institute, is being established to facilitate the systematic investigation of the human factors bearing on the development and utilization of space. The Institute's purpose will be to coordinate and mobilize the social science and humanities knowledge and expertise which must accompany technical development of the space environment. In doing so, the Institute will work to provide a more complete understanding of the impact of space development on society, indirectly generating a broader information base for planning future space endeavors.

The Institute will seek to aggregate the resources of all the recognized social science and humanities disciplines. Over an extended period of time, the interaction of these disparate disciplines—focusing on the space environment—will very likely result in the evolution of a new discipline possessing its own internal coherence and methodology.

PROGRAMS

The Institute's strategy is to develop an infrastructure by establishing basic programs used in community-building in the social sciences and humanities. Programs will be established as funding permits. Following are some we plan:

A clearinghouse to handle general and specific inquiries from individuals and institutions interested in learning about this new field of study.

Focused publications, such as regularly issued journals, newsletters, and occasional special studies, are primary instruments for building a new field of study. The Institute would develop these communications channels as a means of improving the quality of discussion, facilitating the exchange of information, and encouraging reflection in the field. In this regard, the first volume of the **Space Humanization Series** is already being assembled. The **Series** is a forum for scholarly articles on space social sciences and humanities.

The Institute is developing a carefully focused library which serves as a centralized reference point for prospective researchers.

Additional programs, including the development of conferences, teaching seminars, workshops, and the offering of academic courses in the field—will be established as resources permit.

FUNDING

The ISSSS has applied for 501(c)(3) tax status. If you are interested in supporting the Institute's work, please send your tax exempt donation to: Institute for the Social Science Study of Space, Suite 403, 2135 Wisconsin Ave. NW, Washington, DC 20057.

SPS Research Topics

Are you looking for a topic for your doctoral thesis? The Universities Space Research Association, a consortium of colleges and universities conducting space research, has identified a wide range of topics in the field of solar power satellites suitable for graduate research.

These topics are detailed in "Report of the Solar Power Satellite Task Group," which was prepared by W. E. Gordon, Dean of Natural Sciences, Rice University; Om Gandhi, Dept. of Engineering, University of Utah; Curtis Johnson, Chairman, Dept. of Bioengineering, University of Utah; L. J. Lanzerotti, Bell Telephone Laboratories; George L. Cisco, Atmospheric Sciences Dept., UCLA; John Zinn, Los Alamos Scientific Laboratory; and Harlan J. Smith, Chairman, Astronomy Dept., University of Texas at Austin.

Copies of the report can be obtained from the L-5 Society. Price is one for $3.00; for additional copies add $1.00 per copy. Send orders to L-5 Society, 1620 N. Park, Tucson, Az. 85719.

Space Settlement Shows

The NASA Technology Application Center at the University of New Mexico has completed a presentation for classroom instruction and public briefing on space colonies.

Space Settlement One illustrates basic concepts and technology of space colonization, including

settlement location at L-5
habitat and life support,
lunar mining and ore transport,
zero-gravity construction,
extraterrestrial agriculture, and
space transportation.

The presentation also considers costs and financing, and especially the value of 24-hour solar energy to large cities on Earth.

The presentation package includes a synchronized cassette tape with narration and original music background, printed script with descriptions of visuals, and a discussion guide with additional information and questions on the topics covered.

It is a 14 minute tape-slide presentation with 68 slides, synchronized cassette tape with audible advance.

Price is $98; $105.05 with carousel tray. Send your check or purchase order to Audiovisual Institute, 6839 Guadalupe Trail NW, Albuquerque, NM 87107. All overseas shipments must be prepaid.

If you wish to design your own slide show, write for the 74 slide L-5 Society Slide Show catalog, 1620 N. Park, Tucson, AZ, 85719.

Book Reviews

Colony, Ben Bova; Pocket Books/Simon & Schuster/Gulf & Western Corp., 470 pp. 1978.

Colony is the first novel explicitly about the L-5 Community. Earlier novels, such as Pamela Sargent's **Cloned Lives**, have incorporated L-5 colonies but only as a relatively undeveloped, undetailed background. With the colony as his subject, Bova focuses on the broadest issue –the *meaning* of development on the high frontier vis-a-vis the global civilization which has sponsored that development.

Bova has set most of **Colony's** action on Earth; only the opening and closing chapters portray Island One. Colony-born David Adams, a computer freak by nature and a social forecaster by vocation, runs away from Island One on an initiatory quest through the rapidly deteriorating global civilization of 2008. On Earth nuclei of great power, a World Government, a consortum of directors from five multi-national corporate oligopolies, the leader of Latin American and African revolutionaries, and the People's Revolutionary Underground, a worldwide terrorist organization, vie for control of Earth's remaining resources like queens in a four-colored chess game. David enters this game as an unwitting pawn of the multi-nationals and agent of the Colony. He achieves self-discovery, the king row and promotion at his adventure's end.

Colony is much more reminiscent of Erdman's **Crash of '79** than it is of Clarke's space station sketches of the 1950's. Details of colony life are woven into the L-5 chapters, details ranging in diversity from Carolyn Henson's goats to glimpses of a new human-machine interface. These details and their implications are regularly subordinated to, often eclipsed by, Bova's grim attention to the inevitable working out of the Club of Rome scenario. The relationship between the L-5 and the Club of Rome scenarios has received scant attention in print, yet the latter's field of diminishing potentials and increasing limits describes the world in which L-5 will be accomplished. **Colony** is most important for having initiated discussions of this issue.

If **Colony** has a weakness it is the weakness of L-5 speculations in general, namely that the soft technologies of economics, society, polity, and culture have not received consideration equal to the discussions of hard technology and short range politics. A half dozen examples illustrate this.

1. **The Political Context**

Bova posits a planetary government for Earth; the United Nations has disintegrated and a new regime with the power to effect its decisions has been organized. This power derives in largest part from the Lunar City/Colony Selene. Bova chronicled Selene's break to independence and autonomy in his earlier novel **Millenium.** Initially equipped as paired U.S./U.S.S.R. bases, Selene has the position power and the equipment to enforce global disarmament and support the World government.

These developments seem unlikely. Lunar urban development (a city comparable to the one portrayed in **2001: A Space Odyssey**) would be exorbitantly expensive, could probably never achieve self-sufficiency and economic independence from its funding agencies and is not, in light of space-medicine findings, a desirable environment for long term human occupation or settlement. The political role played by Selene could be played by an early Satellite, because for Bova, L-5 and Club of Rome the crucial issue in this respect is the probable conduct of nation-states in the off-planet environment. Nation-states are creatures of territory; they are vitally concerned with the defense, maintenance and expansion of that territory. As a consequence, nation-states are inherently martial. Despite the arguments of **Millenium**, which are largely psychological, it seems likely that orbiting military colonies would not be motivated to support global disarmament at the expense of their national governments.

World Government also runs counter to the global trend of the past two centuries. Settlement of the last terrestrial frontier marked the climax period of nation-states and territorial empires. Since then empires have fragmented and decolonialized into increasingly more local and autonomous political units. The world of 2007 will likely see many smaller states engaged in multiple and shifting mutual-interest alliances as prefigured in O.P.E.C. and the Association of Equatorial Nations.

2. **The Economic Context: Global**

The Eurodollar crisis of 1965 was a key battle in a silent revolution. The multi-national corporate oligopolies emerged as "the largest and most inclusive groups that make and implement decisions about the exploitation and allocation of energy potentials in the environment" displacing the nation-states along the leading edge of human adaptation. These new units are stable; for example the pattern of directorate interlocks in the New York oligopoly has remained constant for 20 years, from 1957 to 1977. The MNC's have very different objectives from the nation-states. Planning regularly extends their horizons in both time and space. Predictable markets and sales growth have replaced raw profit as their primary objectives. The MNC's thus have vested interests in global peace and a steadily rising global standard of living. Their interest in territory per se is negligible and they have most to gain from development on the high frontier. The export of major industry into orbit is the natural next step in a sequence which can be traced from Great Britain through the United States to Germany and Japan, then to the newest fourth generation industrializing nations.

Bova suggests a relatively late involvement of the multi-nationals in developing the high frontier; typically the MNC's have used the larger governments to underwrite the high costs of prototype development, committing themselves to projects only after the period of greatest initial research and development expense. Bova seems to favor earlier involvement of the MNC's in L-5 development, yet portrays the directors as crass, gluttonous, selfish robber barons, anarchronisms from the earliest phase of the industrial revolution. This will not attract **their** favorable consideration.

3. **The Economic Context - Local**

The local economy of the Colonies remains virtually ignored in the L-5 literature. Bova suggests a credit card economy - underwritten as today by the corporate Eurodollar? – and only a few colonial exports - the satellite solar power systems, automata in diversity and biological products resulting from safely insultated recombinate-DNA research and experimentation.

The MNC's will always want to own and control their orbiting industrial facilities, but ownership of the residential systems may prove neither feasible nor desirable. Studies of frontier economies and industrial communities argue that company towns stagnate rapidly. The residential system sold by its multi-national contractors to the residents collectively would encourage the 'free' exploration of the production possibilities of the orbital environment, and a rich and diverse export economy for the Colony.

The reader can only infer from **Colony** that information may be one of L-5's most valued exports. For example, the construction and management of the complex Colonial ecologies – both industrial and biological – may generate

the theories and techniques for the rehabilitation of Earth's battered native systems.

4. **Information**

One of **Colony's** brief but most exciting speculations is a new man-machine interface. David Adams has grown up with a micro-terminal implant; he has learned to use the Colony computer as naturally as a bicycle. But on Earth, deprived of access to that tool, David feels naked, incomplete. However, Bova does not recognize LOGLAN as the language appropriate to the man-machine interface and as a lingua franca for a polyglot human population in a high stress environment.

5. **Energy**

Energy is what it's all about for **Colony**, The Club of Rome and the L-5 scenarios. The capture and control of that energy is the human adaptive challenge for the closing years of the 20th century. Bova warns that the Colony, at the center of the SSPS network, could easily become more tyrannical in its control of energy than any nation-state or multi-national corporation yet recorded. This is not an encouraging speculation, but it is realistic. The soft technologies which will govern the resources of **Colony** must be as rigorously and humanely pre-thought as the hard technologies which will deliver that energy.

6. **Characters**

In addition to David Adams and the corporate directors, two characters deserve special mention. Appearing only briefly in the early chapters, an architect has been commissioned to rebuild the Hanging Gardens of Babylon. The pointless expense of this undertaking succinctly illustrates the decadence which will likely accompany the earlier phases of the Club of Rome scenario. In sharp contrast, David's social father, the senior administrator of Island One, Dr. Cobb, emerges almost as a deus ex machina. Cobb was employed in this position by the corporate directors because, as an applied anthropologist, he was a jack of all social science trades. Much of the happy ending seems to trace to his deft manipulation of the Colony system: Social scientists take heart!

Colony is worth reading. Its real value will be measured by the counter-speculations it provokes in both the fiction and non-fiction realms.

Reed D. Riner
Assistant Professor
of Anthropology
Northern Arizona University

Letters

The L-5 Society needs to become much more vocal in Washington, D.C. because of Carter's recent announcement rejecting "spectacular" space missions. Let's group together and support a presidential candidate in 1980 who will at least attempt to support the colonization and industrialization of space. Also, with the current interest in space so prevalent among the younger people in this nation, it becomes imperative to keep that interest kindled so that the majority of voters in 10 years will support the L-5 Society's goals. I hopefully intend to continue my membership until space colonization is achieved.

Barbara A. Mackinder
Denver, Colo.

Let's stop using the misnomer 'artificial gravity' to refer to the forces used in spinning toroid or cylinder structures, forces which simulate gravity and give a sort of ersatz or *pseudo*-gravity. Of course it is not gravity, it is inertia, and it is not physically correct to call it gravity, no more than it would be correct to say that astronauts blasting off experience a gravity field three times as strong as on earth.

So here's my proposed term: PSEUDO-GRAVITY. It is left to the reader to devise six ways by which an experimenter in a sealed room could easily differentiate between spin pseudo-gravity and mass-induced planetary gravity.

Why be picky? Because in a decade or a century or a millenium, we will be able to produce appropriately named 'artificial gravity,' by manipulating the fabric of space/time with tricks undreamed of today. A dozen Nobel prizes are waiting. The application of energy and cleverness will allow humans to turn on and off gravity fields or whatever level they desire—and *that* is what should be termed 'artificial gravity.' So *save* the terminology for what deserves it, and be satisfied—as we shall be for a few decades or centuries—with space-based PSEUDO-GRAVITY.

IF we need it at all. Bill Thornton, a NASA astronaut-physician, stressed to me the other day that 'calcium loss' is not a universal physiological effect but hits less than half the population, and it can be predicted pre-launch. Further, everything else in weightless adaptation levels off, plateaus, so perhaps calcium loss will too. And vertical stress of at most two hours a day counteracts most if not all calcium loss. So MAYBE artificial (oops, I mean pseudo-) gravity is not even a prerequisite for space habitats. If it is, Edward Gilfillan suggests, "Why, so what? Accept the price of a one-way ticket—you'll still get volunteers who don't care that they never will have to return to Earth, never can return to earth."

So much for my comments of/on gravity.

James Oberg
Houston, TX

An important stage in the growth of the idea of solar power satellites and space colony development is the use of these themes in major science fiction novels. For one thing, science-fiction fandom is large and organized, but a surprising proportion is amazingly unaware of the real-world possibilities of space development. For another, the novelists, for purposes of dramatic interest, have focused on the potential of SPS and space colony development for personal tragedy and global disaster. That makes them required reading for SPS/colony proponents, since we may tend to forget that they may not come into being as benignly as O'Neill suggests.

All three of the major novels published to date—Terry Pournelle's *High Justice*, Ben Bova's *Colony*, and *Skyfall* by Harry Harrison—convey their authors' conviction that SPS/colony development is a logical and desirable goal, while depicting in harrowing detail what may happen if that goal is pursued in a venal, short-sighted or malicious way. Human nature being what it is, that is perfectly possible; and like it or not, any highly concentrated, highly centralized energy system—like SPS, breeder reactors, or thermonuclear fusion—has the potential for catastrophic mismanagement to balance its potential for human good. An SPS system may be less prone to bungling, but it cannot be made immune from it. (That helps to explain why anti-nuclear forces have not, by and large, become pro-SPS—they're basically pro-decentralization, and to the, an SPS is just more of the same old thing). Harrison's *Skyfall*, showing what political expediency, pettiness, and general stupidity could do to a joint Soviet-American SPS launch, is a good example.

In any case, anyone interested in space development could read any of the three stories for pure entertainment—they're excellent novels by first-rank writers— apart from their thought-provoking value for anyone with a stake in our future in space. If that's where we want to go, we must do it with both eyes

open for human pitfalls as well as technological ones.

Peter H. Shaw
Albuquerque, New Mexico

Thank you for the very interesting article (Nov. '78 *L-5 News*) giving the several sides to various aspects of the SPS concept. I have several comments pertaining to various statements in the article.

Mark Gibson is incorrect in his 2500 km^2 estimate of the area required for the 10 GW rectenna. The 5 GW rectenna proposed by NASA would be an oval 10 km X 13 whose area would be about 103 km^2. Adding a restricted public access strip 1.28 km wide along the perimeter to reduce the microwave radiation level to 100 microwatts/cm^2 brings the total area to about 150 km^2 or about 37,000 acres. This is comparable to the Dallas-Fort Worth airport (based on my estimate of the DFW land area). For comparison, using a surface collector solar system to power Dallas would require a land collecting area approximately 10 times the area of that city.

A computer study conducted by Jim Blackburn of Rice University has concluded, after examining the entire U.S., and applying certain exclusion variables, that the SPS concept should not be ruled out on the basis of the contiguous land area necessary for rectenna siting.

Mr. Gibson criticizes the variability of rectenna cost estimates between the Johnson Space Center and Marshall Space Flight Center designs as evidence that the cost estimates are not trustworthy. In fact, the JSC and MSFC rectenna designs are very different. The JSC concept calls for individual discrete dipole rods whereas the MSFC concept at the time of the cost data referred to by Mr. Gibson was a so-called stripline multilayer printed circuit board, probably far cheaper to manufacture and erect. Rather than criticizing such design variability, it should be encouraged.

I question the authenticity of Mr. Gibson's statement, which he attributes to NASA, that to be competitive with terrestrial systems, the SPS must meet all projected electricity demands by 2025 using a 112 satellite fleet deployed in 30 years. At one time, NASA did, for calculational purposes, entertain a 112 satellite fleet scenario. This was for the purpose of flushing out resource limitation problems. However, the present NASA baseline scenario calls for one 10 GW or two 5 GW satellites to be built per year. The SPS is still expected to be economically competitive at this pace. Economic competitiveness is not determined by such parameters as demand supplied. Rather it is determined by such parameters as cost/kw of installed power and the cost of resulting electricity, etcetera.

Mr. DeLoss criticizes previous SPS cost estimates as having been made by those interested in seeing the SPS fly. Rice University has a privately funded program whose goal is to "objectively" evaluate the practicality and feasibility of the SPS concept. Aware of the criticality of cost to ultimate SPS acceptability, and to criticisms of the type put forth by Mr. DeLoss, we attempted our own modest SPS cost estimate with the help of a consultant, Mr. Paul Purser. Using rather different costing techniques, principally extrapolation of historical unit cost data for the U.S. and U.S.S.R. space programs and the size exponent and learning curve methods we established that the NASA estimates are consistent with the estimates obtained by these other techniques.

One area that your article did not deal with is the SPS evaluation program being undertaken by the Department of Energy. I am very pleased with the planned scope and thoroughness of this program. It is important that we examine as completely as possible the ramifications of all new technologies before they are deployed. We will not be able to have all of the answers before we plunge ahead on SPS. However, the very existence of this rational examination of the SPS technology may be the signal of a new maturity in man's collective intelligence. There is a burden on all of us to look at things analytically and not emotionally. The SPS concept does indeed face serious problems, not the least of which are emotional public reaction and premature judgment.

John W. Freeman
Professor of Space Physics and Astronomy and Director, Space Solar Power Research Program
Houston, Texas

On October 4, 1978, the twenty-first anniversary of the Sputnik launch, the USC L-5 Society, at the University of Southern California, held its founding meeting. Although it is hoped that UCLA will establish an L-5 chapter, the listing in the October *L-5 News* was incorrect. We are USC, not UCLA, and perhaps you could note the error. The two schools are intense rivals. The USC L-5 chapter has numerous plans for activities on campus, including a week of space films, speakers, a bookstore display, and the establishment of a USC L-5 library of books, films, slides, etc. We deeply appreciate your assistance in establishing the club, and hope to contribute to the overall L-5 growth, especially in terms of international development for the society.

John A. Blanton
President, USC L-5 Society

My thanks to Gordon Woodcock for his concept of the energy market as having several segments (*L-5 News*, Nov. 1978, page 9). He has clarified some ideas which I have had for a long time:

There are three major segments to the energy market: heating & cooling, electrical appliances (ranging from table radios to the giant aluminum-producing crucibles), and transportation. Intrinsically, there is no reason why any two segments should be served by the same fuel/system, except for the current state of technology.

Two hundred yearrs ago the three segments were supplied by wood, coal & water power (for machinery), and grass (for horses). Today, the segments are supplied by oil, oil & coal & uranium, and oil.

At the current state of technology and energy transport systems, SPS will only supply the second segment, electrical use. Distributed-solar enthusiasts should be assured that they can have segment one, heating & cooling, all to themselves, and that segment three, transportation, is being left alone for gradual, undirected change.

Howard G. Beatman
New London, Conn.