L5 NEWS

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NEW MOONS: Mining the Asteroids

All but the newest readers of the L-5 News are familiar with the "orthodox" aporoach to space habitation/industrialization. In this approach, the lunar surface is used to supply new materials, though mention is given to the later use of asteroids as richer sources of materials. The "heretical" approach skips the lunar surface and goes directly to the asteroids. Even more outrageous things will be reported in coming months-laser launched rockets ($2O/kg to geosynch) and high performance solar sails, etc. But for now ....

Towing Asteroids into Earth Orbits for Exploration and Exploitation

Special Session of the Eighth Lunar Science Conference, March 16, 1977 organized by Dr. David Criswell

Two recent developments encourage immediate consideration of the possibility of bringing asteroids into orbits about the Earth for exploration

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and exploitation:

(1) The distribution of crater sizes on the Moon, Mars, Mercury, and the Earth, and recent astronomical surveys indicate the possible existence of many thousands of asteroids larger than 100 meters in diameter in orbits approximately 1 AU (astronomical unit) from the Sun and with velocity differences with respect to Earth of approximately 3 km/second, or less. Retrieval of such asteroids requires 10 to 100 times less energy than for similar main belt asteroids located between Mars and Jupiter.

(2) The mass-driver, first proposed for ejecting soil pellets from the Moon, can be used in space as an electric rocket engine. A mass-driver coupled to a 100 megawatt power plant (possibly a solar array) could be assembled in low Earth orbit. Reaction mass necessary to propel the mass driver tug for the 3 to 9 month cruise to rendezvous with an asteroid could be obtained by pelletizing the oxygen/hydrogen tanks from the 30-50 shuttle flights necessary to lift the tug assemblies into low Earth orbit. After rendezvous, the tug would cruise back to Earth in 3 to 5 years using approximately 80 percent of the asteroid as reaction mass. Conceivably, the initial venture could return 10,000,000 metric tons of material to Earth orbit for less than 20 cents per kilogram (versus $1000/kg for shuttle and tug launch to geosynchronous orbit) by the mid-1980s at a cost of one to two billion dollars.

Scientific results of immense importance should result from studies of virtually unlimited quantities of the materials returned. Asteroids should provide considerably less altered samples of early solar condensates than obtained from the Moon or certainly from Mars. At long last cosmochemists can do "whole" rock analyses. Of far wider interest is the possible economic potential.

Speculative Scenario:

Between mid-1977 and 1979 intense ground-based and space (possibly using surveillance satellites) searches discover several Earth-crossing asteroids larger than 100 meters diameter, with small velocity differences with respect to Earth. A nuclear or solar powered tug is deployed by 1981 in the first major shuttle program, and asteroid rendezvous and docking occur in mid-1982. Automatic analysis of asteroid material supplied to the mass driver allows between 1982 and 1985 for design, fabrication and deployment of chemical processing equipment and manufacturing machinery. People, machines, and the asteroid rendezvous in high Earth orbit in 1985. Now hollowed-out, the asteroid provides raw materials for construction of space solar power stations of three trillion watts output and simultaneously a shelter against radiation for workers. (Presently, the U.S. consumes 500 billion watts per year and needs 60 billion watts per year of new electrical generating capacity.) The first remotely located ground/sea stations are designed to receive very high microwave beam densities from the space platforms in order to speed construction, lower costs and allow industrially significant production of synthetic fuels for immediate input to the U.S. tanker and pipeline networks starting in 1987. They will meet all demands for new energy supplies for the U.S. by 1990.

L-5 in Congress

Testimony of Dr. T. Stephen Cheston, Associate Dean, Graduate School, Georgetown University, Before the Science and Space Subcommittee, Committee on Commerce, Science and Transportation, United States Senate, March 17, 1977

Senator Stevenson and Members of the Committee:

I appreciate very much your invitation to share with the Committee observations on developments related to the proposed NASA budget.

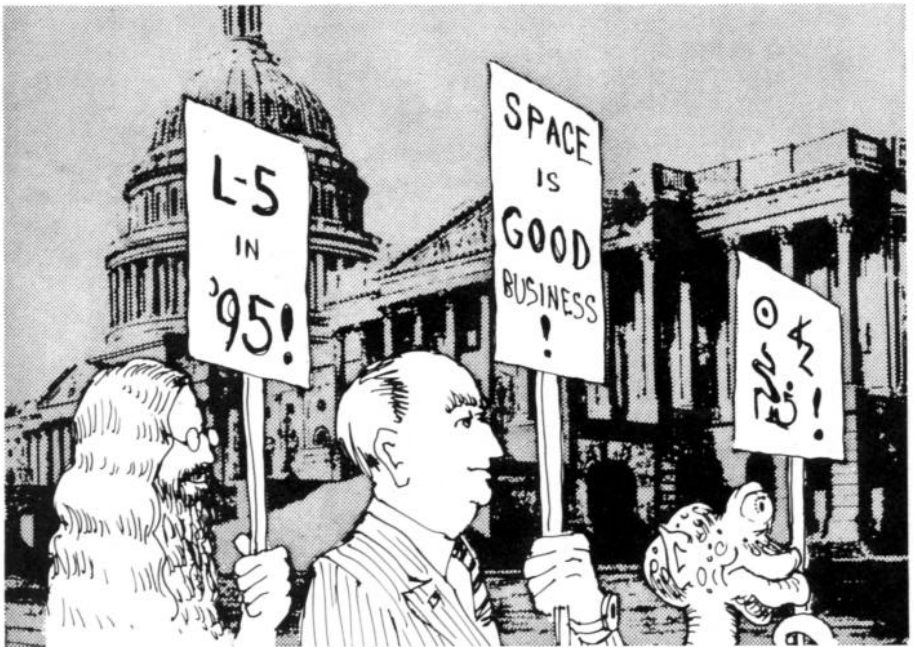
My principal intention is to invite the Committee's attention to two new groupings that are emerging in regard to space development. One is oriented towards educating public opinion, while the other is primarily academic and university-based.

I would like to begin by outlining very briefly the background of support for space endeavors, albeit in a very simplistic fashion. Surveys have concluded that popular support for space during the 1950s and 1960s arose from the public's desire to have the United States preeminent in its competition with the Soviet Union. Space was a symbol of national prestige and U.S. progress in this area polished the American image around the world. This support provided the backdrop for the development of the well-sized space enterprise that begat substantial labor and industry involvement. These interests, in turn, became advocates of space for the obvious reasons that it provided jobs and company earnings. With the winning of the race to the Moon, the force of public support for space dissipated to a large degree and left advocacy for space development primarily in the hands of labor, industry and professional groups who were its immediate beneficiaries. These latter groups were not sufficiently strong to protect NASA in the early 1970s from fairly substantial budget reductions and a major debate over the efficacy of the Space Shuttle.

In the mid-1970s, however, a subtle but significant change began to take place. New concepts emerged focusing on the utilization of space that triggered interest and support for space development from groups and individuals who had not been previously involved in it. I wouldcount myself among them. In this regard, I think we should take a special note of the work of Gerard O'Neill, Professor of Physics at Princeton University, on space manufacturing/colonization, Peter Glaser of Arthur D. Little, on the satellite solar power stations, and Krafft Ehricke of Rockwell International, on space industrialization. Their work gained prominence for the first time, or renewed prominence in the case of Peter Glaser, in the wake of the environmental and "limits to growth" concern about the outcome of the exponential growth of our current industrial patterns. Unhappy conclusions were being drawn about the future of our society and creative thinking was necessary to come to grips with these critical issues in a substantive way. Creative thinking came from O'Neill, Glaser, and Ehricke, who posed ways to partially solve the problems of pollution and resource depletion by moving at least some of our industrial capacity into space. I won't go into any specifics about their concepts on the assumption the Committee will receive this information from other sources. I will just say that these concepts have caused space to be looked at in an entirely different light than before, and it is viewed this way by groupings in our society that are only now beginning to manifest their interest.

The first of these new groupings is fairly well-articulated and identifiable. It is the various coalitions of individual citizens that have united their resources and energies to educate the public on the potential of space. They are kind of "Common Cause" organizations for space development and reflect deep grass-roots interest. Some of these coalitions are propelled in part by youthful energy that is somewhat reminiscent of the anti-war movement of the late 1960s and at times are strange combinations of disparate sectors of our society. They combine under single organizational roofs elements that remind one of counter-culture/radical activism, with senior officials of industry, whose hallmarks are restraint, caution and conservatism. They combine utopian visionaries with pragmatic bureaucrats whose primary concern is next year's budget.

A group of this sort that I have concrete knowledge about is the L-5 Society, based in Tucson, Arizona. It came into being in July, 1975, with the professed goal of educating the public about space industrialization, satellite



solar power and space habitats. It has over one thousand members and is growing rapidly.

Some youthful members in these public education organizations have difficulty in understanding why the United States does not immediately devote vast resources toward these goals. . . . For the most part, however, the membership of organizations such as L-5 are very realistic, seeking common-sense solutions to resource and environmental problems through the utilization of space. They are a healthy force on our body politic.

The important element here is that these citizen groups did not exist until very recent/y and they are growing. It is not unreasonable to expect that they will develop some political force, but the level to which it will develop is a matter of debate and conjecture at this time. However, it should be recognized that this force is now in its embryonic state.

As mentioned before, the focus of these citizen groups is on the industrial utilization of space and this activity is reflected in various areas of the NASA budget. First among these, of course, is the Space Shuttle. It is the key to access to orbit at commercially tolerable costs. No doubt the Committee has heard about the value of the Shuttle as an economically acceptable space transportation system from other sources and in detail. I won't belabor the point, but only add that many in the citizen groups I have noted look upon the Shuttle as one of the wisest investments in the nation's history.

At this time, NASA does not have a separate and so-named organizational entity to coordinate space industrialization efforts. The Office of Space Flight Operations has assumed this responsibility and is approaching its tasks in this area with a great deal of dynamism. However, I believe that it might be advisable to develop formats for tighter coordination of programs related to space industrialization which may entail establishing a new, high-level office within NASA that would enjoy wide ranging authority. This might be an item worthy of the Committee's attention during the upcoming year. In the meantime, the following sectors of the proposed NASA budget cover activities that are directly relevant to the progress of space industrialization:

I. Space Flight
  Space Flight Operations
    Advanced Programs
    Planning and Program Interaction
I I. Space Sciences
  Life Sciences
I I I. Space Applications
  Materials Processing in Space
  Space Communications
IV. Aeronautical and Space Technology
  Space Research and Technology
    Research and Technology Base
    Systems Studies
    Systems Technology Programs
    Experimental Programs
    Low-Cost System Programs
V. Energy Technology Applications

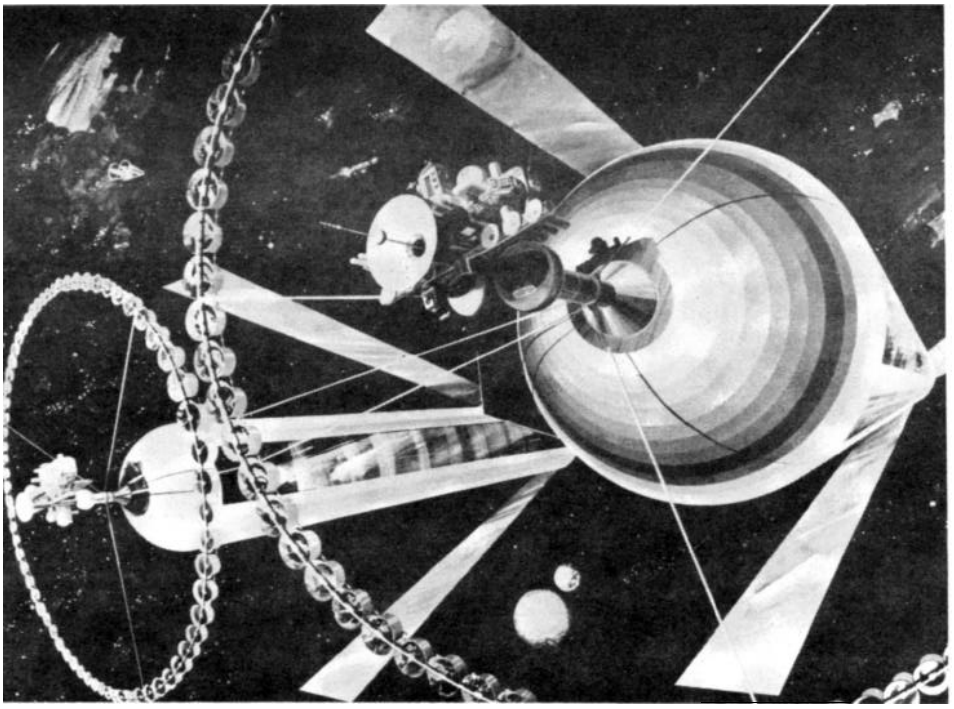
There is an additional item in the budget related to the industrial utilization of space that deserves the Committee's attention. In the FY '78 budget, there is $1 million for Satellite Solar Power Systems under Energy Technology Applications. Presumably ERDA was to take up fiscal responsibility for these activities in accord with the recommendation of the ERDA Task Group on Satellite Power Stations, which called for funding SSPS at either $3.25 million or $5 million per year for the next four years. The work in this area would be undertaken through the joint ERDA/NASA Coordinating Committee. However, in ERDA's FY '78 budget there is only $200,000 for SSPS.

Consonant with the basic thrust of the recommendations of the ERDA Task Group, the House Subcommittee on Space Science and Applications increased the FY '78 authorization for Energy Systems/Satellite Solar Power Systems by $5 million to support much needed further study on system definition and to initiate a comprehensive environmental impact and benefit analysis of SSPS. I believe the House action is a valuable contribution to advancing research on this promising area of future energy production and deserves serious consideration.

The second new grouping that I would like to bring to the Committee's attention has no specific shape and at the moment is of ill-defined size, but draws its members from the academic and intellectual community related to the social sciences and the humanities. These individuals, for the most part, have not been previously involved or even interested in space development. They passed through the Apollo era as passive observers and took no specific initiative to participate in it. They did not at that time exhibit the spontaneous, genuine interest that is the well-spring for new activities. This, however, is now changing, albeit still on a very modest scale. The Glaser, Ehricke, and most especially the O'Neill concepts have caused these academics to begin looking at the potentials of space from the perspective of a variety of disciplines. Anthropology, sociology, history, psychology, architecture, political science, law, economics, geography, ecology and international relations are being brought to bear on these concepts by spontaneous individual action rather than program initiative from NASA. Dr. O'Neill's correspondence now runs well into the thousands, with many of the letters coming from social scientists and humanities scholars. Concrete manifestations of this interest have taken such form as a course in space colonies now offered at the University of North Florida and a faculty working group at Georgetown University to look at the possibilities of developing faculty seminars, graduate and undergraduate courses and a scholarly journal on space industrialization and its impact on society.

In looking at the dialogue that is emerging on space development, one gets a sense that the academics feel that something is up and that it is important -- important enough for at least some of them to begin to examine the new directions of this industrial development which they perceive as beginning to take form in the 1989s and 1990s. They recognize that the "Copernican Factor," as I call it, is beginning to seep into our industrial thinking and that it is only a matter of time before it becomes a

(Continued on Page 12)



(1) Exterior of a possible "Island Three" space community. Living areas, agriculture, and industry, though located within a few miles of each other, have separately chosen temperature, climate, day-length, and gravity. (R. Guidice, NASA)

islands in space

Excerpt from The High Frontier, *Gerard K. O'Neill, William Morrow and Co., Inc., 1977. By permission.*

Over half of the people in the Society haven't yet ordered O'Neill's The High Frontier *from us! We hope it's because you have convinced your local bookstores to carry this incomparable treatise on the human future in their front window by descending upon them in a book-buying frenzy. Those few of you who haven't obtained the book by one method or another are missing something! Following is a choice excerpt- for the rest of the picture, dash down to your nearest bookstore or dump an order in the mail to the L-5 Society. - C H*

I have argued that there is only one way in which we can develop truly high-growth-rate industry, able to continue the course of its development for a very long time without environmental damage: to combine unlimited solar power, the virtually unlimited resources of the Moon and the asteroid belt, and locations near Earth but not on a planetary surface.

I will describe first a community of what I like to call "moderate" size; it is larger than the first model habitat, but far below the dimensions of the largest that might be built. "Island Three" is efficient enough in the use of materials that it could be built in the early years of the next century. The numbers will seem staggering, but they are backed by calculation: within the limits of present technology "Island Three" could have a diameter of four miles, a length of twenty miles, and a total land area of five hundred square miles, supporting a population of several million people. The largest communities that could be built, within the limits of ordinary, present-day structural materials like iron and aluminum, and with oxygen pressures equal to 5,000 feet above sea level on Earth, could be about fifteen miles in diameter, seventy-five miles long, and could have a total land area of as much as seven thousand square miles; about half that of Switzerland. It would be uneconomic at first to build habitats that large; they would be wasteful of materials. In the long run, though, the human race may build habitats of that size, or, with more advanced technologies, even larger.

We need to provide gravity, water, land, air, and natural sunshine in an Earthlike environment. Rotation can simulate gravity, and fortunately there are at least two geometries that allow rotation while giving us the real Sun stationary in the sky. One is a coupled pair of cylinders, whose long axes are parallel to each other (Figure 1). The cylinders are closed by hemispherical endcaps, and contain oxygen. Each cylinder rotates about its long axis, so that people living on its inner surface feel an Earth-normal-gravity.

The cylinder circumference is divided into six regions, three "valleys" alternating with three arrays of windows. By locating three large, light planar mirrors above the windows, and pointing the cylinder axes always toward the Sun, we can arrange that the valleys will receive natural sunshine, and that the Sun will appear motionless in the sky even though the cylinder is rotating. Varying the mirror angle will give dawn, the slow passage of the Sun across the sky during the day, and sunset. The day-length, weather, seasonal cycle and heat balance of the colony can be regulated by the same schedule of mirror-angle variation. A large paraboloidal mirror at the end of each cylinder can be collecting solar energy twenty-four hours per day, to run the community's power plant.

If we then set up many smaller cylinders near the big ones, and use the small ones for the growing of crops, we will achieve what has never been possible on Earth: independent control of the best climates for living, for agriculture and for industry all within a few miles of each other.

The "valley" areas, in Island Three, would each be two miles wide and twenty miles long, rising beyond that to mountains. These mountains, formed on the inner surfaces of the cylinder endcaps, could have a height of up to 10,000 feet (Figure 2).

In the simplest version of a space-community design, sunlight will be reflected into the habitat by large plane-surface mirrors, attached by many cables to each rotating cylinder and rotating with it. A dweller in one of the valley areas will look up and see a blue sky, obtained probably by art rather than by nature. It will be rather easy to control the reflectance of the mirrors and the tinting of the windows ("solars") to produce the most pleasing combination of warmth and brightness for the sunshine falling on the valleys, and to give a blue tint to the solars. There will be no sensation of rotation, though the cylinder will be turning once every two minutes; gravity in the valley areas will be Earth-normal. No one in the space habitat will be in any doubt as to where he is, though: high above him, far above the clouds at a height of 20,000 feet, he will see, dimmed by distance, the other two valleys of his home. From that far away they will be as indistinct in detail as the Earth's surface is from an aircraft four miles high, but the inhabitants will be able to see them.

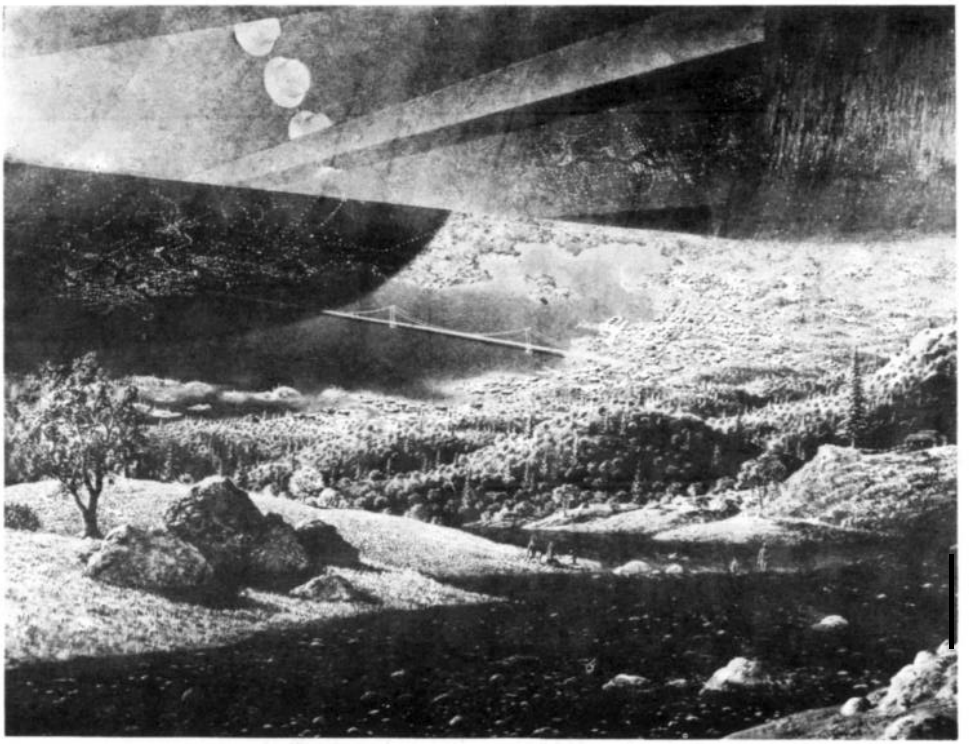
The angle of the sunlight entering the habitat will be controllable, and will depend only on the lengths of the cables which hold the mirrors. As the mirrors slowly open in the morning, the Sun will rise, but will move in the sky only as fast as it does on Earth; there will be no suggestion from its appearance that the cylinder is actually rotating. Only with very delicate instruments could one find

that the image of the Sun's disc is rotating around its center.

With control over the angle of the Sun in the sky, the residents of space will also have control over the lengths of their days, the variation of the day-length, and so the average climate and the seasons. They are unlikely to indulge in any sudden or capricious changes in those variables. Humans can adjust quickly, as the jet age has shown us, to changes in the day/night cycle and the climate; plants and trees, though, are not so adaptable, and once a cycle has been established there will be good reason to make changes in it only very slowly.

By the time a community as large as Island Three is built, space habitats may not be occupied at the ecological limit: the highest population density that the land can support. In the early years of the next century Earth will be from two to three times as crowded as it is now, and the population density in space habitats may be falling toward the same value as that of Earth, ultimately to cross it and fall still lower. Island Three, however, could support quite easily a population of ten million people, growing its food in agricultural cylinders near but outside the main habitat. In the figure of habitat cost per person, I will assume that higher density. We are used to the perpetual conflict, here on Earth, between industry, agriculture, and living space, but we must realize that in a space habitat economics will dictate escaping that conflict by locating agriculture a few miles away from the living areas. It is relatively expensive in materials to build large cylinders, with diameters of several miles, and relatively expensive to provide sunlight of normal appearance. Plants do not need such luxuries, and can be grown very efficiently in places where the solar intensity is high, but where there are no visual amenities.

With industry and agriculture located outside, the dwellers in Island Three can use their two hundred and fifty square miles of land area for living space and recreation. I suspect that as colonists from various countries of Earth arrive to settle the many communities in space, there will be a great variety in the ways in which land area will be used. Some immigrants may choose to arrange their land area in small villages, with single-family homes, the villages being separated by forests. Others may prefer to build small, intimate towns of high population density, to enjoy for example the color and excitement and human interaction that is so much a feature of small villages in Italy. With many new communities to choose from, the emigrants from Earth will settle in those they like best. I would have a preference, I think, for one rather appealing arrangement: to leave the valleys free for small villages, forests, and parks, to have lakes in the valley ends, at the foot of the mountains, and to have small cities rising into the foothills from the lakeshores. Even at the high-population density that might characterize an early habitat, that arrangement would seem rather pleasant: a house in a small village where life could be relaxed and children could be raised with room to play; and just five or ten miles away, a small city, with a population somewhat smaller than San Francisco's, to which one could go for theaters, museums, and concerts.



(2) A possible interior landscape for an "Island Three" community. Artist's view is from a hillside high on an endcap, looking over one of the valleys. (D. Davis, NASA)

HOW FARE WOMEN SCIENTISTS?

The number of women employed full time as scientists and engineers by universities and colleges reached 35,900 in January, 1976. This was the second consecutive year that their numbers have increased by five percent. Men, still far outnumbering women, totaled 194,000 in 1976, but their rate of increase was only two percent in each of the last two years, according to findings reported in the National Science Foundation's *(NSF) Science Resources Studies Highlights.* Also, despite the higher growth rate for women, there has been little change in their share of the full-time scientists and engineering total-up from 15 percent to 16 percent between 1974 and 1976.

The Commission on Human Resources of the National Research Council also reports that women PhD.s in science and engineering continue to make less money and find themselves out of work more often than their male counterparts.

According to the 1975 profile, the median annual salary for all men and women doctoral scientists and engineers was $23,000, with engineers earning the highest median salary -- $25,000. The median salary for men was $23,000, while the median for women was only $19,000. Female doctoral engineers fared slightly better: their median salary was about $21,000, compared to over $25,000 for male engineers.

The 1975 report also shows a 3.0 percent rate of unemployment among female science and engineering PhD.s, compared to 0.8 percent for men. However, there is a slight improvement over 1973 figures when this job market showed 3.9 percent unemployment for women and 0.9 percent for men.

ON THE O'NEILL SPACE COLONIES

Ju!iann M. Forman

A glowing ring of fire
thrown wide and free
cradled in black
it calls to thee.

Come work and live
come breathe and run
rotating
revolving
held by thread of gossamer
tied to Earth and Sun.

Quiescent, the silver ring waits
animation. Questing, the ship
probes slowly within.
The ring fills with life.

"'Home," comes the whisper.
Home, and thereby
hope springs eternal
that man not die.

Waste Heat Rejection Methods for Space Habitats

Given we have large scale space communities, how do we keep them cool? Air conditioning technology applied on a macro-level provides two possible answers.

H. K. Henson

[Author's note: The following article is by no means the last word on this subject. It was written for a class on space agriculture mostly to illustrate the use of physical and economic models Cost figures are arbitrary.]

In a space farm, virtually all of the incoming energy, in the form of sunlight or electricity, will wind up heating the air. The Stanford torus, for example, has about 80 square meters per person of living space, illuminated to an average level of 500 watts per square meter, or about 40kw. per person.' Most of the heat load, 90 percent or more, is from crop illumination. The alternative to growing food is importing food, scrubbing the carbon dioxide from the air and adding oxygen from the industrial plant. One or two percent of the energy falling on crops is converted into stored chemical energy. However, this is balanced by an equal amount of heat being returned to the system through the metabolism of food and waste being burned for carbon recovery.

Consider then the problem of disposing of this 40kw. per person, or 400,000kw. for a colony of 10,000 people. Forty kw. is the equivalent to melting eleven tons of ice per day. This "ton," 12,000 btu per hour in the English system, is a commonly used measure in air conditioning. To get a feel for the size of the problem, the University of Arizona with 35,000 students has about 7,000 tons of air conditioning capacity. The space farm with only 10,000 people will require 110,000 tons!

The only way to dispose of large amounts of heat in space is by radiation. The radiation rate is given by:

$$R = erT^4$$

Where: R is the radiated energy in watts per square meter, e is the emissivity of the surface, r is the Stefan-Boltzman constant, (approximately 5.67 x 10^{-8} watts per square meter-degree K^{-4}).

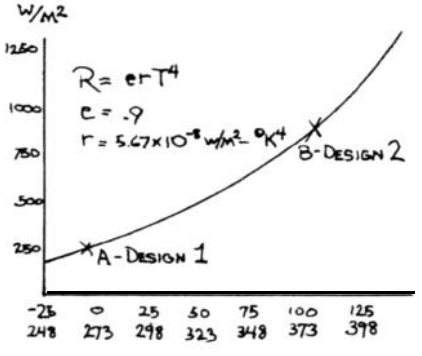


Figure 1

Surfaces with emissivity of 0.9 are not hard to produce. (The graph Figure 1 is radiated heat vs. T, for e = 0.9.)

It becomes apparent that, even though the emitted energy is a function of T^4, the range over which we are interested is so small that the effect is almost linear. There is little reason for air conditioning temperatures to go much below freezing (O°C) and the upper temperature (125°C) is determined by the energy considerations and available air conditioning technology.

Two radiator systems will be designed and compared: a low temperature or "passive" system which operates at point "A" on the graph, and a high temperature or "active" system operating at point "B." Costs are determined from Table 1.

Table 1 – Cost Standards

Lunar Oxygen	$ 5/kg
Lunar Aluminum (simple shapes only)	20/kg
Earth-L-5 Transportation	200/kg
Electric Power	2000/kw

First, let's consider a design for an inside portion of the system which could be connected to either radiator system. A chilled water air conditioning system has advantages in that the heat exchange medium is non-toxic, non-combustible, and has high conductivity and specific heat, the technology involved is well developed, and with rotating joints it would be easy to separate the rotating section of the space farm from the non-rotating radiator.

Some of the disadvantages of this system are that large amounts of expensive water are required and that the lowest temperature is not very low. This makes large and thereby costly heat exchangers necessary. The standards[2] used in the design of the heat exchangers within the farm are: 8 feet per second velocity water flow; 2 gallons per minute per ton of capacity flow rate; 150 kg of heat exchanger per person; 1 kw. blower power per person.

With these numbers, and the dimensions of the Stanford torus, we can compute the materials needed and the cost per person.

1000 kg of water @ $25/kg	$25,000
150 kg of heat exchanger @ $200/kg	30,000
1 kw. of blower energy @ $2000/kw.	2,000
Total per person	$ 57,000

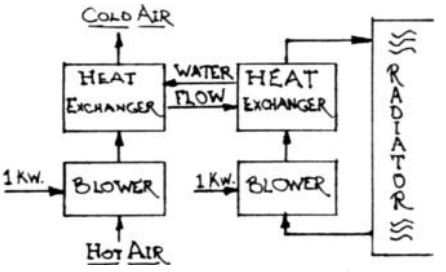


Figure 2A

Now let us consider two methods of disposing the heat which our conditioner accumulates, a passive system (2A) and an active system (2B).

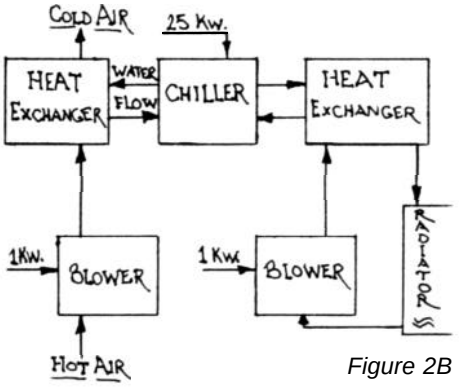


Figure 2B

Design one, the low temperature system, operates at -8°C average temperature and radiates 250 watts per square meter. The area required per person then is 80 square meters (both sides are used) or 800,000 square meters for our population of 10,000. This is equivalent to a square almost 900 meters on a side! A reasonable minimum thickness would be approximately one percent of the linear dimensions, or 10 meters. The radiator must be filled with something to transfer the heat, and since oxygen is inexpensive, let's fill it with oxygen at 5 psi. This way we can work within it when repairs are required due to meteor holes. In section it might look like Figure 3.

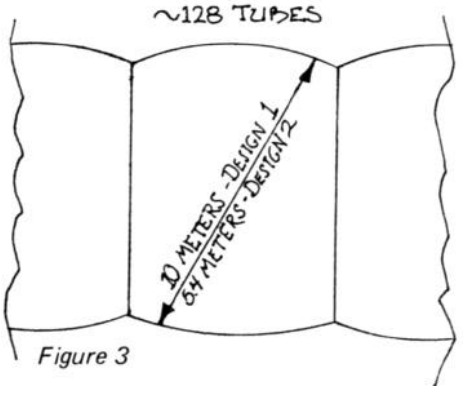


Figure 3

The aluminum required to hold 5 psi in this configuration would have an equivalent thickness of .9 cm or .35 inch. More calculations yield:

1940 kg of Al @ $20/kg	$ 38,800
312 kg of oxygen @ $5/kg	1,560
subtotal	40,360
150 kg of heat exchanger @ $200/kg	30,000
1 kw. of blower power @ $2,000/kw.	2,000
subtotal	32,000
total	$ 72,360

The high temperature design radiates four times as much heat, 1 kw. per square meter at an average temperature of 373°K (100°C). Due to the energy added by the chiller (25kw. per person), the total heat radiated per person is 65kw., which implies an area (two sided) of 37 square meters. This is 46 percent of the area of the low temperature design and only about 30 percent of the mass. (Corresponding to a square 610 meters on a side). Using a thickness of 5.4 meters and scaling from the low temperature design we get:

540 kg of Al @ $20/kg	$ 10,800
86 kg of oxygen @$5/kg	430
subtotal	11,230
150 kg of heat exchanger @ $200/kg	30,000
250 kg^3 of chiller @ $200/kg	50,000
26 kw. of power @$2,000/kw.	52,000
subtotal	132,000
total	143,230

or about twice as expensive per person.

So, for this example, with the choice of cost factors we made, the cost indicates that the low temperature heat radiator system is superior. Building the chiller out of lunar materials and lower cost power would, however, change the picture.

References:

1. NASA SP-431, p. 85,98.
   Note: Page 85 gives 1000 w/m^2 for agricultural areas approximately one-half of the total, 200 w/m^2 for residential and 50 Mw. for electricity -- approximately 37 kw. per person. Page 98 gives 131 Mw. total or 13.1 kw. per person.
2. Personal communication with T.F. Walker.
3. Mechanical Estimator Handbook, 1976.

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Economical Orbit: SSoar--A Freighter to Space. Earth/Space Press, 1976.

Carolyn Henson

Interested in the potentials for free enterprise activities in space? This document contains much of value to the hopeful space entrepreneur. To quote Paul Siegler, President of Earth/Space:

> Earth/Space has assembled this document in the hope that it will demonstrate the promise of space to you as a consumer, businessman, or interested individual. When people describe the potential of space only in terms of the scientific advantages to be gained, or as an arena in which strategic control can be assumed, we believe they are mistaken. Our philosophy is that space can be-and will be-used to bring material benefits as well as a sense of adventure to those who live on Earth. Opening up space to peaceful uses by individuals, groups, and nations will enrich our lives in many undreamt ways. Some of the benefits-such as excursions into orbit by small, inexpensive launch vehicles-will soon be visible, promising to put spaceflight within the grasp of thousands. This report will explore the benefits of space and a means of gathering them.

The primary purpose of the document is to describe SSoar (Single Stage to orbit and return), a space vehicle first conceived by Phil Bono, a leading Douglas engineer, in the early 1960s. However, even those who are not transportation buffs will find the sections on subjects such as "Survey of Major Corporations on Space Industrialization," "The Market Potential for Space," "Space Applications for Profit Near Term," "International Law and the Private Launch Corporation," "Space Treaties," etc., to be a valuable compendium of space-oriented information. Hard-bound copies are for sale for $25 each from Earth/Space Press, 4151 Middlefield, Palo Alto, California 94303.

"O'Neill's Space Colonies: An Ecological Solution That's Out of This World," Conway Marsh, *Cosmic Frontiers,* Vol. 2, Issue 1, pp. 54-59.

"Ecological Considerations for Space Colonies," *CoEvolution Quarterly,* Winter, 1976/77, pp. 96-97.

"Salyut-4: The Space Race of Lazarev and Klimuk," James E. Oberg, *Spaceworld, Nov.* 1976, Vol. M-11-155, pp. 4-29.

"A Programme for Interstellar Exploration," Robert L. Forward, *The Journal of the British Interplanetary Society,* Vol. 22, No. 10, Oct. 1976, pp. 611-632.

NEW PUBLICATION ABOUT THE MOON

A new publication entitled *What's New on the Moon?* has been produced at NASA Headquarters. The author is Dr. Bevan M. French, Program Chief, NASA Extraterrestrial Materials Research Program. A geologist, French has studied lunar samples and terrestrial meteorite craters for more than ten years. The booklet, replete with dramatic photographs and diagrams, reviews the events that led to Moon landings and delineates many of the findings that resulted from Apollo missions to the Moon. The booklet is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 as Stock No. 033-000-00653-5. A single copy is $1.00; multiple copies are S.70 each. The text with colored pictures is to be published in the March and April issues of *Sky and Telescope.*

BORROW A PIECE OF THE MOON

NASA has prepared a sample package containing thin sections of lunar material for student and faculty use. The purpose of this program is to broaden the use of the lunar sample collection for scientific and educational purposes. On a first-come, first-served basis, the Thin Section Educational Package is now available to any academic institution offering undergraduate or graduate courses in the geosciences. NASA is also working on a distribution plan for both junior and senior high school levels. For additional information contact: Dr. Michael Duke, Lunar Sample Curator, Code: SN2, Lyndon Johnson Space Center, Houston TX 77058. Telephone (713) 483-4464.

INTERNATIONAL VIEW

EQUATORIAL NATIONS CLAIM GEOSYNCHRONOUS ORBIT PORTIONS

Representatives of Brazil, Colombia, Congo, Ecuador, Indonesia, Kenya, Uganda, and Zaire met in Bogota, Colombia from November 29 through December 4, 1976, for the purpose of studying "the geostationary orbit that corresponds to their national terrestrial, sea and insular territory and [is] considered as a natural resource."

They concluded that "the segments of geostationary synchronous orbit are part of the territory over which equatorial states exercise their national sovereignty. The geostationary orbit is a scarce natural resource, whose importance and value increase rapidly together with the development of space technology and the growing need for communication; therefore, the equatorial countries meeting in Bogota have decided to proclaim and defend, on behalf of their peoples, the existence of their sovereignty over this natural resource."

The equatorial nations have cited Resolution 2692 (XXV) of the United Nations General Assembly entitled "permanent sovereignty over the natural resources of developing countries and expansion of internal accumulation sources for economic developments," as a basis for their claim, as well as Resolution 3281 (XXIX), Article 2, sub-paragraph i, which reads: "All states have and freely exercise full and permanent sovereignty, including possession, use and disposal of all their wealth, natural resources and economic activities."

While the Equatorial nations will "not object to the free orbital transit of satellites approved and authorized by the International Telecommunications Convention, when these satellites pass through their outer space. . . outside their geostationary orbit," they have decided that "the devices to be placed permanently on the segment of a geostationary orbit of an equatorial state shall require previous and expressed authorization on the part of the concerned state, and the operation of the device should conform with the national law of that territorial country over which it is based."

The equatorial nations have dismissed the Treaty of 1976 on "The Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," saying that "There is no valid or satisfactory definition of outer space that may be advanced to support the argument that geostationary orbit is included in the outer space," adding that "what was actually developed was technological partition of the orbit, which is simply a national appropriation, and this must be denounced by the equatorial countries.

Needless to say, this development could cause some complications for communications and solar power satellites!

UN DIGNITARY ON POWERSATS, SPACE SETTLEMENTS

Based on an interview conducted by Elaine Meinel in New York on February 2, 1977, with the Austrian Ambassador, Herr Jankowitsch. Chairman of the UN Committee on the Peaceful Uses of Outer Space.

In our anxiety to persuade the United States government to support an active space program, we tend to forget the international implications and legal entanglements such a program creates. The UN Committee on the Peaceful Uses of Outer Space was first formed in 1957 after the Soviet Union launched the first sputnik. In 1967 a Space Treaty was ratified by the General Assembly. It was a rather general document which states, in essence, "The use of outer space shall be for the benefit of all nations, irrespective to the stage of their development and shall be the province of all mankind . . . no nation may engage in orbital military activity, nor shall any nation engage in environmentally detrimental activity, and that all participating nations shall keep the UN Secretary General informed as to all space activities and plans."

So far, the Committee on the Peaceful Uses of Space has had a low profile since there has been little activity of a commercial nature in space outside of communication satellites so the tension and controversy which has created difficulties for the Sea Treaty has not yet characterized sessions dealing with Space Treaties. Realizing the old treaty was insufficient for dealing with recent advances in space technology, the Committee is presently attempting to draft a new Moon Treaty which, because it is very similar to certain aspects of the Sea Treaty, will not be sent out of committee until the Sea Treaty is completed, which may be sometime in 1980.

Just as much of the resources hidden under the ocean are effectively out of the reach of the developing nations, so to even a greater degree, the Moon's resources are beyond their grasp. Ambassador Jankowitsch pointed out that the establishment of space colonies would really raise a number of problems since the construction of such facilities would be the equivalent of establishing a national territory in space. Already the countries which lie on the equator have held a meeting in December in Bogota, Colombia, where they decided that any artifact, regardless of use, which is set in a geosynchronous orbit over their national boundaries is within their jurisdiction so they may decide what orbits where and perhaps charge rent or whatever for the privilege of using these orbits. Ambassador Jankowitsch had no comment as to how the committee shall deal with this proposition, but he is confident it will not prove to be a stumbling block for the new Outer Space Treaty.

Not that we can ignore the needs of the Third World, cautions the Ambassador. After all, the industrialized nations have greatly depleted most of the easily accessible resources to fuel the development of their economies, leaving little behind for the newer emerging nations. Today it requires great skill and technological know-how to reach and use the same materials and this is beyond the abilities of the Third World, so if countries such as the US, even if they are working on an international basis with, say, Austria or Japan, were to mine the Moon, there would have to be a way for these other nations to get into the act.

One other thing the Committee is doing which touches upon the subject of trying to help developing nations is to encourage the development of solar energy. The Chairman first heard of the L-5 Society because it supports the development of Satellite Solar Power Stations and he hopes that this power will be available for his own country, Austria. But because the technology behind the SSPS is so advanced, it would be difficult for the developing nations to use, so his committee has been encouraging the development of solar energy plants which could power villages and such. Although the UN Committee cannot fund such projects, it may prove to be instrumental in encouraging the richer nations such as Saudi Arabia to underwrite research for this project.

Most of all, Ambassador Jankowitsch would like to see space colonies some day because then his committee shall have a lot to do!

SOVIET MISSION CUT SHORT

James Oberg

The manned portion of the Salyut-5 mission appears to have ended with the unexpectedly brief Soyuz-24 visit in February. Although observers had expected cosmonauts Gorbatko and Glazkov to remain in space for at least two months, they returned to Earth after only 18 days in orbit.

Persistent reports of atmospheric contamination (unexpected outgassing?) in Salyut-5 claim that the first crew last July-August had to cut short their flight by several weeks after an "acrid odor" developed inside the Salyut. While unconfirmed, the report does explain several puzzling features of the Soyuz-24 mission (apparently a duplicate of the Soyuz-23 attempt which last October failed to reach the Salyut).

The crewmen did not board the Salyut for half a day after docking, an unprecedented delay. They later dumped air tanks and purged the entire atmosphere of the Salyut.

While on board, the cosmonauts concentrated on zero-G processing experiments, Earth photography, and medical checks. They made further tests of two systems vital for long flights: a water recovery system and an inertial attitude control system which uses not flywheels but a single two-foot diameter 200 lb steel globe spinning in a magnetic field. Varying the spin rate induces torques in the Salyut.

PROSPECTUS

1977 Ames Summer Study on Space Settlements and Industrialization Using Non-Terrestrial Materials

June 22 to August 2, 1977

The study will consider the economic and technical feasibility of construction of manufacturing facilities and settlements in space using non-terrestrial resources. Detailed studies will be performed in several key technological areas. Parallel with these systems studies, comprehensive plans will be developed for the orderly implementation of future research and development activities to support the industrialization of space.

Study Topics

Space Settlement Systems Technical Study

1. Closed Ecological Systems:

Regenerative life support systems pose some of the most serious design requirements for space settlements. Variables such as cost, total size, number and types of species, length of the food chains, and degree of closure will be considered. This detailed examination of ecological design requirements and their solutions will be incorporated into a long range plan for R&D activities in this area.

2. Environmental Parameters:

This study will examine the impact on habitat design of departing from Earth-ideal human requirements. Within certain limits, human beings can adapt well to changes in environmental characteristics; these adaptations are physiological, behavioral and sociological. A corresponding modification in the specifications for environmental parameters might lead to designs perhaps less costly and more reliable than normal terrestrial conditions.

3. Asteroid Resources:

An investigation of search techniques, remote compositional analysis, orbit determination, and retrieval modes for low velocity increment (relative to Earth) asteroids will be performed. Emphasis will be on the study of optimized transfer of asteroids to Earth parking orbits. Cost effectiveness will be determined relative to asteroid orbit, ΔV, transfer time, asteroid mass, recovered mass, asteroid composition, and mission opportunity.

4. Mass Driver Technology:

This study will define the potential of the electromagnetic mass driver as a propulsion system. It will examine the technical and economic feasibility of employing the mass driver concept in a variety of missions and applications, including its use as: lunar tug, orbit-to-orbit transfer, asteroidal tug, station keeping and control, and as a material launching system. Overall technology needs, as well as those peculiar to a given mission, will be defined. The economics of a given application will compared to those of conventional propulsion systems

5. Non-terrestrial Material Extraction and Construction:

A zero-based approach to the development of non-terrestrial resources will be pursued from discovery through structural component manufacturing. The study will identify and assess processes tailored to the unique conditions of space: gravity, vacuum, energy availability, etc. The economics of developing non-terrestrial resources will be compared to that of Earth resources for various missions and applications.

6. Long-Range Program Planning and Development:

This separate study group will develop near and long-range plans for implementation of research and development activities involving space settlements and industrialization using non-terrestrial materials with due consideration to the Agency's priorities and objectives. The planning group will draw on the expertise of the technical group and will consider all areas of impact, including the required technological needs, the identification of long lead-time programs, and the redirection of some current and planned efforts. In summary, the planning effort will define the sequence of events, from our present capabilities to the ultimate realization of manufacturing facilities in space.

Three L-5 members from Tucson (Annita Harlan, H. Keith Henson, and John Phillips) have been selected as members of Topic I: Closed Ecological Systems.

FASST ANSWERS LDEF QUESTIONS

FASST (Forum for the Advancement of Students in Science and Technology) has received a grant from the Universities Space Research Association (USRA) to increase student and faculty awareness of the possibilities for using the Long Duration Exposure Facility (LDEF) for space experimentation. *(See FASST* News, Sept.-Oct., '76, page 9).

The first LDEF is currently scheduled to be carried aboard a NASA Space Shuttle in the early 1980s and is designed to be left in orbit for long periods of space exposure-from six to nine months.

The USRA consulting agreement enables FASST to assist both members and non-members in acquiring information. Contact: FASST/LDEF, 1785 Massachusetts Ave., N.W., Washington, D.C. 20036.

GETAWAY SPACE OFFERED

NASA has formally announced a "self-contained payload" program for flight aboard the Space Shuttle. Termed "getaway specials," the concept involves attaching containers at various points onboard the Shuttle. These containers would house up to 90 kilograms (200 lbs.) of equipment and space experimentation. Cost per container ranges from $3,000 to $10,000.

The containers are perfect for student space experiments and, in fact, two such containers have been purchased for just that purpose. R. Gilbert Moore, General Manager of Thiokol in Ogden, Utah, purchased one container for $10,000 and offered half of his payload space to the Utah State University for student use.

Dr. L.R. Megill, Chairman of the Space Science Experiment Committee at Utah State will fund a $3,000 payload as a follow-on to Moore's. Under his direction, the available payload space will be offered to high school and college students who submit winning proposals to fly their own experiments. Selected students would be given tuition waivers at Utah State and have the opportunity to earn additional money by working with faculty members involved in space sciences. It is hoped other colleges and universities will consider such programs.

For those wishing additional material on the Utah program write: Dr. L.R. Megill, Chairman, Space Science Experiment Committee, UMC 41, Utah State University, Logan, Utah 84322.

News from ERDA

ENERGY PROJECTS

The following is a list of Faculty Development Projects in Energy sponsored by the Office of University Programs, Energy Research and Development Administration, Washington, DC 20545:

Host Institution	Director	Project Title	Amount
Alabama A & M University, Normal, Alabama 35762	Dr. S.S. R. Murty Solar Energy Task Force	A Faculty Institute on an Introduction to Practical Energy Systems	$ 14,500
University of Alaska Anchorage, Alaska 99504	Dr. George A. Geistauts School of Business and Public Administration	Energy Development-The Alaska Case	20,000
California State College -- Sonoma Rohnert Park, California 94928	Dr. Curtis K. Kjeldeen Department of Biology	A Short Course Entitled "Geothermal Energy and the Environment"	15,400
Florida State University Tallahassee, Florida 32306	Dr. Rodney F. Allen, Department of Science and Human Affairs	Implementing Energy Education in Florida's High Schools	16,604
Georgia Institute of Technology	Dr. Frank J. Clarke College of Architecture	Energy Conservation for Teachers	16,250
University of Florida Gainesville, Florida 32611	Dr. Edward E. Carrolls, Jr., Department of Nuclear Engineering Sciences	Nuclear Power Generation and the Environment	14,400
University of Idaho Moscow, Idaho 83843	Dr. Robert J. Kearney Department of Physics	Energy and the Northwest	16,998
Southern Illinois University Carbondale, Illinois 62901	Dr. David L. Jones Department of Geography	Faculty Institute on Energy	15,849
University of Notre Dame Notre Dame, Indiana 46556	Dr. John W. Lucey, Department of Aerospace and Mechanical Engineering	Workshop on Electric Power Generation Comparative Risks and Benefits	11,532
Kansas State University Manhattan, Kansas 66506	Dr. J. Kenneth Shultis, Department of Nuclear Engineering	Perspectives in Energy; 1977	12,700
Harvard University Cambridge, Massachusetts 02138	Dr. Paul L. Fishman Graduate School of Design	Solar Energy Short Course	17,947
University of Missouri Columbia, Missouri 65201	Dr. Walter Meyer Department of Nuclear Engineering	Summer Workshop on Electrical Power Generation-Comparative Risks and Benefits	13,849
University of Nebraska Lincoln, Nebraska 68588	Dr. Donald W. McCurdy, Department of Secondary Education	University of Nebraska Energy Education Project	17,445
S.U.N.Y. at Stony Brook Stony Brook, New York 11794	Dr. T. Owen Carroll Institute for Energy Research	Three Week Teaching Seminar	27,286
North Carolina State University Raleigh, North Carolina 27607	Dr. Jerome Kohl, Department of Nuclear Engineering	Workshop on Energy Resources and Electrical Power Generation	11,192
Minot State College Minot, North Dakota 58701	Dr. Clark Markell Department of Science Education	Alternative Technologies Available for the Development of Northern Great Plains Coal Resources	15,274
Miami University Oxford, Ohio 45056	Dr. Joseph Priest Department of Physics	Energy for an Industrial Society: Principles, Problems, Alternatives	11,774
Ohio State University Columbus, Ohio 43210	Dr. Donald D. Glower, Dr. Herbert L. Coon College of Engineering	Energy Resources and Electric Power Generation: A Workshop on Background and Fundamentals of Energy Resources Energy Conversion Processes. Plant Design & Comparative Risk and Benefits	12,500
University of Oklahoma Norman, Oklahoma 73037	Dr. Donald Menzie, Department of Petroleum and Geological Engineering	Faculty Development Seminar on Conventional Energy Sources	14,445
Portland State University Portland, Oregon 97207	Dr. George A. Tsongas, Department of Engineering and Applied; Dr. Michael Fiasca Department of Science Education	Energy Institute for High School Teachers	12,015
University of Tennessee Martin, Tennessee 38238	Dr. David S. Loebbaka, Department of Geosciences and Physics	Energy Resources	6,006
Texas Tech University Lubbock, Texas 79409	Dr. Thomas J. O'Brien Department of Chemistry	Faculty Institute for High School Science Teachers	14,355
University of Utah Salt Lake City, Utah 84112	Dr. Gary M. Sandquist Department of Mechanical Engineering	Energy Conservation	9,560
University of Wisconsin Madison, Wisconsin 53706	Dr. Max W. Carbon Department of Nuclear Engineering	Energy Resources and Electrical Power Generation-Comparative Risks and Benefits	11,550
University of Wyoming Laramie, Wyoming 82071	Dr. R. Beiswenger Department of Geography	Summer Institute in Energy for High School and Junior College Science and Social Studies Teachers	18,250
TOTAL: 25 programs			**TOTAL: $367,681**

AT&T ZEROES IN ON SATELLITE COMPETITION

Carolyn Henson

Satellite Business Systems (SBS), owned in equal shares by COMSAT, IBM, and Aetna Life and Casualty, was formed on December 15, 1975. They plan to use 12/14-GHz frequency bands, small Earth stations, and time-division (as opposed to frequency division) access to the satellites' transponder channels. Advantages of SBS's approach are the ability to provide multiple circuit connections with the same ease as single circuits, allowing millions of bits per second connections as easily as hundreds of bits per second connections; accelerated facsimile transmission speeds; less expensive teleconferencing; and decreased likelihood of frequency interference (due to the use of 12/14-GHz frequencies).

AT&T is striking back at her fledgling competition, but not by offering comparably cheap services! AT&T lobbyists have filed in opposition to SBS's application before the Federal Communications Commission, and just in case that move fails, have begun lobbying for passage of the "Consumer Communications Reform Act."

Columnist Jack Anderson has said of this bill:

ATT executives have been lobbying on Capitol Hill to gain favor for a "Consumer Communications Reform Act." Actually, the bill has nothing to do with consumer reforms. On the contrary, if passed into law, the act would effectively eliminate all competition within the industry.

But three courageous congressmen have decided to take on "Ma Bell." They are Richard Ottinger of New York, Charles Whalen of Ohio and Tim Wirth of Colorado. They have prepared a tough resolution to replace ATT's.

The congressmen's proposed act says in part, "Competition in the tele-communications industry should be permitted wherever such competition serves the public." The two bills should give Congress a clear choice between a monopolized telephone system and a free-enterprise system benefitting the public.

The *IEEE Spectrum,* January 1977, in a news report on "Technology and Society," reports:

The question that arises in the mind of at least one observer is why the communications giant should be concerned with SBS. Some might conclude that, beneath the surface, AT&T sees SBS as potential competition and, significantly, it is such unwanted competition that prompted AT&T to press for the passage of the "Consumer Communications Reform Act of 1976" -- potentially the most significant piece of legislation on communications in decades. Commonly known as the "Bell bill," this proposed legislation had been endorsed by 179 members of Congress at last count, and reports in the popular press have suggested that AT&T may be spending as much as $100 million to lobby the bill through Congress. There is neither time nor space to go into the details of the controversy surrounding this proposed legislation, but suffice it to say that AT&T's basic premise is that continued competition for existing services will degrade telephone network and increase the cost of basic telephone service by "skimming the cream off the top" of AT&T's most profitable services. According to AT&T, the bill "in no way intends to eliminate competition for innovative services." To the degree that SBS's proposal allows potential industry and Government customers to communicate outside the aegis of the Bell System, the SBS concept could represent outside competition-but would SBS's service be innovative or duplicative?

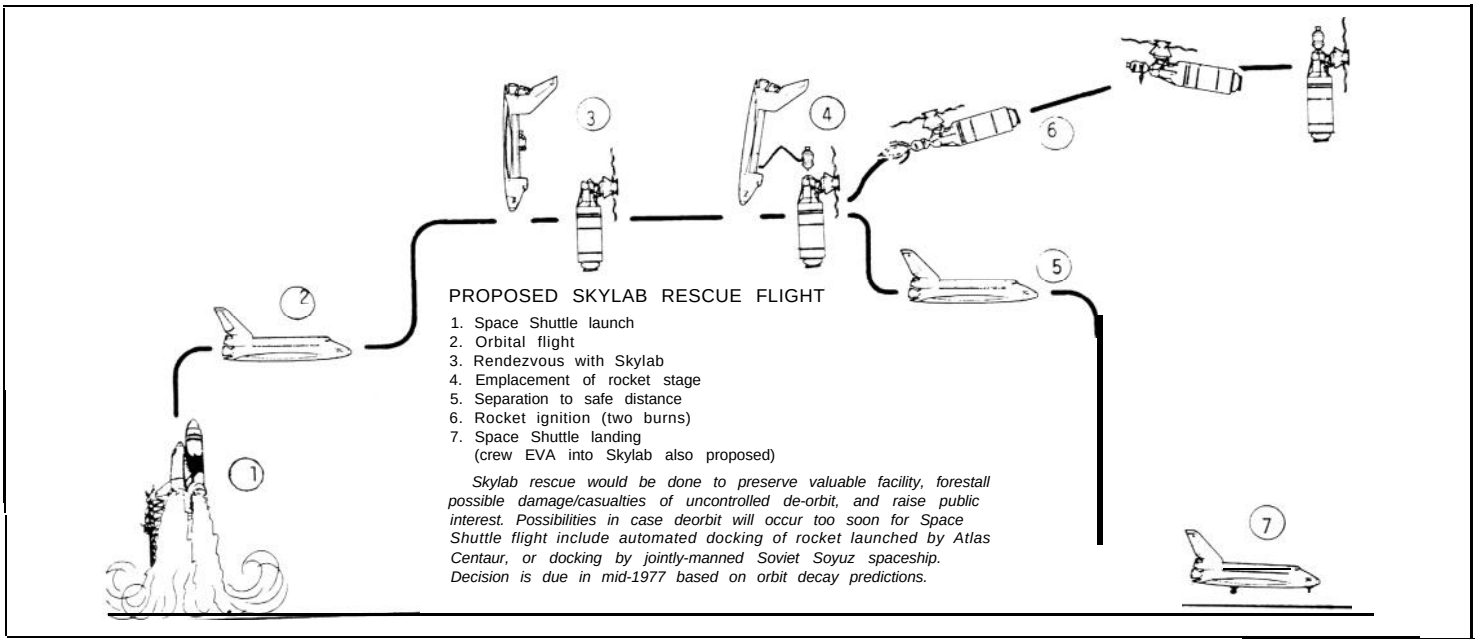
To many in the communications industry, however, that question is moot. Rather, they argue that the Consumer Communications Reform Act and its sponsor, AT&T, would effectively crush competition for innovative services (a view espoused by SBS) as well as existing services-the crux of the debate. AT&T opponents go on to argue that AT&T is pressing for de facto nationalization of the communications industry, thereby stifling "a robust, innovative sector of our economy and denying forever a competitive marketplace," to use the words of John Eger, former acting director of the White House Office of Telecommunication Policy. In fact, Eger has argued : "The lines between our data-processing and communications technologies are blurring, and AT&T knows that the telephone business of today and the communications business of tomorrow are vastly different.

"Already AT&T is providing services that employ stored programming techniques and other data-processing innovations. There is also a $35 billion industry made up of hundreds of companies whose business is to manufacture computers and other related business equipment, as well as to provide so-called software and programming services." The implication, of course, raises the question : why should AT&T be permitted to monopolize in one area and compete in another?

This question was addressed directly by SBS president Philip N. Whittaker in testimony before the Subcommittee on Communications of the House Committee on Interstate and Foreign Commerce on September 29. Said Mr. Whittaker: "Reduced to its simplest terms, the only possible purpose for, and the certain consequence of, the enactment of this legislation would be to grant an absolute monopoly to AT&T in all commercial communications excepting record and broadcast communications. Users of telecommunications services would be tied to a sole source. They would be locked into AT&T's decisions regarding what facilities and what technologies should be used to provide what services, when and at what prices. To make matters worse, AT&T, by this legislation, would be virtually unregulatable in its decision making."

This debate is simmering during the current Congressional recess but it should boil over during 1977. Whether passage of the Bell bill will crush SBS -- as company spokesmen claim and AT&T denies -- remains to be seen. But, at the same time, SBS must fight off objections from a very different quarter. Ironically, while IBM, as a partner in SBS, lines up as an opponent to the specter of an AT&T communications monopoly, it itself is being attacked as a monopolist of the data-processing industry. Several IBM competitors feel that IBM could strangle competition by virtue of its partnership in SBS. A typical question is : would IBM provide below-cost business machines to SBS customers, thus washing out any losses in that sector by profits gained via SBS? Queried by Spectrum, IBM representatives vigorously denied such charges, labeling them "preposterous." And, in addition, in its FCC filing, SBS claims that IBM will not indulge in such practices. Nevertheless, doubts remain in the minds of its competitors who, along with AT&T but for different reasons, have filed in opposition to SBS before the FCC.

Here we have nothing less than a morass of claims and counterclaims that will be resolved by an essentially political -- not technical -- decision-making process; whether that resolution will benefit or hinder technology is not known. But it is certain to alter the sociotechnical landscape.



PROPOSED SKYLAB RESCUE FLIGHT

1. Space Shuttle launch
2. Orbital flight
3. Rendezvous with Skylab
4. Emplacement of rocket stage
5. Separation to safe distance
6. Rocket ignition (two burns)
7. Space Shuttle landing
   (crew EVA into Skylab also proposed)

Skylab rescue would be done to preserve valuable facility, forestall possible damage/casualties of uncontrolled de-orbit, and raise public interest. Possibilities in case deorbit will occur too soon for Space Shuttle flight include automated docking of rocket launched by Atlas Centaur, or docking by jointly-manned Soviet Soyuz spaceship. Decision is due in mid-1977 based on orbit decay predictions.

SPACE PHOTO ALBUM OF THE WORLD AVAILABLE

The most comprehensive and detailed "space photo album" of the world's natural and cultural features has been prepared with images from NASA's Landsat Earth Resources satellite by Nicholas M. Short, Paul D. Lowman, Jr., and Stanley C. Freden of NASA's Goddard Space Flight Center, and Dr. William A. Finch, Jr., of the San Diego State University. Entitled *Mission to Earth: Landsat Views the World,* the atlas size publication contains some 400 Landsat images, most of them in color and close to full-page size. It is available through the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 for $14. The stock number is 033-000-00659-4.

Because of the value of the book to educators, an Educator's Guide is being prepared by the Goddard Center, and will be available at no cost upon request to the Center's Office of Public Affairs, Educational Programs, Greenbelt, MD 20771. The guide contains a "Teacher's Resource Section" which includes classroom activities, exercises and techniques for using the imagery. To facilitate the use of *Mission to Earth,* the guide includes a glossary of geological and remote sensing terms used in the book.

(Continued from page 3)

reality. They do not pay particular attention to whether this or that space industrialization idea (SSPS, pharmaceutical production, etc.) is immediately cost-effective or not. What matters to them is that these ideas are coming up, and in increasing frequency. They believe that once one of these becomes a reality it will mean factories will be established in orbit and that these in turn will then beget other useful ideas for the utilization of space. There will be a multiplying effect that will move rapidly enough to leave analysis of the full social, political and economic impact of space industrialization lagging. To avoid this situation academicians want to start their analysis now. They seem objective toward the benefits and liabilities of technological advance, recognizing that it must be continuously shaped by an ongoing assessment of its potential impact from the point of view of the social sciences and humanities. They add to this a sense of hope that we can indeed come to terms with this planet, at least in part through the careful utilization of space for future industrial growth.

Old timers in the L-5 Society will remember Dr. T. Stephen Cheston. He keeps track of things legislative and administrative for O'Neill. If you are passing through Washington to say hi to your representatives (and to tell them what you think of these new space ventures) give Cheston a call.

EUROPEAN CONFERENCE

L-5 Society, West European Branch, announces a European Conference on Space Settlements and Space Industries, to be held September 20, 1977, at Queen Mary College, University of London, U.K. The Society is sponsoring this conference in order to provide a European platform to discuss and review the state-of-art in concepts, designs and studies of space settlements and space industries. Topics may range from small initial space stations up to large space colonies and from small shuttle-based space manufacturing techniques through to large space-based solar power station concepts.

Papers may consider-but are not limited to-the following topics: materials resources; large space structures; on-orbit space transports; industrial operations in space; system analyses; Earth-to-orbit systems; space community planning; satellite solar power stations; space law; European interests in large-scale space operations; low-cost structures; economics of space-based industries; space manufacturing techniques.

Prospective authors are invited to submit papers on the above and other relevant topics for consideration for presentation at this conference. The selection of papers will be based on summary papers of 300-500 words which must be received at the address below by May 31, 1977. Authors will be notified of acceptance by June 28. Complete manuscripts must be received by August 10.

Attendance at the conference will be limited and all persons wishing to attend and to receive further information should write to: The Director, L-5 Society (WE), 40 Lamb Street, Kidsgrove, Stoke-on-Trent, ST7 4AI. England, U.K.

Ready for rescue-Dr. Timothy Leary at the controls in the SKYLAB in Houston (see SKYLAB Rescue, page 11).

Inside the L-5 Society

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FROM THE L-5 OFFICE

Next Month --

The Society has been accumulating some long but excellent articles-too long for the News but too good not to publish. So, next month we will put out a long issue and the month after cut back to a short (8-10 pages) issue. If this works out well, we may make every third issue a long one (with maybe even a color cover!). Also, the post office informed us that sample copies cannot be mailed at third class rates, so you can expect a brochure in the near future.

Late Flash --

The floodgates are opening on Space Habitat books. T.A. Heppenheimer, well-known to *L-5 News* readers for his lively writing style ("Home, Home on LaGrange" in the August 1976 issue of the *L-5 News,* and many others) has authored a lavishly illustrated book, *Colonies in Space.* There are a number of color plates and over one hundred black and white illustrations. Some of the text is familiar sounding, but Heppenheimer has freely acknowledged the contributions of others in the field.

- *Colonies in Space,* T.A. Heppenheimer, Stackpole Books, 1977. $12.95.

Available from the L-5 Society for $12.00 plus the $1 handling charge.

Energetic Response --

The Society received a request for input from the federal Energy Policy and Planning Off ice on Tuesday, March 8. Our reply (see opposite page, *Dear Dr. Schlesinger. . .*) and a copy of the request were mailed to members of the Society on Thursday, March 10.

Dear Dr. Schlesinger;

Solar energy, while practical for heating and perhaps cooling, is commonly excluded from consideration for supply of our major electric power needs because of the problems of energy storage for periods of darkness and overcast weather conditions.

One way of tapping solar energy which avoids the problems of night and clouds is to collect it in space and beam the energy to Earth by microwave. This would provide a reliable, non-depleting, non-polluting long-term source of energy for all forms of use.

Methods for collecting sunlight in space and transmitting large amounts of energy to the surface of the Earth have been worked out in detail by groups at Arthur D. Little, Inc., and Boeing Company. The remaining problem is the economics of lifting the power plants off the Earth. To bypass this difficulty. it has been seriously proposed (Science, December 5. 1975) that an industrial base be established in space to construct solar power satellites (SPS). mostly utilizing materials extracted from lunar soil.

Careful economic analyses indicate that this method could supply energy at a fraction of current or projected cost for fossil or nuclear power. The original estimates for the cost and time for establishing an SPS construction base were about $200 billion and 20 years. However, recent studies of more effective methods indicate that the cost might be reduced to $20 to $30 billion and the time to six or seven years after the Space Shuttle is available (about 1980). After this point (about 1987), several percent per year of our energy needs could be shifted to this form of solar energy.

In being considered as a major source for energy, this plan suffers mostly from newness and, of course, from competition with well-entrenched interests in industry and the federal bureaucracy.

As you have asked for suggestions, here are mine:

(1) Complete without delay the Space Shuttle. It is the key to space industrialization.

(2) Support the SPS studies and development. Funding for these activities was largely lost in a recent NASA/ERDA jurisdictional squabble,

(3) Ask NASA to request funds for a line item ($ 100-200 million) in the budget, for space industrialization studies. This was dropped from the current budget to avoid starting a new program under the previous administration.

A conference on space manufacturing facilities, partly sponsored by NASA and ERDA, is being held at Princeton University, May 9-12. You or your staff would no doubt be welcome.

Sincerely yours,

H. Keith Henson
President, L-5 Society

c.c. Members of L-5 Society

THE L-5 LOCAL CHAPTER

The L-5 Society is both a national (and international) network acting as a clearinghouse for information on space colonization and space solar power, and a collection of local chapters devoted to publicizing and advancing these issues. It is not necessary to belong to a local group to belong to the L-5 Society nationally, nor vice versa. However, if you now wish to join a local chapter, we can direct you to one. Since there are not yet many local chapters in existence, there may not be a group convenient to you. In that case, don't despair, organize one yourself! It's easier than you might think.

If you have ever been active in any kind of organization, whether political, fraternal, church, or any other sort, much of the following advice will be things you already know about. But even if you have never done anything like it before, don't be deterred. A little effort on your part may bring surprising results.

First, we can help you by sending written material and slides, and by putting a notice in the *L-5 News* that you are interested in forming a local chapter in your area (you may want to get a post office box to protect your privacy).

If you get in touch with other local L-5 members, get together and form the nucleus of a local chapter right then and there, figure out what your resources are and how much you want to do, and get started.

Some sample activities are as follows: holding public meetings (especially at schools and universities) to explain the L-5 idea, giving talks to existing groups to which you or your friends belong on the L-5 concept, bringing in speakers to give a lecture and slide show on L-5 (write or call us in Tucson if you are interested in this), appearing on local radio or TV talk shows and explaining the L-5 idea, writing letters to papers to answer criticisms of space travel, and proposing space solar power whenever energy issues are being discussed (especially when a dispute arises over building a nuclear power plant or a new coal strip mine near your town).

Some things to remember are

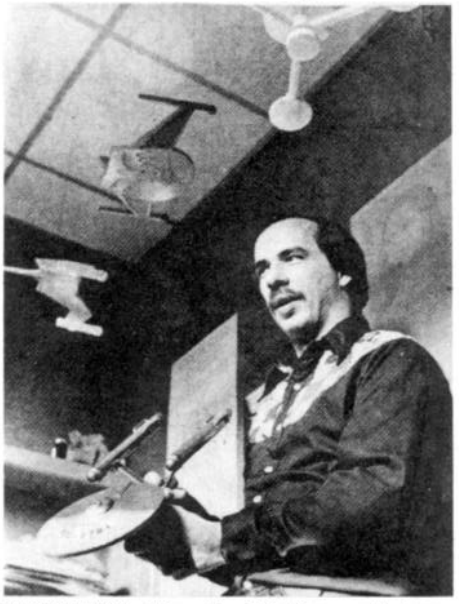
1. Don't attempt more than you are comfortable with. If you don't feel you can give a good talk in the lecture format, don't try. Just sit around a table and discuss the idea, and pass around some *L-5 News* or a copy of *The High Frontier,* or Xeroxes of some of the good magazine articles that have appeared.
2. When you meet interested strangers, get their name, address, and phone number, and make sure they are invited to every event you hold. Keep an accurate, up-to-date contact list, and don't give it out to anyone else (respect their privacy!).
3. L-5 is not a political party, nor a church. We have no "party line," we do not endorse (or oppose) candidates for office, we do not push a specific political or economic system. We just want to get into space! Try to get along with other L-5ers even if you are opposites in politics, lifestyle, hair length, or other trivia. Avoid cliques or "old guards" dominating the group.
4. Good places to spread L-5 information are universities and colleges, secondary schools, and science-fiction gatherings.

If you are a student-see about getting your L-5 chapter recognized as a student organization, then go to the Office of Student Organizations, or whatever it's called on your campus, and find out what help you can get. Usually you can get free or cheap meeting rooms, an office, access to mimeograph or printing. Sometimes they even put up money to bring speakers to campus. And remember, student newspapers and radio stations are always hard up for copy. If you have an article or a program format ready, they will probably be overjoyed to use it.

This is by no means a complete list or strict guidelines. Above all, stay in touch with us in Tucson, tell us your problems and your triumphs and we can all learn something.

Jim Bennett

San Marcos Daily Record



DISPLAYING SOME miniature replicas of futuristic space craft and space stations, local L-5 Society organizer Troy Welch explaines the advantages of colonizing space in the near future. He says massive enclosed space colonies could provide an alternative to Earth living as well as supply badly needed solar power. The L-5 Society is dedicated to spreading the word and gathering support for space colonization.

LOCAL PUBLICITY

The San Marcos L-5 Chapter made the front page of their local newspaper, *The San Marcos Daily Record,* recently. How did Troy Welch manage it? We suggest writing him c/o Physics Department, Southwest Texas State University, San Marcos, TX 78666 for hints on local publicity.

Another red-hot society publicist is Mike Shields, who arranged two major lectures and two television appearances for L-5 spokespeople in San Diego this March. For details on how he does it, write to 695 Nardo Avenue, No. G-8, Solana Beach, CA 92075.

L-5 ON TEXAS TV

The L-5 Society has some enterprising and resourceful members. One of the best is Dr. Harlan Smith, Director of the Department of Astronomy at the University of Texas at Austin. Dr. Smith and his colleague, Dr. Alex Dessler, professor in space physics and astronomy at Rice University, were featured on an hour-long documentary, "The High Frontier," on KPRC-TV in Houston, March 9. The writeup we received about the show (sponsored by Fannin Bank) went this way:

> Two noted scientists predict how we will solve the energy crisis by collecting solar energy in space and transmitting it to Earth via microwaves, how man will create "planets" of his own orbiting the Earth, what the human race can expect for the next 200 years.
>
> More than interesting-valuable family viewing.
>
> "This is a fantastic special that everyone should see." --C.W. Skipper, TV Editor, Houston Post.

Small wonder the Texas membership is so large.

WHAT'S AVAILABLE FROM THE L-5 SOCIETY?

- Xerographic reproductions of articles from other publications (please ask for list).
- *The Hunger of Eve: A Woman's Odyssey Toward the Future,* Barbara Marx Hubbard, Stackpole Books, 1976. $8.00.
- *The High Frontier: Human Colonies in Space,* Gerard K. O'Neill, Wm. Morrow and Co., 1977. $8.00.
- *The Fourth Kingdom,* William J. Sauber, Aquari Corp., 1975. $6.
- *L-5 News,* back issues $1 each (Volume 1 included 16 issues).
- Bernal Sphere color postcards (interior, exterior). 15¢ each; 50 of one kind, $3.
- Bernal Sphere 14" x 17" color posters (interior, exterior). $2 each.
- Introduction to the L-5 Concept, 18 slides, $9.
- Space Industrialization, 28 slides, $14.
- Satellite Solar Power Stations, 12 slides, $6.
- Space Habitats, 18 slides, $9.
- The L-5 Society Slide Show, all 76 slides, $38.
- Individual slides, 50¢ each. Write for catalog.

Note: Postage and handling per order, add $1. Prices subject to change without notice. Wholesale pricing available on some items. Write for details.

ANOTHER UNIVERSITY SPACE STUDY GROUP FORMED

A student-faculty group has been formed at the University of Arizona to study space habitation and industrialization. The primary goal of the group is to take advantage of talent present at the university to solve problems regarding construction of an industrial base in space. Other goals range from defining the technical aspects of constructing large structures and refining lunar materials, to the social, political, and economic aspects of such a project.

Another equally important area for work is to increase public knowledge about the benefits of expanding into space. To fulfill this goal, the group will sponsor a series of films and slide shows on the campus.

The group is affiliated with the L-5 Society. Stewart Nozette, president of the Tucson L-5 Chapter, is also president of the study group. Those who wish to contact this group can write to Stewart Nozette, c/o The Lunar Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

Letters

A small contest. I'm doing a book (with Rick Sternbach) for St. Martin's Press on space colonization/space industrialization. Having a hell of a time with the title. I wanted to call it *Space to Grow In,* but the editor doesn't like it-not snappy enough (I have to agree.) Said editor wants to call it *The Final Frontier,* which I don't like for several reasons, not the least being that it sounds like a rip-off from O'Neill's book.

So if anybody can come up with a title that suits both me and the editor, she-he-it will win ten glorious bucks and an autographed copy of the book. Earliest postmark, etc. Offer void where prohibited by law. Employees of St. Martin's Press or the author must disguise their identity. Send your title to Joe W. Haldeman, Box 855, Iowa City, IA 52240.

I would like to make a few comments on the article "Space Research and the Military," excerpted from *Skeptic* no. 17, in the February L-5 News

a) The passages printed contain some statements which I believe are factually incorrect, or at least misleading. The most important example is that to the best of my present knowledge and belief, the United States does not include, nor seriously contemplate including, a first strike plan as a part of our military policy or strategy. There may be some officers, or even some civilian officials of the Defense Department, who might *wish* we had such a policy, but it is my understanding that such individuals have been thus far successfully restrained by administration leaders who have considered (and I believe correctly) that such a policy would have a destabilizing effect and add fuel to the arms race. I can't speak for the Soviets; maybe they do have first-strike plans. But I seriously doubt that we do.

b) A nation with a laser-equipped powersat can deny access to space to anyone else? Only if the same outfit manages to have two or more such satellites ready simultaneously, and before anyone else does. With only one, how does it prevent launches from the opposite hemisphere?

c) Could not the power-sat project be put under international control, with inspections to insure that no one installs weapon-grade lasers on them?

d) If we've got to have weapons around, I'd much rather they be precise, selective, surgical tools like lasers than indiscriminately destructive nuclear bombs.

e) If people are inevitably going to be belligerent, as the article seems to suggest, and if military services are

inevitably going to acquire every weapons system they can, do you suppose we are safer if we remain earthbound? One of the reasons for getting large numbers of people into space is that it will reduce the likelihood that any one disaster, natural or man-made, can simultaneously wreck all of humanity. Or to put it in the words Jerry Pournelle used in the December Galaxy, "We won't *have* to have outgrown our damn foolishness to insure our survival as a species."

Larry Friesen
Webster, Texas

This is a response to John Holt's attack on space research, on the grounds of the potential resultant hazards to humanity. In reality, such research and development can not substantially increase the existing probability of large-scale violence. The existing weaponry deployed by most of the world's governments and some other organizations, including biological, thermonuclear and "conventional" weapons, already offers an enormous overkill factor-use of less than one tenth of it could virtually extinguish life on this planet. Additional weapons, no matter how spectacular, can only add very small increments of risk.

The use of L-5 satellites to provide massive new energy resources for Earth could substantially *reduce* the risk of world war, if a fair share of the new energy is made available to the Third World. If the major industrial nations fail to deal with the needs of the Third World, the probability of war will steadily increase. History provides abundant examples of civilizations with relatively advanced technology being overwhelmed by "barbarians," and messianic leaders usually believe that they have nothing to lose and everything to gain. The well-being and perhaps even the survival of the industrial nations depends on their willingness to use space research and other forms of high technology to establish an acceptable quality of life, or better, for everyone on the planet.

The question of whether or not to design and construct sophisticated weapons is completely out of our hands. Such matters are decided by governments, and a referendum or specific mandate in this context is exceedingly rare. Historical comparisons suggest that weapons procurement people of several nations are already deeply involved with preparations for warfare in space. This is not a doomsday prediction that such wars will necessarily take place, but merely a statement that some organizations are in fact doing everything they can to equip themselves for it, and that there is virtually nothing an individual can do about that.

What can be influenced is the peaceful use of space technology. It makes no sense to be negative or apathetic towards it, on the basis of ill-founded fears. Those who see the enormous potential for peaceful and humanistic applications of space research do have the option to support it, and perhaps even the moral obligation to do so.

Paul B. Shewan
Spokane, Washington

Eric Drexler, in L-5 News *No. 14,* points out that "a completely closed ecological (or even agricultural) system" is not a prerequisite for space colonization. Of course, he is right. In fact, *understanding the basis of a fundamental agricultural/ecological system* definitely should not be a prerequisite to the construction of the colonies, because any earth-bound *understanding* necessarily can be only analogous and theoretical without on site data collection. The point is not to disparage the power of reasoning at a distance, but rather to avoid geocentricities during initial development when such misconceptions could be most detrimental.

Considering the anticipated populations of full scale colonies as compared to the size of construction crews, the immediate need for on site photosynthetic carbon recycling is minimal. Since carbon, hydrogen, and the other elemental constituents of life support have to be provided for the full scale colonies and food products (dehydrated) have an appropriate mixture of these elements, it is reasonable to plan for *long range* food supply from earth with "waste materials" being stockpiled.

During this time, on site agricultural research can be initiated in unison with developments in lunar ore processing, environmental controls, shape geometry, etc. Emphasis might first be directed to small scale "kitchen gardens" that intend only to add fresh foods to the highly manipulated food products being shipped from Earth.

The idea of total self-sufficiency in life support systems is very appealing. Indeed, until full scale space farming is a reality, the colonies will remain space stations and cannot be considered true habitats. However, with time, as data and stockpiles accumulate, the opportunity to make better long range design decisions will increase. It should be recognized that total agricultural development is not urgent and need not be hurried.

Pierce Jones
Gainesville, Florida

On the other hand, some research on crop yields needs to be done before a space settlement can even be designed. Cost of a space habitat is area dependent and crop area estimates have varied from 32 to 250 m^2/person.

What a perfectly splendid letter you wrote to Dr. Schlesinger on national energy policy, and what a swell job you did in getting the word out to the L-5 membership. I had just written the enclosed [letter to President Carter] when I received your mailing.

If enough of us make a noise, perhaps something may be accomplished.

Frederick H. Osborn, Jr.
Garrison, New York

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

NL 704

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

NAME: _____

ADDRESS: _____

CITY/STATE/ZIP: _____

AFFILIATION/TITLE OR POSITION: _____
(OPTIONAL)

I am-am not-interested in being active locally. Phone (optional) ___-_____

Please enroll me as a member of L-5 Society ($20 per year regular, $10 per year for students). A check or money order is enclosed. (Membership includes *L-5 News,* $3 to members; the balance -- $17 or $7 -- is a tax-deductible donation.)

__ Please enter the above as a nonmember *L-5 News* subscriber ($20 per year). A check or purchase order is enclosed.

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

I have *read* a couple of articles about the possibility of having space colonies within the next twenty to thirty years. This really fascinates me and I would like to be a part of this venture when it takes place. I don't think my chances will be very good, though, considering that I will be at least 43 years old, or probably older by the time it becomes reality. I'm not rich, either, another mark against me. And I doubt an experienced coal miner would be much use, either. My wife thinks the idea is crazy. Nevertheless, the idea of living in space attracts me very much. So I would like for you to send me information, or suggestions that might increase my chances in participating in the migration to space.

Stephen Durbin
Corydon, Kentucky

Experienced, hard working people will be needed in space sooner than the rich, and lunar or asteroid mining won't be all that different from coal mining. If you want to help, talk your union into supporting space migration. After all, somebody will have to represent the asteroid miners. And finally, don't despair, the move into space may happen much sooner than we think.

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Has anybody discussed the mechanics of prospecting for carbonaceous chondrites on the Moon? A crater produced by the infall of a carbonaceous chondritic meteor might be a much more practical source of hydrogen, carbon, and nitrogen than the asteroid belt.

Intuitively it would seem that the material in the vicinity of such a crater would have a different heat capacity than the stuff in a "just-plain-old" crater. Therefore it would cool at a different rate; an orbiting probe with an infrared radiometer would be able to pick it out from its surroundings as darkness fell.

The polar-orbit probe that NASA has scheduled for 1980 might do the trick -- or the data might already be available, from Apollo orbital observations.

It might be, though, that the high temperature generated by the impact of a large meteorite would vaporize the compounds that we're interested in, and so disperse them over an impractically large area. Still worth looking into.

Joe W. Haldeman
Iowa City, Iowa

I temporarily agree with [the] . . . conclusion . . . that it is a waste of time and resources to search for radio messages from other galactic civilizations. The search for other galactic civilizations can only properly and economically be accomplished from outer space, where the Earth's rotation, atmosphere, and sources of light and other radiations do not interfere. The apparent ease of manufacturing the required instruments in outer space, and the availability of virtually unlimited solar energy in outer space to provide the energy required lead me to conclude that other intelligent civilizations will assume we will go to outer space to attempt to receive their messages. So, I conclude that we should wait until we have colonized space before attempting to detect (or transmit) such signals.

Jay S. Huebner
University of North Florida,
Jacksonville, Florida

[Reprinted from The Physics Teacher]

I have been receiving and reading your newsletter for about half a year, but I have not yet seen an article or letter on/by/about women in the space program. I have applied for one of the Mission Specialist Astronaut positions which are opening up in conjunction with the Space Shuttle and would like to hear from other women who are doing the same.

I haven't met any other applicants in my area. I've also heard that the percentage of women applying is much lower than was expected. How many of us are there?

I am 24, have a joint bachelor's degree from U.C. in biology and chemistry and two years' experience as a research technician aboard a Geological Survey research ship. I'd like to know what kinds of background other people have. Also, has anyone heard from NASA yet? Maybe we can give each other support during the long wait for notification.

I'm sure I'm not the only one doing this and I'd like to get in contact with others.

Clare L. Bell
1649 Alma St.
Palo Alto, Calif. 94301

I'd like to see somebody start real international law studies of the treaties governing exploitation of Antarctica and the sea floor, compared as precedents with treaties in force and in negotiation regarding the Moon and other celestial bodies. Question: could the United Nations block/tax/control the construction of space power systems? Question: what country or countries would not want to see the building of a space power station by the United States, and why not? What means would they use to prevent it, and how could the United States circumvent these means (ranging from diplomatic protests to sabotage to physical assault-including boarding)? Is a solar power station a "weapon of mass destruction" (space treaty)? Somebody, help think about it.

Jim Oberg
Dickinson, Texas