LATEST DEVELOPMENTS IN SPACE INDUSTRIALIZATION, SATELLITE SOLAR POWER, AND SPACE HABITATS

L5 NEWS

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A SPACE BASE FOR THE 8Os?

Introduction

With the advent of the Space Transportation System (Space Shuttle) in the 1980s. the cost and complexity of human space operations will be substantially reduced, and new opportunities for space research, development, and applications programs will emerge. In preparation for these opportunities, NASA is examining the potential of a permanent, inhabited earth-orbit facility.

The Multipurpose Orbital Facility* will initially provide living and working quarters for four persons. Later, should user needs so dictate, addition of more four-person units can modularly expand capabilities and enlarge operational capacity.

*Actually, the manuscript we have calls the station the "Manned Orbital Facility," but in keeping with current NASA policy regarding such language we have used "Multipurpose Orbital Facility" to avoid a barrage of letters from the female astronaut-candidates while keeping the same acronym.

Program Overview

Operations could begin by 1985 with the launch of the first four-person facility from the Eastern Test Range by the Space Transportation System (STS). The circular orbit will be nominally 200 nautical miles high and inclined at 28.5°. Additional STS flights would be made at 90-day intervals to replenish supplies, deliver and retrieve payloads, and exchange personnel.

The MOF will offer capabilities that are significantly more advanced than those of the space facilities and laboratories of the past or those planned for the near future. In particular, the time that a team of scientists and technicians can remain in space will be significantly extended. The longer-duration missions will allow time-dependent phenomena such as physiological adaption and physical growth processes to be investigated, and advantage can be taken of the improved efficiency that will result from the crew becoming fully adjusted to the space environment and learning to work more effectively through repeated performance.

The longer missions will also offer potential cost savings. Timelines and work schedules can be less constrained than in the past, and therefore less subject to compromise if mission anomalies are encountered. Moreover, it will be possible to perform a given amount of work with fewer costly earth-to-orbit flights, and savings will also result in ground operations from the reduced number and complexity of turnarounds, refurbishment cycles, and checkout operations.

In addition, the longer-duration missions will increase the breadth of research, development, and applications opportunities. For example, new instruments to survey, inventory, and monitor the distribution of the earth's natural resources will be used in MOF

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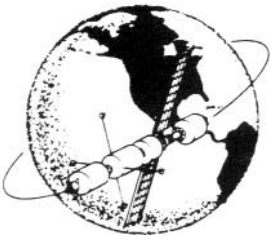
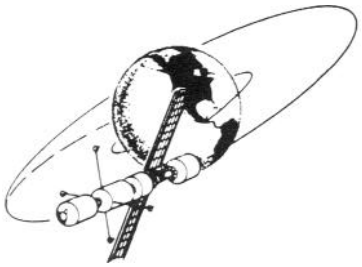
Figure 1

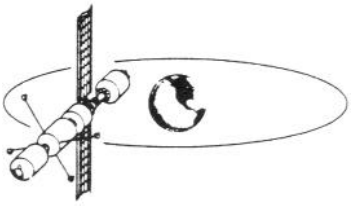


LOW EARTH ORBIT, NOMINAL INCLINATION

LOW EARTH ORBIT, POLAR INCLINATION



HIGH EARTH ORBIT. PHASED FROM LEO



GEOSTATIONARY ORBIT

payloads to obtain extensive, detailed information over the full cycles of the seasons. Similarly, in the life sciences, the MOF laboratories can be used to study many problems requiring lengthy activity periods, complex manipulation, and control of multiple environmental factors.

It is expected that as the payloads are operated in orbit, their products -- whether scientific data or materials fashioned in space -- will lead to requirements for further missions and flights. Because of the modular nature of the Orbiting Facility concept, eight- to twelve-person facilities could follow earlier four-person missions as 1990 is approached. As an example, it could be speculated that after an initial five years of prototype and pilot-plant operation, a space-manufacturing activity on a commercial scale would be warranted. These industrial-class operations would, in turn, call for much larger work forces and more MOF units.

Additional Orbiting Facilities could be established in high-altitude subsynchronous and geostationary orbits for such missions as satellite servicing and synchronous observatory operations.

The space station can service payloads for many different missions in a variety of orbits, as shown in Figure 1. The STS is capable of delivering the station and its payloads directly to low earth orbits (altitudes less than 300 nautical miles) in either 28.5° or polar inclinations. These two classes of low earth orbits, which are achievable from the Eastern and the Western Test Ranges, offer a wide spectrum of mission opportunities in fields such as earth observations, stellar and solar astronomy, and space physics. In addition, these orbits provide the microgravity environment useful to life-science and material-research programs.

The space station could also support payloads that require stations in high-altitude earth orbits (perhaps 400 nautical miles). For example, the facility could be used to assemble a large-aperture (200-400 meter) radio telescope in low orbit. After final checkout, the telescope could be transported to the higher orbit to begin its program of unattended operation.

Perhaps the most important attribute offered by MOF is the presence of people to conduct and support onboard payload operations. By relying on manual functions rather than automation, many elements of the facility and the payloads can be made simpler, less costly, and more reliable. Add further the inherent intellectual capacity of people, which will permit on-the-spot objective judgments to be made and innovative or remedial action to be taken to compensate for the unforeseen, and the MOF offers significant advantages to potential users.

Baseline Design Description

The space station configuration is made up of four basic elements (Fig. 2). Subsystem Module (SM) -- provides electrical power, environmental control, centralized communications, stabilization and control, maneuvering capability, and hygiene facilities. Habitability Module (HM) -- provides for basic crew needs such as eating, sleeping, and recreation; also serves as the central focus and control point for payload operations. Logistics Module (LM) -- provides for resupply of consumables and changes of equipment; also serves as additional habitable volume and storage space in orbit. Payload Module (PM)- houses scientific apparatus, applications equipment, and service-oriented functions.

The cylindrical modules are fitted at each end with an International Docking Assembly to permit their attachment and clustering in space. The International Docking Assembly also furnishes a standardized means of access for rescue operations.

The HM and SM are mated on the ground and launched together as a single unit. The HM, SM, and LM are “core” modules that provide support resources for a variety of interchangeable PMs.

The first STS launch inserts the HM and SM into orbit. The second launch delivers the LM and the first PM. Resupply flights follow at nominal 90-day intervals. On these flights, the LM is interchanged to replenish the station with 90-day stores of food, propellants, and other expendables. The PMs may be launched with the LM or launched individually, depending upon available and needed weight, volume, and schedule. Supplies and equipment for payloads already onboard also may be carried as required on logistic flights.

Payloads are retrieved when the STS Orbiter is on station and are returned to

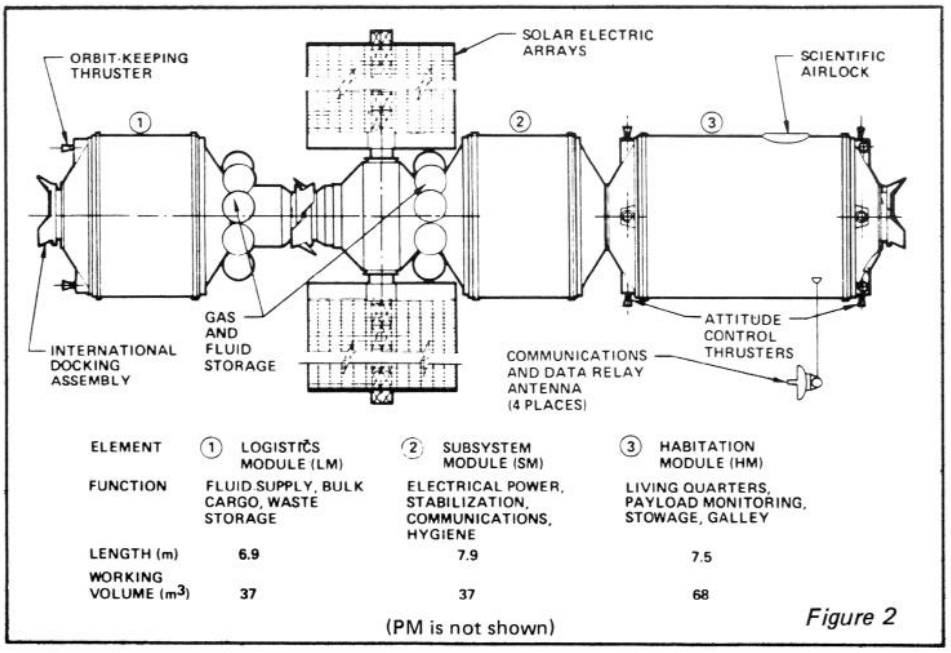


Figure 2

earth or retained for reactivation at a later time in the Orbiter payload bay. If traffic conditions warrant, payloads and PMs can be left attached to the station in a deactivated condition for return to earth at a later time.

For some payloads or missions utilizing the orbital facilities' resources, a geostationary orbit may be required or attractive. Such higher-energy orbits can be achieved by using the Space Tug (which is also launched by the STS) for a series of staged boosts.

Structure

The basic module pressure shells consist of 13-foot nominal-diameter cylindrical sections about 9 feet long. The sections are constructed of machined aluminum-alloy plate and are joined at bolted, gasketed flanges, which also mate with the conic end-dome sections and the International Docking Assemblies at the ends of the modules. The interiors of the pressure shells are outfitted with standardized floors and equipment or storage racks. Outside the pressure shells are shrouds that provide thermal insulation, meteoroid protection, and support for the fluid circuits of the thermal control system radiators.

The HM, SM, and LM provide approximately 5,700 cubic feet of working volume. Additional space is available in the payload modules. Storage space, in addition to that required for the provisions and supplies needed to sustain 90 days of operation, is included to accommodate payload equipment and payload-related supplies. About 100 cubic feet are enclosed in standardized lockers and cabinets, and about 500 cubic feet of free space are available in which items can be secured to the floor or the bulkheads.

The HM is equipped with two airlocks, one for EVA and another for the deployment of payloads outside the MOF. Conveniently located viewports have optical-quality windows suitable for precision photography. The installation and design of the equipment racks permits access to all items that require periodic maintenance or may need to be repaired.

Environmental Control and Life Support System

The atmosphere conditioning, purification, and distribution functions are performed by the environmental control and life support system. The system not only maintains the cabin atmosphere at the comfort-zone level of 72 ± 2° F and 40% relative humidity, but also removes metabolic carbon dioxide and other trace contaminants. Thermal loads up to the equivalent of 12 kilowatts (9 kilowatts from the payloads) are also rejected by this system. The onboard supply of water for crew use is maintained by a closed-loop recovery subsystem, which eliminates the need to resupply large quantities of water on each logistic flight.

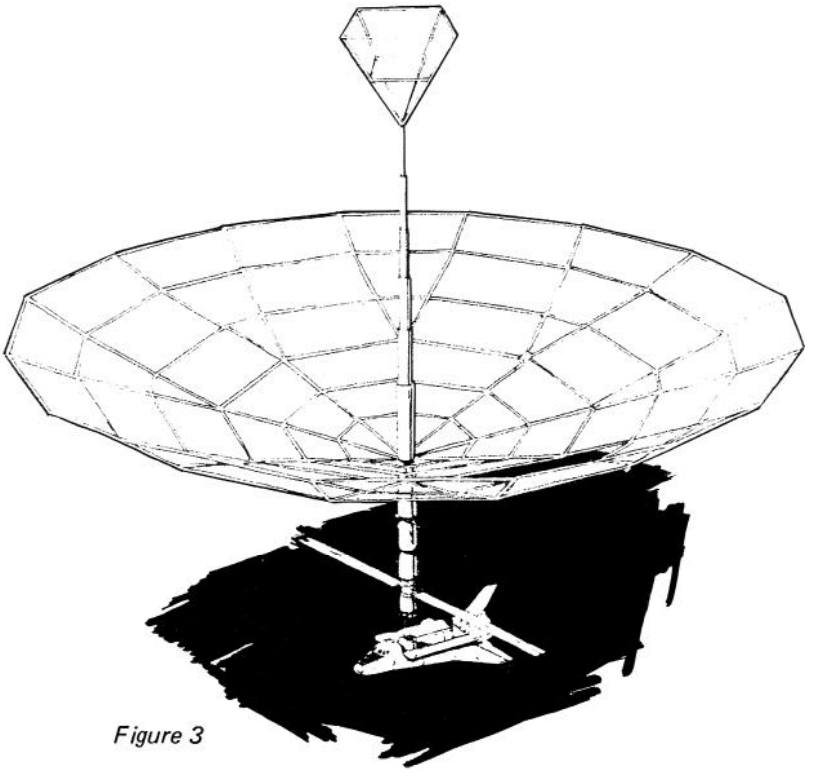


Figure 3

The atmosphere consists of a standard sea-level nitrogen-oxygen mixture controlled to a nominal 15-psia pressure. The system is open-loop with oxygen uptake, leakage, and loss due to airlock operations made up from storage tanks. The atmosphere supply is replenished by logistic flights.

Crew Support System.

Equipment and facilities for crew hygiene and for food storage and preparation, as well as furnishings, wearing apparel, and equipment for exercise and recreation, are provided by the crew support system. Also included are general-purpose aids such as mobility devices, restraints, cargo handling fixtures, tools, test equipment, portable lights, cameras, and radiation-monitoring devices. Emergency supplies of oxygen and food maintained in each module are also part of this system.

Payload Support Services: Overall Support Characteristics

The most important payload-support characteristic of the Multipurpose Orbital Facility is the availability of people as observers, decision-makers, and operators. Experience on Skylab offers substantial evidence that the presence of astronauts can add significantly to mission success and enhance the productivity of spaceflight activities.

Human presence in orbit offers particular advantages with respect to improvisation and modification. The resetting of circuit breakers and the relocation of power cables to service different apparatus are two examples of how crews have played contributory roles.

The presence of a crew may also allow the heat-rejection system to be simpler and lighter because temporary measures can be installed to accommodate periodic or transient above-normal loads. This was illustrated on Skylab when the crew corrected the heat balance of the workshop by erection of makeshift thermal shields. (Later in the mission, the crew also prevented serious difficulties by restoring the malfunctioning coolant loop to service.)

In data management and communications, the crew will play a role of prime importance. Their presence will allow the system to be simpler and less expensive, with plug-in panels instead of automatic switching, and they will be able to make discretionary judgments with respect to what data are to be handled, how they are to be channeled and processed, and where they are to be routed. A member of the crew can also initiate or suspend communications or data-management functions as required to better use the capacity of the system.

To make maximum use of human visual perception, viewports and other optical devices will be provided for functions such as overall control of vehicle orientation and maneuvering. In this case, the operator will be positioned so that he can see directly through viewports, particularly during close-in maneuvers (for example, during docking). Remote sensors will also be used to present information on visual displays.

Also of great importance is the

Figure 4

continuous microgravity environment offered by the space station. This environment cannot be duplicated on earth except for short periods of time, during which gravity-induced convection and seismic vibrations can disturb many measurements. In space, such disturbances are avoided or minimized. The role of gravity in life processes can be studied systematically, and the long-duration life-science investigations that are essential to planning and design of very-long-term inhabited space missions can be conducted.

Also of significance from a payload-support standpoint are access to an unlimited vacuum; availability of a vantage point from which the earth, the sun, and stellar objects can be viewed without the disturbances encountered on earth; access to solar energy as a source of contamination-free thermal power; and the availability of deep space at 4° K as a radiation sink.

Structural Assembly in Space

Large space structures (Figures 3 and 4) offer the opportunity to develop scientific and observational capabilities that are not obtainable on earth. In addition to large-aperture radio telescopes, large devices have applications

in the fields of communication, media broadcasting, surveillance, and advanced power-transmission concepts (for power satellites).

The assembly of large space telescopes, as an example, would be greatly simplified by the availability of people to rig and deploy the structure. Structural members could even be formed in space -- truss elements could be extruded, thereby requiring only the raw materials to be transported as cargo to the facility. The structure could be assembled with simple, sequential manual operations, instead of complex automated or remotely controlled procedures. The space station offers the orbital platform on which to base these operations as well as to support the needs of the crew.

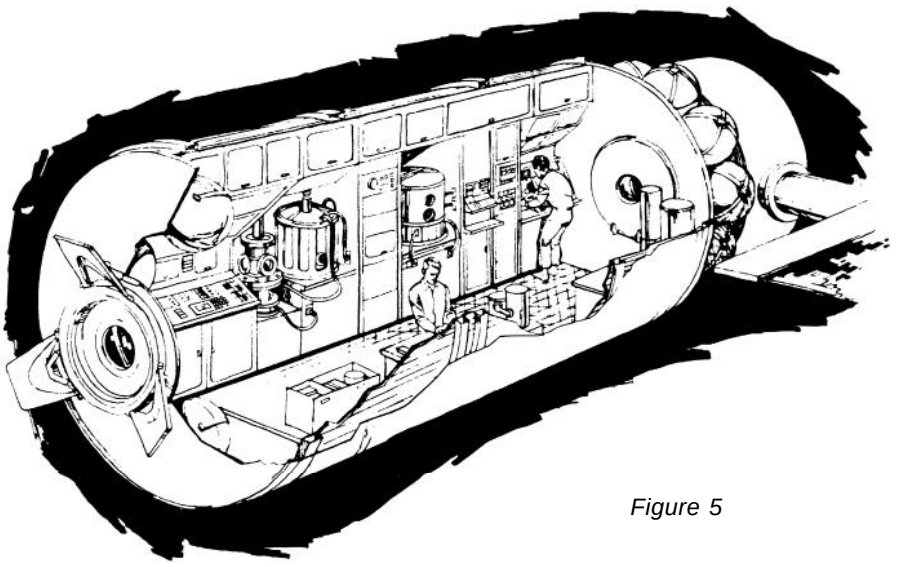


Figure 5

Manufacturing in Space

The microgravity environment, in addition to its scientific interest, offers potential economic and industrial rewards (Figure 5). Materials could be produced in space that would possess unique and highly desirable features which would be prohibitively expensive or impossible to produce on earth. For example, space processing techniques that are currently being studied involve production of eutectic materials. Potentially valuable commercial eutectics include certain binary mixtures. When these mixtures solidify, one of the two phases can form fibers, filaments, or platelets in a matrix of the second phase. These materials when produced on earth are limited in perfection owing to discontinuities, faults, and surface irregularities caused by mechanical vibrations or gravity-induced thermal convection in the melt during solidification. If the solidification process is performed in microgravity, where vibration and mechanical disturbances are minimized, continuous fiberlike eutectics can be produced with special electrical, thermomagnetic, optical, and superconducting properties of immediate commercial value.

Production in microgravity would also be advantageous for many other promising processes and materials. Typical are growing of perfect, large-size crystals from a liquid or vapor phase; large-scale electrophoretic separation of biologicals; contamination-free, containerless melting and solidification; production of ultrapure substances; manufacture of microscale surface acoustic-wave components; and production of semiconductor-grade silicon in ribbon form as a substitute for conventional sliced-silicon slabs.

General-Purpose Laboratory

A payload module will be outfitted as a general-purpose life-science laboratory (Figure 6). The facility will be provided with the standard instruments and analytical services necessary to pursue a broad range of research in the life-science and health fields. These disciplines, perhaps uniquely more than others, can benefit from the orbital facility environment, where long-duration research is possible and continuous exposure to microgravity can be maintained for periods up to 720 days. Since many different investigations would use common equipment, the general-purpose laboratory would include basic capabilities such as microscopy, blood chemistry, metabolic analysis, fluid analysis, specimen preservation, and animal holding.

Other general-purpose laboratory configurations could be created to support investigations in physics, chemistry, material processing, space and plasma physics, cosmic-ray research, and earth observations.

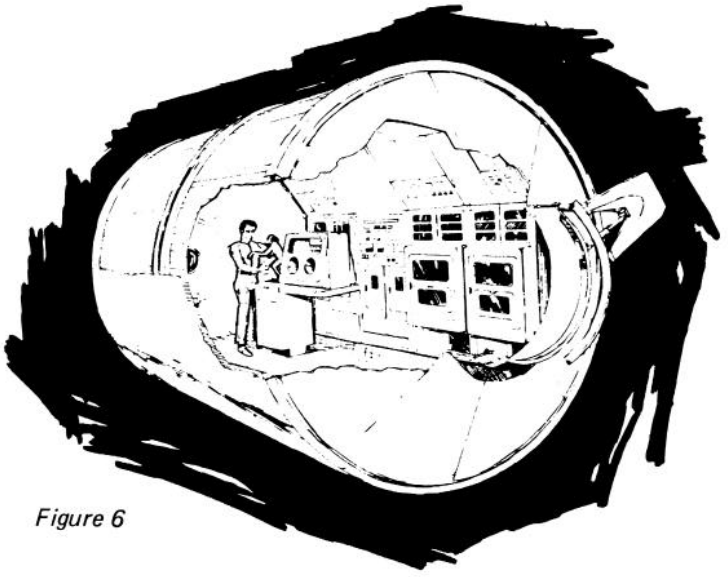


Figure 6

Payload Accommodation: A Construction Shack for the First Colony?

In general, the Multipurpose Orbital Facility is intended to support the following classes of space activity:

Scientifically oriented investigations in the fields of astronomy, astrophysics, solar physics, physics and chemistry in microgravity, life sciences, and earth sciences.

Technologically oriented applications in the fields of meteorology, earth observations, communications, navigation, material processing, and manufacturing in space.

Space-basing operations, including assembly of large structures, station buildup, construction of permanent inhabited facilities, and (eventually) building of space colonies.

Support of space operations through in-orbit spacecraft servicing, vehicle refueling, and maintenance and repair of space-system elements.

Monitoring and control operations, including staffing of permanent, inhabited air- and space-traffic control facilities, communication stations, and observatories.

Military applications and defense measures.

MULTIPURPOSE ORBITAL FACILITY OVERVIEW

Features	Capabilities
Human onboard support to payloads	Initial facility in 1985 with four-person crew; potential growth to crew of 12 by 1990 if requirements dictate
Payload traffic to orbit1	Nominal changeout and/or resupply at 90-day intervals; other payload service intervals available as required
Onboard payload volume	Pressurized modules available to accommodate up to 5,800 cubic feet of payload equipment and supplies; payload capacity of Orbiter cargo bay for a single launch, about 10,000 cubic feet; multiple modules and/or launches available to handle very large payloads
Electrical power	8,000 watts continuously available for payloads; additional auxiliary power available as required
Environment	Pressurized sea-level shirtsleeve environment with full temperature and humidity control
Data management and communications	Continuous ground contact; real-time or delayed transmission; wideband (60 MHz)
Space-platform orientation	All-orientation vehicle stabilized to 0.1° with horizon and stellar attitude reference

Heretofore only the first two classes have been studied in some detail. The baseline design has been configured to accommodate 19 payloads that are related to these classes. The payloads were derived from the Space Shuttle Payload Description Activity (SSPDA), a NASA planning effort that has defined more than 200 individual piloted and automated payloads for the first 12 years of STS operation. The 19 payloads chosen for use in establishing the orbital facility baseline are representative combinations of SSPDA payloads and the classes of activities that could be served by the orbital facility in the initial six-to eight-year time period.

Colonies on the Moon

Bob Parkinson

L-5 is not the only site proposed for an extraterrestrial community. Indeed, from the beginning, proponents of a Space Colony have recognized that a settlement on the Moon will be needed to provide the essential raw materials base. The British Interplanetary Society, which has a long history of encouraging speculative concepts in astronautics, has recently been studying the possibilities for a colony on the Moon. This article is a brief survey of some of the ideas which have emerged.

With budget cut-backs, NASA has turned away for the moment from the idea of an immediate return to the Moon. In 1970 it proposed to use the NERVA nuclear rocket to place a sizable scientific community on our natural satellite. However, lower cost options are available. With the Space Shuttle providing relatively low-cost transport into Earth orbit, the existing Centaur high energy stage could be used to place payloads in excess of seven tons into orbit about the Moon. With a slight stretch of its propellant tanks, Centaur could land nearly four tons of cargo onto the Lunar surface. By using unpiloted cargo deliveries to assemble a minimal space station in orbit about the Moon, or to provide shelters and scientific equipment for surface explorations, the size of piloted vehicles could be kept to a minimum. Crews would use the Centaur as a booster, and space storable propellants derived from the Space Shuttle orbital maneuvering system for the Lunar Landing Craft and Orbital Recovery Vehicle. A single Shuttle launch would allow two or three astronauts to visit an orbital station about the Moon. A second Shuttle launch could deliver a Lunar Landing Craft to descend and allow them to work on the surface.

This low-cost, non-nuclear proposal is important because it would allow an early return to the Moon for exploration and for experiments in the utilization of Lunar resources. For a cost of perhaps one-third that of a single Apollo launch two or three astronauts could live and work on the Moon for up to three months. As transport capabilities grow, so this bridgehead could be expanded into a permanent base, and eventually into a self-supporting colony.

An early objective in a program to exploit Lunar resources has been identified as the production of liquid oxygen from Lunar rocks. Schemes already exist by which this could be done. Besides reducing the supplies which the Lunar Base requires ferried up from the Earth, it would also provide a source of rocket propellant. Some 89% of the propellant mass for a hydrogen-oxygen rocket is liquid oxygen. An on-site supply would have dramatic effects on transport economics.

Key events in the progress towards a self-supporting Lunar Colony are seen as: the return to the Moon; the establishment of a permanent base; the use of local resources; the advent of low cost transport to the Moon; the first export of Lunar material for economic ends; and the first permanent colonists.

To these, one other item should be added, looking innocent but in fact crucial to the movement towards a colony. It is major de-programming of the explorers' activity.

In the early stages of the exploration of the Moon the time available will be so limited that the explorers must be continuously directed -- "programmed" -- from the Earth. While this is necessary to maximize the achievement, it is also unnatural. Even in the Apollo program a certain amount of natural reaction was evident. It is not simply a question of letting the explorers make their own decisions, we must allow for movement tangential to the Earth-planned program. The explorers will climb Lunar mountains "because they are there." They will grow flowers instead of food in the Lunar farm. If the Moon is to be colonized by human beings this activity is not simply "light relief," it is central to the question of values. We must discover not only that we can work together on the Moon, but also that we can live together.

A critical factor in the exploitation of Lunar resources is the electromagnetic rail launcher familiar to Space Colonists. The idea for this goes back at least to 1948 and Arthur C. Clarke, who observed that it was a means of getting cargo into Lunar orbit without having to bring propellant up from the Earth. A side-effect of such a rail launcher is that a considerable electrical generating power will be required, and that this power can also be used to refine local minerals for titanium, iron, aluminum and silicon. An economic analysis was made on the basis that it might be cheaper to supply space manufacturing industries with their basic materials from the Moon, rather than launching them from the Earth. The analysis revealed that a Lunar industrial site might pay off when it could export

about 700 tons per year in the way of material for space-borne industry. While this is high in comparison to initial estimates for orbital manufacture, it is very modest if a significant market develops for foamed metals, non-miscible alloys and whisker-strengthened materials.

A corollary to the use of Lunar materials for orbital industries is that the first Space Colony could well be in a "swing" orbit between the Earth and the Moon, approaching the Moon once a month, and at the point of closest approach to the Earth making its deliveries of finished products on a worldwide scale.

One use of Lunar resources will be in constructing the Colony itself. A novel suggestion is to use "concrete" made from available crushed rock aggregates and a binder (possibly epoxy resin) imported from the Earth. Concrete is a versatile material, easily made on site with the minimum of machinery. If concrete structures do appear on the Moon they are likely to be far removed from the domes and cylinders of conventional conceptions of the Lunar base.

Finally, we may speculate on the quality of life in a Lunar Colony. Colonies in Space have aimed at reproducing the most desirable features of the terrestrial environment. The Lunar Colony may well be more aware of the changed environment in which it finds itself-more dependent upon its members' technical expertise for its survival. One aspect of the Lunar environment that will almost certainly have its impact is the monthly cycle of light and darkness. Solar power is a natural energy source for the colonists, and the fortnight of daylight may well be a busy period of construction and industry, with the two weeks of night a time for thoughtful planning and analysis. Among their social rituals the Lunar colonists are likely to have a special one called "sunset." With the pioneer souls the Colony is likely to attract, it is unlikely to be a quiet time.

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Comment on "Colonies on the Moon" by Keith Henson

These comments are not meant to disparage Bob Parkinson, who, through the British Interplanetary Society, has kept the flame alive for so many years. But this shopping list of lunar colony proposals and motivations needs to be weighed against the political, economic, and technical factors which now dominate studies of the industrialization and colonization of space.

We know enough about the composition of the lunar surface to make further purely scientific missions or bases on the moon unlikely, given the current economic and political climate, for a long time. NASA recognizes this. What lunar base plans they do have are for 1995 or later. Space colonies are not in the plans at all-but this could change, and fast, for good (economic) reasons.

Many people, when presented with the space colonization and industrialization proposal, have asked, "Why not on the moon? You have to go there anyway to get the lunar rock."

There are several reasons, though they all boil down to cost. Remember, the project has to be able to make a profit if we hope to get it done soon. First, it's more. expensive to go to the moon. With no atmosphere for braking, rockets must be used to get rid of at least 2.4 km/sec. The cost difference between lunar surface and high orbits like geosync or L-5 is about 5 to 1. Another factor is the cost of energy. Solar energy is more expensive on the lunar surface than in space. For one thing it is usable only half the time, due to the two-week lunar night. If concentrators are used, they will have to track the sun which makes them heavier and more expensive. The latest work (Summer Study '76) shows solar energy on the lunar surface to be less expensive overall than nuclear energy there, but not by much. "Sunset" will be quits, at least the machines will stop. The last factor favoring space over the moon is the value of zero gravity for processing and construction. On the lunar surface you are stuck with l/6 g minimum. (You can get more with a centrifuge, but you can do that in space, too.) Metals could be refined out of lunar rock and launched as ingots but the cost would be 3 to 5 times higher than refining in space. Getting liquid oxygen off the moon by a small transport linear accelerator (freely acknowledged as a contribution of BIS member Clarke) seems a bit difficult as a lot would evaporate on the way up.

The minimum-cost lunar mining base envisioned by the space colony studies is small. Twenty people would run it, though two hundred would be needed to build it. Three things I can think of would make it grow: the discovery of processes that are cheaper on the lunar surface, scientific exploration and tourism. If we don't make it any other way, I hope to see you there as a tourist, Bob.

DECLARE THE EARTH A WILDERNESS AREA

WHAT NEED NOT BE DONE

Eric Drexler

In talking to people about space colonization over the last six years or so, I have found many trillions of dollars of research and development expenditures lurking near a mental pigeonhole labeled "prerequisites to meaningful space colonization." These "prerequisites" range from devices that violate physical laws to technologies that may be highly desirable and easy to develop, but still not necessary. Also lurking near that pigeonhole are years of delay and dissention associated with social and political developments, believed necessary to the step into space.

To get where we're going at reasonable cost we do not need nuclear rockets, better fuels, faster-than-light drives, space warps, solar sails, single-stage-to-orbit freighters, reactionless drives, or gravity control.

To live comfortably in space we do not need to terraform Mars or Venus, to develop starflight, to find a "stable orbit" for a colony, to make an imitation Earth, or build a Dyson sphere.

We do not need a complete understanding of living things, zero-g adapted people, a completely closed ecological (or even agricultural) system, conquest of aging, a hermetically sealed test city of 10,000 on Earth, or a failsafe eggplant.

To eliminate terrestrial energy problems through space industry we do not need an all-electric economy, safe breeder reactors, a hydrogen economy, controlled fusion, cheap energy storage, or antimatter energy systems.

To build what we need in space we do not need new alloys, skyhook cables, new superconductors, vapor deposition systems, ringworld foundation material, or unbreakable shoelaces.

To get needed materials we do not

need fusion torch processing, distillation of rock, mass spectrographic processing, H-bomb processing, or the philosopher's stone.

To make space expansion meaningful to social evolution we do not need equality for all, a self-sufficient community of 10,000, a new family structure, world literacy, world cooperation, a moneyless economy, psychic breakthroughs, elimination of communism/capitalism, or the elimination of crackpots.

To support expansion into space we do not need to be certified neurosis-free, and we do not need written permission from God, Buddha, or our mother.

Several of the above aims are dear to my heart, but I suspect that the human race can muddle untidily into space, as elsewhere, with imperfect but good results.

RECENT DEVELOPMENTS IN THE ECONOMICS OF POWER FROM SPACE

Mark Myron Hopkins

A debate has begun between proponents of nuclear power and advocates of satellite power stations (SPS) mad on and launched from earth. This debate will no doubt intensify since there are billions of dollars riding on its outcome. A recent study by ECON, Inc., found that the busbar price needed to pay for power from such SPSs is 35 mills per K.W.H. (26 if the costs of R & D are written off). In 1974 the average cost of nuclear power in the U.S. was 15 mills (excluding environmental costs). The question of which of these two options is best rests on whether or not the costs of nuclear power corrected for its effects on the environment will exceed that of SPS power by the time that SPS power could be commercially available.

The answer to this question is unclear at present; it may also be irrelevant because of a third option that is quite familiar to L-5 Society members: namely, building space colonies which produce SPSs primarily from lunar materials. The most recent economic analysis of this possibility-based mainly on the 1975 NASA Ames Summer Study of space colonization-finds that the resulting power could be paid for by a price of 10.8 mills per K.W.H.

A fourth possibility has arisen within the last year. This may be called space industrialization via the use of lunar materials. As in the case of space colonization, this approach builds SPSs in space primarily from lunar materials.

However, unlike space colonization (which includes a virtually closed ecological system complete with facilities for a permanent population of space workers and their dependents) space industrialization would house its workers in space stations of the type frequently designed by NASA in the past. The ecological system would thus be open, requiring resupply from earth. Space workers would periodically be rotated to and from earth where their dependents would remain. The 1976 NASA Ames Summer Study, which has just been completed, conducted an analysis of space industrialization. The cost and time schedule produced there has as yet not been analyzed from an economic view to determine the price for electricity which it implies. However, the numbers indicate that this will be less than the 10.8 mills estimated for space colonization.

With respect to one criterion, the programs of space colonization and space industrialization represent different extremes. On one hand, we have a permanent population with negligible resupply. On the other hand, we have a transient population with high resupply. It is well worth noting that the optimum may be between these points, i.e., a space station to which a space farm has been added. It is also likely that the optimum moves over time toward increasing permanence. These possibilities taken together constitute a fifth option which currently shows promise of being the best of all.

STUDENTS TO FLY ON SPACE SHUTTLE?

"As the Shuttle program advances into future years, it is possible that outstanding students would be selected to serve as actual payload specialists aboard Space Shuttle missions."

This statement, recently released by Dr. James Fletcher, Administrator for the National Aeronautics and Space Administration (NASA), came in conjunction with the announcement of plans for the development of a college program which would solicit student developed experiments to be carried aboard the Space Shuttle, and, as Dr. Fletcher pointed up, may allow for actual in-space experimentation by student crewmembers.

Senator Frank Moss, (D-Utah) Chairman of the Senate Committee on Aeronautical and Space Sciences, and a member of the National Advisory Board of the Forum for the Advancement of Students in Science and Technology (FASST), actively supported this organization's efforts to interest NASA in a college-level student space experimentation program. In an exchange of letters between Senator Moss and Dr. Fletcher, the Senator encouraged NASA to designate an office and/or person who would be the primary interface point with FASST and other student groups, in the development of a student payload program.

In 1972, a high school student Skylab program was implemented with nineteen student experiments being chosen to fly onboard the orbiting space station. Senator Moss, however, pointed out in his communication with Dr. Fletcher that, "unfortunately, there has been no such program for college students, and the cost and long lead times involved in current space experiments have acted to discourage widespread involvement of college and graduate students. The advent of the Space Shuttle, with its projected routine, frequent flights, and sharp reduction in payload costs and long lead times for preparation, should allow for greater participation of students at all levels."

In direct response to the Moss request, Dr. Fletcher emphasized that NASA shares fully the Senator's desire for student participation in the Space Shuttle program, and intends to conduct nationwide competitions for both secondary school and college students and their instructors/faculty advisors on scientific experiments and demonstrations which would fly on the Space Shuttle. He noted that the student program would provide for "adequate assistance and followthrough in order that the results of these student projects could be added to our national store of scientific knowledge." Fletcher also expressed the desire that the program "excite the imagination and enlist the talents of imaginative young people."

Although still in the early stages of development, the student payload program should provide a wide range of experimentation, such as studying the effects of zero-gravity on biological processes or evaluating the damage caused by solar and cosmic radiation on various materials, as the space environment provides conditions that are unattainable in Earth based college laboratories.

The Forum for the Advancement of Students in Science and Technology (FASST), a national membership organization committed to increasing student awareness of, and opportunities for student involvement in science and technology, is assisting in the development of this college program for space experimentation.

For those students who wish additional information on this new program, please contact FASST at 1785 Massachusetts Avenue, N.W., Washington, D.C. 20036 or phone (202) 483-2900.

MODEL ROCKETRY

The Encyclopedia of Model Rocketry and Space Modeling provides information of use to hobbyists and space enthusiasts, including information on space colonization. To obtain a copy, write to *The Encyclopedia of Model Rocketry and Space Modeling,* P.O. Box 101, Mineral Point, WI 53565.

Rockwell Wins Space Industrialization Study

Carolyn Henson

The company building the space shuttle, Rockwell International, has been awarded a $95,000, eight-month study contract on space industrialization. It is a sister study to the one being conducted by Science Applications Inc. *(L-5 News,* September, 1976).

Kraft Ehricke is study manager and Chuck Gould his key assistant. Other members of the study team include Bertrand Catel, Chief of Science Applications of the United Nations; Samuel Epstein, of California Institute of Technology; Gerard O'Neill of Massachusetts Institute of Technology; Reed Powell, Chairman of the National Advisory Council for Small Business; Charles Cheeseman, of General Electric; and Ernst Stuhlinder of the University of Alabama.

In an October 4 phone interview, Chuck Gould explained that "the center of gravity" of the study is not to lead into space mining operations or large space habitats "as an end in themselves." Gould stressed the need for space industry to "translate into jobs and balance of payments improvements," and improving people's quality of life on Earth. "We'd like to make Earth a better garden."

The study team will consider the potentials of both services and goods from space. Lunar resources will be considered where appropriate. "If we're moving massive things into geosynchronous orbit, we may at least want to be getting oxygen (for rocket fuel) from the moon," explained Gould. "Solar power satellites are one of the most exciting space industries, but by no means the only. Some of the others can be done quickly and are not so technically challenging. We're especially looking for space products that will create new industries, as large scale integrated circuits created calculators."

The Rockwell team brings together a wide range of talent. Kraft Ehricke and Gerard O'Neill share interests in solar power satellites, lunar mining, and large space habitats. Bertrand Catel will consider world impact of space industries. Samuel Epstein is an expert on climate and ecology. "If his projection from past weather trends is accurate," warns Gould, the dry, cool trend expected over the next 30 years "adds to the urgency of solutions." Reed Powell will consider ways for small businesses world wide to participate in space industrialization. Charles Cheeseman represents General Electric, which, along with TRW, have done most space processing and manufacturing work. Ernst Stuhlinder will bring in his expertise as a participant in past NASA long-range planning.

The results of this space study team with its global perspective will be available by June 1977.

CONSTRUCTION IN SPACE

Grumman is completing a study (NSS-OC-RP005) of an "Orbital Construction Demonstration Article," an open framework and power supply that would be deployed by several Shuttle flights and used as a test bed for a large number of space industrial projects. Among them would be a test of a complete 18 x 18 meter subarray for microwave transmission of power to the Earth. A considerable number of necessary techniques such as the assembly of large structures would be demonstrated just by putting the test frame together.

Cost of the frame is bracketed between 189 and 337 million dollars at present. The study will be completed by the end of November. *L-5 News* will carry an extensive review of the results as soon as possible thereafter. We hope Grumman will turn their excellent graphics department loose on this one!

RENSSELAER POLYTECHNIC INSTITUTE SPACE POLITICS STUDY

The Department of History and Political Science at Rensselaer Polytechnic Institute in Troy, New York, is sponsoring a course entitled "The Politics of Outer Space." The course is being directed by Professor Dennis Livingston, who holds a PhD. from Princeton. He is a specialist in alternate futures and the interactions of science and public policy.

Those who would like a course outline (13 pp.) and the excellent bibliography (17 pp.) Livingston has compiled should send $2.50 to the L-5 Society.

PRINCETON RESEARCH POSITION PLANNED

Subject to total funding and its allocation locally, it is possible a post-doctoral position for space colonization research can be opened at Princeton during the next year. A strong background in planetary physics and/or aerospace engineering would be optimal; considerable versatility and organizational ability would be expected. Because the funding situation is uncertain, however, Princeton may not be able to process applications for several months.

ENERGY RESEARCH AT CALTECH TO EXPAND UNDER AWARD FROM ERDA

Energy research in six major areas will be expanded at the California Institute of Technology (Caltech), Pasadena, California, under terms of a recent award by the Energy Research and Development Administration (ERDA).

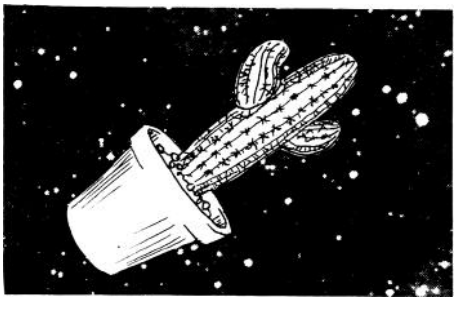
Approximately $250,000 has been authorized for the first phase of an advanced research program to study: geochemical energy sources; combustion and heat transfer; molecular processes associated with energy production, storage and use; solar energy; and energy-related environmental and economic impacts.

Caltech will also perform specific analyses on the economics and projected environmental impact of geothermal energy production, the relationship of tax policy to energy use, and the structure of energy-related regulations.

U OF A SYSTEMS COURSE LOOKS AT SPACE FARM PROBLEM

Growing food for space colonists and regenerating the atmosphere in space habitats is the subject of a course sponsored this semester by the Systems and Industrial Engineering Department at the University of Arizona in Tucson. The course is under the direction of Dr. Wayne Wymore, who has had extensive experience leading interdisciplinary teams. Social and psychological factors are being considered, along with the biological and chemical design constraints, in an effort to produce a space farm design based on a systems approach.

As an initial exercise, the class has



divided into six teams and each team has developed a systems model of a plant. Eventually, the class plans to make recommendations for research into biologically-based life support systems, including, if necessary, experiments for the Space Shuttle. The University of Arizona is a member of USRA, the University Space Research Association, which is co-ordinating University participation in the Space Shuttle program.

HOW MUCH WILL ENERGY SUPPLY INVESTMENT COST?

Excerpted from the FEA 1976 National Energy Outlook Executive Summary

Energy investments in the United States will be about $580 billion (in 1975 dollars) in the next 10 years. While this investment seems large, it is about 30 percent of fixed business investment, which is energy's historical share. In certain sectors, such as utilities, large demands will be placed on the capital markets.

Oil, gas, and electric utility capital spending will almost double in the next 10 years. The largest portion of the energy investment will be in the electric utility sector which could account for 47 percent of the total.

Oil and gas investment depends greatly on the pricing and policy strategies that are adopted and could range from about $160 to $315 billion. Coal investment could increase to $18 billion or only 3 percent of the total, but representing a 200 percent increase from the 1965-1974 total of $6 billion.

Investments to increase energy efficiency could also be significant, perhaps an additional $250 billion through 1985. Conservation investments are difficult to separate from non-energy investments and will be spread throughout the economy.

How Much Can New Technologies Contribute?

Solar, geothermal, and synthetic fuels will make only a small contribution to domestic energy supplies by 1985 (about 1 percent). The major contribution from solar, geothermal, and synthetic fuels will not be felt until after 1990.

The technology for these sources, exists, but must be proven economically viable on a commercial scale. It will take several years to build the first full-size plants; hence a large industry will not be possible during the next 10 years.

It is likely that few, if any, synthetic fuel plants will be built by 1985 without Federal financial assistance. Unless commercial size plants are started now and proven economic by 1985, it will not be possible for these new sources to replace dwindling supplies of oil and gas in the post-1985 period.

COMMENTS ON FEA NATIONAL ENERGY OUTLOOK

Carolyn Henson

Last month the *L-5 News* reported on a NASA research team's proposal to begin beaming energy to Earth in 1992 from solar power satellites built from lunar resources by thousands of people living in space. The price tag: $30-60 billion. This may seem like an enormous investment. When compared to the $580 billion to be invested in energy in the next ten years alone, however, solar power from space may be a real bargain.

SOVIET UNION LOOKS AT SPACE COLONIES

The expanding U.S. space colonization effort is attracting attention in the USSR. Following are summaries of some of the discussions on the subject which have appeared in the Soviet press:

ı Source: *Tekhnika-Molodezhi, No. 4,* 1976, pp. 30-35, "Man and Space" Conference, report 3: "Mankind's 'Space Optimism' (Problems of Mankind's Future in Space)."

This section (reviewer: G. Kuznetsov) was concerned with the future of mankind. It accepted the optimistic viewpoints of Tsiolkovskiy about the future capability of mankind to move to other solar systems.

I. Bestuzhev-Lada, Doctor of Historical Sciences, and A. Ursul, Doctor of Philosophical Sciences (See LC/FRD Item No. 3190) concentrated on criticism of the theory of "ecological collapse" (MIT, *Limits of Growth, 1972)* and, perhaps, for this purpose, a full-page box is included on activity of the Club of Rome and its prognostic studies.

I. Shklovskiy, Corresponding Member AS USSR, reported in detail on the project of Dr. G. O'Neill for human space colonies including energy supply to Earth. The description includes two pages of picturesque illustrations. According to Shklovskiy, the conversion of a type-I (terrestrial) civilization into a type-II (Solar-system) civilization, while preserving exponential development, can take 500 years. After that, the same causes will push a type-II civilization, possessing a tremendous energy potential of 10^{30} erg/sec, into the Galaxy. Shklovskiy discusses the velocity of the "shock wave of intelligence," and estimates that colonization of the whole will take several million years, a figure comparable to the duration of man's evolution on Earth. This time span is considered to be small compared with the Galaxy's age of ten billion years. Galactic civilization will possess material resources of 10^{42} g and the respective energy resources sufficient for the systematic conquest of the Metagalaxy.

ı Source: *Priroda,* No. 4 (April), 1976, pp. 4-13, "Dr. Agadzhanyan Discusses Biomedicine in the US and USSR Space Programs, and Space Colonies."

N. A. Agadzhanyan, Dr. of Med. Sci's and Laboratory Head at the Institute of Biomedical Problems, USSR Health Ministry, reviews biomedical progress in the US and USSR space program.

Success in solving biomedical problems helps to apply this achievement to practice in public health. Orbital stations may become special clinics for treatment of certain diseases (for instance, varicose veins).

He further discusses the problems and results of the Apollo-Soyuz, Salyut, and Skylab missions, mentioning the problems of different atmospheric pressures aboard Apollo and Soyuz, and the biological experiments conducted during the joint missions. He also discusses problems of circadian rhythm and weightlessness effects and successful preventive measures such as physical exercises.

Finally, he touches upon the future of man in space, particularly the project for a space town (20,000 population) developed by a famous aviation project engineer, D. Romik, and G. O'Neill's project for space colonies.

ı Source: *Nauka i zhizn', No. 5* (May), 1976, pp. 50-51, "Cosmonaut Feoktistov Comments on G. O'Neill's 'Space Colonization.' "

Soviet cosmonaut Feoktistov (Dr. of Technical Sciences) comments on G. O'Neill's article "Space Colonization" (which is discussed in the same journal, pp. 46-50). 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 or 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. (Dr. O'Neill's article is also discussed briefly in *Priroda, No. 5* (May), 1976, pp. 132-133.)

SPACE IS THE PLACE FOR THE HUMAN RACE

conferences

TREKKIES FLEX MUSCLES; SHUTTLE RENAMED "ENTERPRISE"

Nearly 100,000 Star Trek fans, in response to a request in a Trekkie newsletter, sent petitions to President Ford asking that the first space shuttle, *Constitution,* be renamed *Enterprise.* In an election year. how could Ford resist?

Now that they have their *Enterprise,* the Star Trek group has vowed to continue their push for a strong U.S. space program.

THE FOUNDATION INSTITUTE

The Foundation Institute was incorporated in 1971 as a non-profit 501 (C)(3) Minnesota corporation. The Institute is a diversified research and development organization formed to engage in advanced scientific and engineering studies. Funds are provided by contract research for the government and industry, as well as by donations, gifts and internal business profits.

Capabilities include theoretical research and study, systems research, and development of services and products. A high level of effort is presently being expended in astronautics, especially the commercial utilization of outer space and the need for economical space transportation.

The Institute has a permanent and consulting staff of professionals and semi-professionals to call upon including engineers, designers, scientists, communications experts, management specialists and the like. Offices are in St. Paul and Minneapolis, Minnesota, with planned facilities in Washington, D.C.

Address: The Foundation Institute, Suite 704, 810 Thornton St. S.E., Minneapolis, MN 55414. (612)332-6621.

THE EARTH WOULD BE ALL RIGHT IF WE WOULD JUST LEAVE IT ALONE

REPORT ON THE CONFERENCE OF THE AMERICAN ECONOMIC ASSOCIATION

Mark Myron Hopkins

The economic aspects of space colonization were presented informally by Mark Myron Hopkins to economists at the September 16-18 American Economic Association's meeting in Atlantic City, New Jersey. It was discovered that few economists had heard of space colonization, but that they were favorably impressed by the concept as long as a presentation was made at length and backed up by several published articles. The Rand Corporation was particularly enthusiastic.

Of special interest to environmentalists and would-be space colonizers was a paper entitled "Long Run Impact of Energy Use on Climate" by William Nordhaus, a renowned professor of economics at Yale University. He found that the burning of fossil fuels was increasing the percentage of carbon dioxide in the atmosphere. This in turn is increasing the average global temperature due to a greenhouse effect. He argues that even small increases in temperature are important because the weather and hence agriculture is quite sensitive to such changes. By 1985 a global increase in temperature of one-half degree is expected with the problem becoming severe in 40-50 years unless measures to reduce the predicted consumption of fossil fuels are taken. Further, the problem was found to call for action within the near future because the half life of carbon dioxide in the atmosphere is very long. About one-half of all carbon dioxide produced by industrial activities is still in the atmosphere. Consequently, stopping the atmospheric carbon dioxide buildup is not so much a matter of preventing increases in fossil fuel consumption as it is a long-run phasing out of such consumption altogether. Nordhaus' conclusion, in what he freely admits is a speculative paper, is that alternative sources of energy will have to be found of which by far the most important is likely to be nuclear.

If Nordhaus is correct, then environmentalists will find a choice between fossil fuel and nuclear power with its well-known environmental problems to be most unappetizing. But this choice is very likely to be the one we face, unless there exists an economically viable, large-scale, pollution-free, inexhaustible means of obtaining energy of which Nordhaus was unaware. The readers of this newsletter will have no difficulty in guessing what that means might be.

STARSEED SEMINAR AIMS FOR MUTATION, MIGRATION, REJUVENATION

Robert Anton Wilson

Dr. Timothy Leary was the guest of honor at a two-day seminar on his SMI^{2}LE scenario held at the Institute for the Study of Consciousness in Berkeley, California, on August 14-15. (SMI^{2}LE, if you haven't heard yet, means Space Migration + Intelligence^2 + Life Extension. [The mysterious Intelligence^2 signifies intelligence studying and understanding intelligence; the nervous system aware of its own laws. Cf. John Lilly's concept of the self-metaprogrammer in *Programming and Metaprogramminq in the Human Biocomputer.]* Leary feels that any one of these, or any two of them, might create more problems than solutions. All three, he says, are necessary to what he calls "the next step in neurogenetic evolution.")

Starseed Seminar No. 1, as the occasion was called, featured, in addition to Dr. Leary, such speakers as Dr. J. Peter Vajk, who is on L-5's Board of Directors and recently represented us at the UN Habitat Forum; Dr. Jack Sarfatti, president of the Physics/Consciousness Research Group and co-author of *Space-Time and Beyond;* Paul Segall, a Ph.D. candidate at UC-Berkeley who has spent 17 years in life extension research and recently succeeded in arresting the aging process in experimental animals; and Nick Herbert, a physicist involved in research on the possibility of faster-than-light information transfer (which doesn't contradict Special Relativity if Herbert's interpretation of Bell's Theorem is correct.)

The audience was heavy with distinguished Bay Area researchers and clinicians, who participated in the discussions. Among those who contributed comments were psychologist Jean Mayo, physicist-psychologist Saul-Paul Sirag, systems engineer Michael Mohle and mathematician Jerry White, President of the Bay Area Cryonics Society.

Nobody present dissented from Leary's assertion that the SMI^{2}LE program can be carried out in this generation, but some were skeptical about whether it would be. Most of the cynics believed such a program could only be financed by government and their doubts were based on strong feelings that Washington is very slow to move on new ideas.

Dr. Leary, however, replied to such doubters by asserting that the SMI^{2}LE scenario would not be, and should not be, implemented by government. Rather, he

hopes to instigate 500 interlocking think-tanks functioning as a cooperative corporation which does not seek or accept backing from any government. Each local think-tank would specialize in some aspect of the research on space migration, intelligence raising or longevity-immortality; and each would, eventually, produce its own spaceship, some to remain in the Earth-Moon system like L-5 and produce new resources for Earth, some to move into the asteroid belt or elsewhere in the solar system, and some to leave the solar system entirely.

Dr. J. Peter Vajk of the L-5 Society spoke on our chance for "a choiceful future" and presented evidence against the gloomy predictions of the Club of Rome. Many were impressed with Dr. Vajk's erudition, not just in physics, his own field, but in many other areas. His slides of possible L-5 colonies were greeted with delighted "oohs" and "ahs" and many excited questions.

Dr. Jack Sarfatti and Nick Herbert, of the Physics/Consciousness Research Group, presented various aspects of their work on physical models transcending what they call the "electro-magnetic chauvinism" of Special Relativity. Their theories of information-without-transportation, quantum "consciousness," new models of the Jung-Pauli "synchronicity" principle and other approaches to faster-than-light consciousness provoked many questions from other physicists present, but the consensus was that they might well be onto something. In particular, Dr. Sarfatti's quantum model of consciousness seemed to offer provocative new insights into both "un-ordinary realities" parapsychology and into life itself and new approaches to immortality.

Robert Anton Wilson, sci-fi writer and L-5 member, collaborated with Leary in explaining the Periodic Table of Energy -- Leary's model for the evolution of consciousness in four terrestrial and four post-terrestrial stages. Many were interested in the suggestion that Leary's terrestrial stages of conditioned consciousness ("Pavlov's Dog," in Wilson's term) operate on linear-Aristotelian mechanisms, while Leary's 4 post-terrestrial stages ("Schrodinger's Cat," Wilson calls them) may operate as the quantum consciousness suggested by Sarfatti.

Gerontologist Paul Segall presented two talks on longevity-immortality, first discussing his own work with rats in which he has found three ways to stop aging-all of them, alas, producing undesirable side effects. Such research, he said, will eventually uncover the genetic trigger that causes senescense and death, giving the chemical formula to rejuvenate and live forever. In a second talk, Segall presented six other approaches to life extension (in all of which he has some research experience) and insisted that cryonic suspension at "clinical death" is the best hope for those seeking immortality right now.

SPACE COMMUNITIES TOPIC AT ANTHRO CONVENTION

The American Anthropological Association (AAA) will discuss space communities at its annual convention at the Washington Hilton in Washington, D.C.

Thursday evening, 5 to 7 PM, November 18, Brian O'Leary, and others will give talks on the topic "Anthropological Factors in Space Colonization," chaired by Professor Harkins. Saturday morning, November 20, L-5 Society Director Magoroh Maruyama will chair the Speculative Anthropology Symposium. Speakers will be Michael Michaud, Peter Vajk, Shirley Varughese, Annita Harlan, James Herrick, and Susan Shatanof. They are winners of the Cultural Futuristics Contest of the AAA. All excepting Herrick will present papers on the anthropological aspects of space communities.

PRINCETON SPACE MFG. FACILITIES CONFERENCE

While the '77 SMF Conference at Princeton is open, rather than invitational, the seating capacity of the Conference auditorium is limited. L-5 members are urged to make reservations early to insure that they can attend. Write '77 SMF Conference, c/o Gerard O'Neill, Physics Department, Princeton University, P.O. 708, Princeton, NJ 08540.

TECHNOLOGY ASSESSMENT

The International Society for Technology Assessment is having their 2nd International Congress on Technology Assessment at the University of Michigan, October 24-28, 1976. Dennis Livingston from Rensselaer Polytechnic Institute, Troy, New York, is talking on Space Colonization and Jerry delli Priscoli, Washington, D.C., will be leading a discussion.

resources

THE HUNGER OF EVE:

A Woman's Odyssey Toward the Future, by Barbara Marx Hubbard. Stackpole Books, Harrisburg, Pa.

Reviewed by K. Eric Drexler

The wave of the sixties left something submerged-hope. Hope, first cleansed and scoured by cultural change, then buoyed and strengthened by technical advance, now floats higher and brighter than in times past. Barbara Marx Hubbard has focused her life on advancing this hope. In *The Hunger of Eve* she tells its story through her own autobiography. The result may crack the crust on a cynic or two.

Barbara Hubbard's life has been driven by a hunger for meaning, for life, and for the universe itself. Over a decade ago this hunger drew her to goals that are only now proving achievable.

This woman, a persistent student and mother, may have come up with a forecast of the future more accurate than the male-oriented think tanks. She sought out the "great men" and pieced together a view of the future more comprehensive and "wholistic" than most of them even dreamed of.

Her vision of the future has led her to a degree of self-actualization that is rare today. It has attracted her from a traditional woman's role to that of an activist, a writer, and a founder of the Committee for the Future.

For years news and opinion has carried the theme of pain. Because of its immaturity the human race has been proclaimed a failure. Because its cradle has sides the human race has been condemned to a closed system forever.

Barbara Hubbard has looked at the human race with an evolutionary perspective and saw us at a time of transformation toward global society and universal development, through the space program, the development of mind potential, and life extension. She waited years before NASA studies, humanistic psychology, and the biological sciences came together in such a vision with direct purport for public policy.

She believes that futurism must be politicized. People have a right to know their options. Neither party and no candidate is outlining the new possibilities to the electorate. Therefore, people are being denied a choice about their own future. It will be left to "experts" to decide.

Order from L-5 Society, 1620 North Park Avenue, Tucson, AZ 85719. Two hundred twenty-four pages, $8.95.

BIBLIOGRAPHY UPDATE

"MHD Propulsion by Absorption of Laser Radiation," L. N. Myrabo, *Journal of Spacecraft and Rockets,* Vol. 13, No. 6, August, 1976, pp. 466-472.

In this conceptual design for a laser-riding air-breathing single stage space shuttle which would use magnetohydrodynamic (MHD) forces to accelerate the engine working fluid, a gigawatt power-level photon beam delivered from an orbital laser power station would be focused by the shuttle craft onto internal engine working fluid to create, within an annular ionization chamber, a confined air plasma stationary wave.

While this may be technically feasible, the political feasibility of such a system (see L-5 News *debate on orbital lasers) is a real question not addressed in this article.* - K H

"Engineering a Space Manufacturing Center," Gerard K. *O'Neill, Astronautics and Aeronautics,* Oct. 1976, pp 20-28, 36.

This is an overview of NASA's 1976 Summer Study on Space Manufacturing. "Before the discovery of oil no one would have chosen to settle Alaska's Prudhoe Bay," states O'Neill. Likewise, he adds, "Even if space colonization for its own sake finds no appeal, it will follow as an almost inevitable consequence of any long-continued high orbital activity."

"The Outlook for Space Power," Jerry Grey, *Astronautics and Aeronautics,* Oct. 1976, pp 29-36.

In order to keep the bibliography as up-to-date as possible, we are now generating computer records of bibliographic information. An updated list will be sent out with each publication order, or on request ($1).

THE NETWORK

The Network is a clearinghouse for distributing information and for making contacts among persons interested in Space Migration, Intelligence Increase, and Life Extension (SMI^2LE).

The goal of the Network is to ease and speed communication which will evolve and expand the human experience into new areas of both inner and outer space, and have a good time doing it.

Members receive the newsletter *Neurolog,* plus reports and other publications of the Network. New members also receive *Neurolog* issues No. 1 and 2, and reprints from an earlier newsletter. Members who wish may also join Face to Face, a personal contact program.

Membership, $7 per year. Supporting Membership, $15; Eternal Lifetime Membership, $50. Mail to the Network, P.O. Box 317, Berkeley, CA 94701

FILMS ON SPACE

For those L-5 members who are interested in audiovisual material, many films on space are available for no rental charge, just payment of return postage and insurance, Members who want films for noncommercial showings should send in their request four to eight weeks in advance and include alternate dates. Write to the following addresses for more information.

NASA has 73 general audience films of from 12 to 28 minutes with color and sound. Eight regional centers handle distribution to nearby states.

National Audiovisual Center, Washington, DC 20409 -- for Conn., N.Y., N.H., Ver., Me., Mass., and R.I.

Modern Mass Media, Inc., 315 Springfield Ave., Summit, NJ 07901 -- for Del., D.C., Md., N.J., and Pa.

Langley Research Center, Langley Station, Public Affairs Office, Mail Stop 154, Hampton, VA 23365 -- for Ky., N.C., S.C.. Va.. and W.Va.

JFK Space Center, Public Affairs Office, Code PA-EPB, Kennedy Space Center, FL 32899 -- for Fla., Ga., Puerto Rico and the Virgin Islands.

G.C. Marshall Space Flight Center, Public Affairs Office, Marshall Space Flight Center, AL 35812 -- for Ala., Ark., Iowa, La., Miss., Mo., and Tenn.

L.B. Johnson Space Center, PTD Audiovisual and Motion Picture Production Office, Code JL-l31, Houston, TX, 77058 -- for Colo., Kan., Neb., N.M., N.D., S.D., Oka., and Tex.

Lewis Research Center, Office of Educational Services (6-3). 21000 Brookpark Road, Cleveland, Ohio, 44135 -- for Ill., Ind., Minn., Mich., Ohio, and Wis.

NASA Audiovisual Facility, 918 N. Rengstorff Ave., Mountain View, CA 94040 -- for Alaska, Ariz., Calif., Hawaii, Ida., Mont., Nev., Ore., Utah, Wash., and Wyo.

In addition, both the Lewis and Ames Research Centers have films of a more highly technical nature which are distributed nationally for university and industrial audiences. For a list of the 20 Ames films, write to the California address given above. The 81 Lewis films run from 4 to 40 minutes and are distributed from Lewis Research Center, Attn: Chief, Management Services Division (5-5). 21000 Brookpark Road, Cleveland, OH 44115.

Sources other than NASA:

Department of the Interior

EROS: Response to a Changing World -- 14 minutes, 1976, with color and sound. On Landsat and the EROS Data Center. U.S. Geological Survey, Branch of Visual Services, 303 National Center, 12201 Sunrise Valley Drive, Reston, VA 22092.

Department of Commerce

Pathfinders from the Stars -- 48 minutes, late 60's, with color and sound, about progress determining, position, and the satellite triangulation system. Three to six months notice is necessary. Department of Commerce, NOAA, 12231 Wilkins Ave., Rockville, MD 20852.

American Institute of Aeronautics and Astronautics

Slide shows accompanied by cassette narration, including one on Earth resources called *A View from Space,* 60 slides, 28 minutes. AIAA, 1290 Avenue of the Americas, New York, NY 10019.

"The Age of Space Transportation" is a twenty-minute color and sound film primarily concerning the Space Shuttle. While it is oriented toward general audiences, it can also be enjoyed by those who are more technically inclined.

"The Age of Space Transportation" ends on a breathtaking note, with exterior and interior views of the cylindrical O'Neill space colonies. This film can be used as an excellent lead-in to a lecture on space colonization.

The film is distributed free of charge by the AIAA. They request that you identify your group by letter, allowing at least thirty days to fulfill your request, to: Public Information Department, American Institute of Aeronautics and Astronautics, 1290 Avenue of the Americas, New York, NY 10019.

National Environmental Satellite Service branch of NOAA

Twenty-eight technical films on a variety of meteorological topics. Also a set of 43 slides co-ordinated with a 66 page text. Best interpreted by a weatherperson. Lending Film Library, Planning and Coordination Group, NOAA-NESS, Washington, DC 20233.

Films are also available to Alaska residents through the Department of

Audiovisual Education, University of Alaska, College, Alaska 99701 for a small fee. Hawaii residents can also write to the Audiovisual Service Section, Hawaii State Department of Education, Kahala Office Center, Room 103, 4211 Waialae Ave., Honolulu, HI 96816.

SPACE ORGANIZATIONS

THE BRITISH INTERPLANETARY SOCIETY

Membership of the British Interplanetary Society is open to all persons throughout the world. The present membership totals 3,000, one-third of whom reside outside the United Kingdom. Membership carries with it the following privileges:

(1) To receive either of the Society's monthly publications, *JBIS* or *Spaceflight* by post, free of charge.

(2) To receive the second of these publications at an annual subscription of £6.00 ($15.50).

(3) To attend lectures, meetings, symposia, exhibitions and film shows arranged by the Society free, or at a reduced registration fee when one is charged.

(4) To borrow recent books (within Great Britain) and Technical Reports (within Great Britain and W. Europe) from the Society's postal lending library.

The Society was founded in 1933 and became an Incorporated body in 1945. It helped to found the International Astronautical Federation in 1950 with the Society as the U.K. representative body. In 1967, it was registered by the U.K. Charity Commissioners. The Society's income, which is largely derived from membership subscriptions, is entirely devoted to promoting its aims through publications, lending library services, visits, meetings and international relations. The annual subscription is £8.50 ($22.00) for Ordinary membership, with higher rates for other grades. Further information concerning the Society's activities and grades of membership may be obtained from: The Executive Secretary, The British Interplanetary Society, 12, Bessborough Gardens, London, SWIV 2JJ. (Tel. 01-821-9371).

THE UTAH SPACE ASSOCIATION

Aurora is printed quarterly by the Utah Space Association, a nonprofit organization devoted to the ideas of space exploration and utilization. Meeting dates are listed in the calendar. Annual activity dues are $5.00 and corresponding memberships are $2.50. Write to J. David Baxter, 778 "I" Street, Salt Lake City, Utah 84103.

THE IMMORTALIST

The Immortalist, journal of the Cryonics Society of Michigan, Inc. is interested in publishing serious speculative articles about life in either the near or the far future. Articles may deal with any aspect of life in the future: technologies, social, governmental, or political forms, philosophical changes or "strange" lifestyles will all be of interest to us. The articles should however be serious speculation, in the sense that any suggested social form or technology should be somehow justified rather than arbitrarily stated. We specifically do *not* want fiction. An excellent example of the kind of thing we would like is the article in *1975 Analog* by the science fiction writer Larry Niven on the subject of where people might live if they did not live on planets. Articles such as that by T. A. Heppenheimer ("Astrolling the Astroturf") in May L-5 News are also good examples of what we would like.

The Immortalist is a small newsletter. Payment for articles will be in copies only.

The Immortalist is a general journal reporting all news of scientific advances or events in society bearing upon immortality. Readers will know of cryonics, which is the practice of freezing and storing people until they can be revived and rejuvenated. Articles however need not have anything to do with immortality.

Thomas Donaldson
Assistant Editor

inside the L5 Society

L-5 SMALL GRANTS SERVICE

Do you have a small-scale space-habitat research project that needs funding? The L-5 Society is organizing a small grant service to match good projects with willing donors. MIT Professor Gerard O'Neill has already obtained funding for a research assistant through the Society's matching service. Send written proposals to L-5 Small Grants, 1620 N. Park, Tucson, AZ 85719. Additional donors are appreciated as well!

L-5 FANTASY

from Not Man Apart, *publication of Friends of the Earth.*

There are gloomy environmentalists (present company excepted) prophecying the inheritance of the planet by the very meek-the cockroaches and microbes. There are the "serious" ludicro-scientific, like Carl Sagan, Gerard O'Neill, and the L-5 Society, with their multi-billion dollar plans for space colonies. Do not underestimate this fantasy. Just because it's silly doesn't mean it won't get funded-look at the breeder reactor! The L-5 Society's plans really tickle some very intelligent people's fancies. *National Geographic* recently ran a long spread, replete with full-color illustrations, on O'Neill's projected space colonies. It is obvious to environmentalists that these zero-gravity "plans" are based more on the style of science-fiction illustrations than on solid ecological thinking and planning. But they are powerful, none the less. More powerful, apparently, than all the press releases of environmentalists laid end to end. We have the New York Heavy Metal Sludge advancing on Long Island, but science fiction has giant locusts devastating Tokyo! We have smog alert over Los Angeles, but science fiction has giant blobs eating electricity in Westminster Abbey! We have an IBM copier, but 2001 has HAL! We have appropriate technology, and the L-5 Society has space colonies.

L-5 members might wish to consider the following letter by Dr. Michael Mautner as a model for constructive replies to articles such as the above.

Approximately two years ago, as my private circumstances permitted, I sought to become involved in civic activities for causes that merit the most urgent public attention at this time. It appears that at this point in history there exist real dangers for the survival of our species, and logically, all social progress is contingent on human survival. For this reason, I joined the FOE-NY activities and other efforts aimed at controlling nuclear power, which seems to pose the most severe danger to human survival. At the same time, the concept of space colonization started to receive public attention. It occurred to me that large numbers of self-sufficient, independent human societies present the best guarantee that the species, as a whole, will not end up as the victim of some act of technological suicide. It was additionally gratifying to find out that space colonization, via the construction of satellite solar power stations (SSPS), has the potential to become the ultimate, ecologically most benevolent energy source, supplying all the energy needs for the total world population indefinitely. The advantage of this form of solar energy use, as opposed to nuclear or coal power, is that it does not create radioactive waste or chemical pollution, and that SSPS power, transmitted in the form of microwaves to Earth receivers, creates about four times less thermal pollution than nuclear or fossil fuel sources. In addition, lunar and asteroid mining will become possible, thereby decreasing the burden on Earth resources. Thorough preliminary technical studies found no flaws in the feasibility of this option.

Because of these outstanding human and environmental prospects of space colonization, I was distressed to see several adverse references to this concept in NMA. I wish to suggest that Friends of

the Earth and other environmentalists give serious consideration to space colonization as opposed to other alternatives (war, hunger, overpopulation) that may well limit population on Earth in the long run in a much less humane manner.

Michael Mautner, Ph. D.

ACTIVE MEMBERS, TAKE NOTE

A letter was sent out recently encouraging active members to form local chapters of the L-5 Society in their areas, where no local chapters exist, or to join local chapters, if a local chapter has already been formed.

In those states with more than one member, a list of names for all the active members in the state was included with the letter. For those states in which there is only one active member, no lists were sent, obviously, since there was no one else in the state to include on the list. Those of you who received the letter and no list are not missing anything-you're just the only active member in your state.

So go out and get a couple of other people to join and form a local chapter. Then, next time, we'll send you a list, too!

VISITING L-5 STAFF

One of the most effective ways to have a hand in the policies of the L-5 Society is to come out and work on the staff. Members of the staff browse through the files, write and edit copy for the *L-5 News,* and write and edit responses to correspondence. The Tucson staff enjoys the fresh perspectives and additional expertise of visitors.

Free room and board for visiting staff is available with the households of Jim Kempf or Keith and Carolyn Henson. Write the Society to let us know when you plan to join the ruling clique at Headquarters.

"SPACE WORLD" CALLS FOR L-5 CONCEPT ARTICLES

Ray Palmer of *Space World* magazine says, "Tell the L-5 people we'd be happy to be an outlet for their movement, and will cover anything they want published in each issue. . . but it should be made clear we are on a very close budget and don't very often pay for articles." Palmer adds that color illustrations are especially appreciated.

Palmer can be reached at Tomorrow River Printers, Amherst, WI 54406.

"L-5 NEWS" CALLS FOR L-5 CONCEPT ARTICLES

Carolyn Henson of *L-5 News* magazine says, "Tell the L-5 people we'd be happy to be an outlet for their movement, and will cover *almost* anything they want published in each issue. . . but it should be made clear we are on a very close budget and don't very often pay for articles." Henson adds that black and white illustrations are especially appreciated.

Send news, articles and illustrations to L-5 News, 1620 N. Park, Tucson, AZ 85719.

L-5 NEWS - COLOR NEXT?

Many readers have complimented the staff on recent improvements in *L-5 News* quality. Where will it all end? Because the Society is a non-profit organization, income from memberships and donations has only one place to go-membership services.

An additional 30 new members per month (beyond our current 60-80 per month) would pay for a color cover, or 8 more pages of news and articles, or. . . .

Let us know how you think the Society can best use additional income.

Daniel Lomax, however, is reluctant to put color into the Newsletter. He worries, "Once they taste blood, . . ."

Color fans should jealously guard the right to open the next copy of *L-5 News* It is planned to contain a treat for our mail chauvinist readers.

If you are lecturing on the L-5 concept, let us know how many membership application flyers you can use and we will send some to you. Encourage your friends to join; don't let them get away with xeroxing your copy.

L-5 NEW YORK

The L-5 Society in New York is sponsoring a meeting November 8, 7:30 P.M., at the Rockefeller University Auditorium.

Bill Agosto will introduce the space habitat concept, and Professor Gregg Matloff will speak on "Space Habitats, a Resource for Energy Production and Deep Space Exploration."

The New York L-5 group is in the process of reorganizing; for more information about New York activities, including the upcoming meeting, call Elaine Meinel, (212) 996-6925.

L-5 NEWS FORMAT

As our readers may notice, this issue of *L-5 News* is "self-cover." That is, the paper on which the cover is printed is the same as the paper on the inside.

We had a cover planned, on closed environments in agriculture, but decided to hold it until next month, when we hope to have more information to publish on the subject.

Trying to pull forward our publication date also left us with not enough copy to fill a longer newsletter, and our financial position is still such that the economy of not printing a cover is important.

With approximately 600 members, it is still necessary for us to continue to expand in order to maintain membership services at the current level.

L-5 SOCIETY MEMBERSHIP FORM (please type or print)

NL610

L-5 SOCIETY
1620 N. PARK AVE.
TUCSON, AZ 85719

NAME: _____

COMPLETE ADDRESS: _____

AFFILIATION (OPTIONAL): _____

TITLE OR POSITION (OPTIONAL): _____

I am -- am not -- interested in being active locally.

__ Back issues of *L-5 News* available, $1.00 each.

__ Please enroll me as an L-5 Society Member. I am enclosing a check for $_____ (regular membership, $20.00; student membership, $10.00; memberships include subscription to L-5 News).

__ Enclosed find a donation of $_____ (donations to L-5 Society are tax-deductible).

letters

Powersat Microwaves, the Ionosphere, and the Biosphere. Many people that I have talked to about the space power concept have expressed a concern for the possible adverse effects of microwave absorption in the Earth's atmosphere. I have not been able to locate any detailed account of this problem in the literature; perhaps you can correct my ignorance. If definitive research has not been done in this area, the L-5 Society should encourage such research.

I am taking steps to become familiar with the physics of the upper atmosphere, and am even considering starting an undergraduate research project to study the problem. Studies of increased microwave exposure to biological systems should also be undertaken.

I believe that the Powersat development program should proceed in steps. An environmental monitoring program must accompany Powersat service. If microwaves create unusual structural changes in the atmosphere, service should be halted, etc.

The L-5 colonization program should not entirely depend on the economics of Powersats. I am glad to hear about the SAI team's intentions to study alternative economic programs.

If the L-5 Society does not express concern about possible environmental effects of its program, unneeded and destructive public criticism will result. We do not want to give anyone the impression that we want to escape the Earth and leave behind a microwave oven. Instead, we must subject ourselves to self-criticism many times over to design a project acceptable to all people who will be paying the price tag and receiving the benefits.

Possible Adverse of Low-Intensity Magnetic Fields on Biological Systems. In a book entitled "Proceedings of the Work on Extraterrestrial Resources" (NASA SP-177, 1968). page 6, a brief mention is made of this factor:

> The possible biological effects of the low lunar magnetic field are not known, but recent studies by Busby indicate that they may be significant. In an experiment in which mice were raised in magnetically shielded cylinders, abnormal behavior, loss of hair, and early death were exhibited after the first generation, and reproduction stopped after the fourth generation. Other experiments on human and animal subjects (including micro-organisms) have also produced indications of significant biological effects from low-magnetic-field strength. On the other hand, men working in lowstrength magnetic fields for several days at a time show no ill effects. Busby points out that much additional work in this field is needed before the possible effects of very long exposure to weak magnetic fields can be known.

There is a simplistic rationale for suspecting that Earth-evolved biological systems need an Earth-like magnetic field for proper functioning: life has evolved for billions of years in the Earth's field (which may be subject to polarity reversals and field strength variations). It has been suggested that the magnetic field provides spatial-orientation clues to bio-molecules, and figure in biochemical reactions as subtle, yet important, forces.

Perhaps L-5 members who are specialists in biology and biophysics will investigate biomagnetics.

Jeff Bytof
Cardiff, California

Hey, Leary's OK with me. . . .

Society name change? I'll agree on anything you choose, but "L-5" still gives me shivers so why change it? I vote *keep it.*

"L-5" does not own the idea of space colonies, and I am against squabbling over possession of the "gospel according to O'Neill." Look: the colony cultures will be far more diverse than homogeneous America-that's one of the sociological advantages. Think of all the real *wierdos* who left Europe in the 1600s and 1700s to "do their thing" in the isolated wilderness. I think the diversity of groups excited by the "forever frontier" is one measure of its tremendous cross-cultural pansocietal (just made that word up) appeal . . . and should be stressed, not restricted.

Jim Oberg
Dickinson, Texas

Just received Vol. 1, No. 13 of the *L-5 News.* Looks good. Of course I take exception to a few of Eric's [Drexler] remarks ["Another View"] but I respect his opinions because I think he is intelligent, thoughtful and honest. I do not want to write a rebuttal because I think the issues on which we have disagreed are symbolic rather than substantive and are hangovers from the intense group interactions of the summer of '75.

Charles H. Holbrow
Hamilton, New York

It states in the *L-5 News* that the L-5 Society will disband after realizing its initial, "to get tens of thousands of people living-and working in space." When the appropriate time comes and this goal has been accomplished, would you consider taking a full membership vote on whether or not to continue the important work of the Society?

I am sure that during the early development of space colonization there would be many new areas and problems L-5 could direct its efforts towards.

Robert Bartholomew
Whitehall, NY

Although we sometimes make the statement about disbanding, in fact it would require a two- thirds vote to dissolve the Society. D. L.