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

L5 NEWS

VOLUME 2, NUMBER 2 A NEWSLETTER FROM THE L-5 SOCIETY FEBRUARY, 1977

Opportunities for Students!

NASA HOPES TO FUND STUDENT STUDIES

Plans are underway at NASA Headquarters to ask Congress to fund students to work on space industrialization and settlements in fiscal year 1978 (which begins next October). Those interested in this program should send pre-proposals to Robert F. Freitag, Deputy Director, Advanced Programs, NASA, 600 Independence SW, Washington, D.C. 20546, and to John Billingham, LT: 229-7, NASA Ames Research Center, Moffet Field, CA 94035.

Freitag is interested in students who wish to do in-depth, 2-10 year studies. He warns people not to get their hopes too high, however, as it is ultimately Congress and the President that will decide whether hundreds of students next winter will be working on the L-5 concept.

The following list has been suggested as a source of ideas that may be worth further study. Robert Freitag adds that some topics not included in this list, especially those in the social sciences, may also be of interest to those in NASA who, Congress and the President willing, will be funding researchers next year.

Those interested in sending in preproposals should mail them in as soon as possible, as NASA is planning to finish its budget request by mid-March and needs input from students.

Study Topics List

I. Selected most urgent research recommendations

Systems Studies (resulting in reports) :

1) SSPS-Brayton Cycle: Optimization for Lunar Materials
2) SSPS-Photovoltaic: Optimization for Lunar Materials
3) Free Flyer (Shuttle Payload) for Rotational Parameters Studies (Human-rated):

(Continued on page 15)

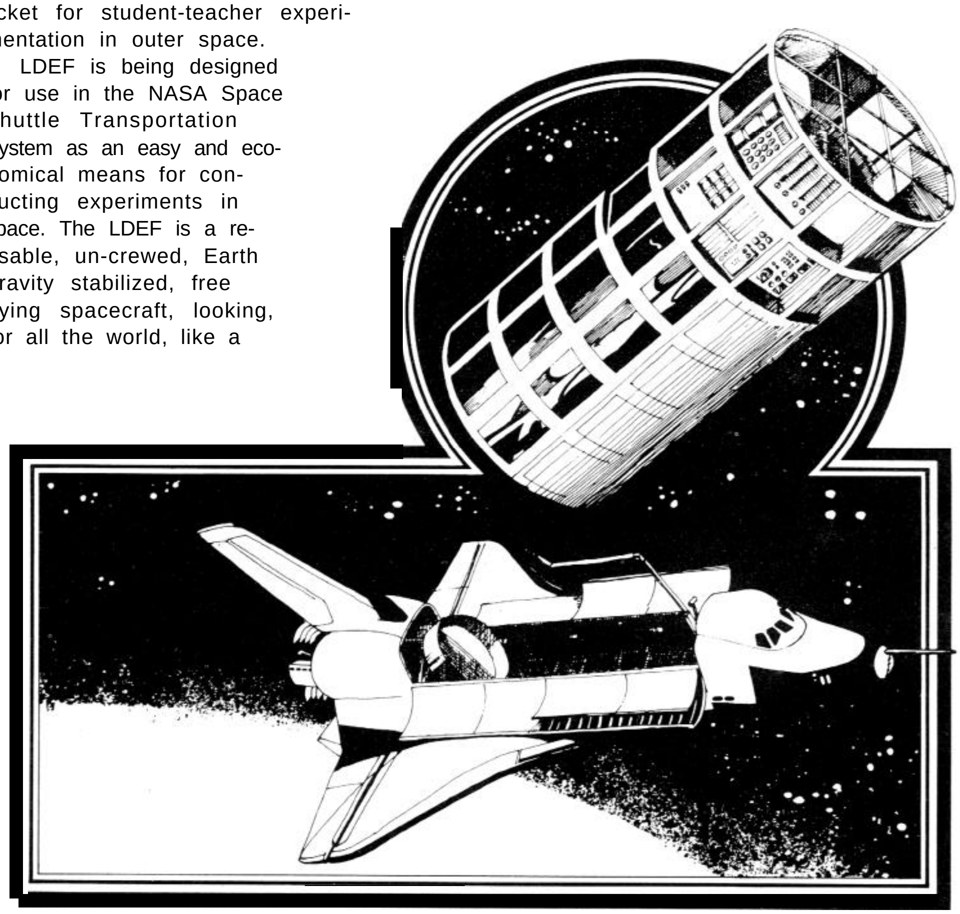
LDEF AND THE EDUCATIONAL COMMUNITY

Leonard David, FASST

There's going to be something new over the horizon -- about 300 nautical miles straight up, or 556 kilometers for you metric afficionados. Pronounced in the most suitable acronym that NASA can drum up, LDEF (spoken "el-deaf") stands for Long Duration Exposure Facility. It might not impress you at first, but it may provide an inexpensive ticket for student-teacher experimentation in outer space.

LDEF is being designed for use in the NASA Space Shuttle Transportation System as an easy and economical means for conducting experiments in space. The LDEF is a reusable, un-crewed, Earth gravity stabilized, free flying spacecraft, looking, for all the world, like a space-based automat. The structure is a twelve-sided, bolted metal frame cylinder, some 30 feet (9.14m) long by 14 feet (4.27m) in diameter, weighing in at about 6,000 pounds when empty.

The key to its simplicity lies in its 76 separate "trays" which are mounted to the framework of the LDEF. The experimenter has an option of having an experiment exposed or covered to the space environment while sitting in its tray. No word yet on white-walls, air-



Published monthly by L-5 Society, Inc., at 1620 N. Park Ave., Tucson, AZ 65719, Subscription price: L-5 Society members, $3.00 per year, included in dues ($20.00 per year, students $10.00 per year). Subscription price to non-members available on request. Single copies when available $1.00 each. Send Form 3579, ADDRESS CHANGES AND SUBSCRIPTION ORDERS to L-5 SOCIETY, 1620 N. PARK AVE., TUCSON, AZ 85719. Second class postage paid at Tucson, Arizona.

conditioning or AM-FM radio!

The trays themselves measure 50 inches (1.27m) by 38 inches (.97m). Depth of the tray is varied, either three, six, or twelve inches depending on requirement. Experiments will be accepted from full use of the tray to within any multiple of 1/6th of the tray. It is required that no experiment can protrude beyond the planes defined by the 12-sided LDEF structure.

LDEF Mission Profile -- Present plans call for the first LDEF to be carried onboard the Space Shuttle in 1979. Once in orbit, the Shuttle mission specialists will remove the LDEF from the Payload bay by using the Remote Manipulator System (RMS). Using this mechanical arm, the LDEF will be aligned to the local Earth vertical, and all LDEF motions will be dampened. The Shuttle will then depart the scene, leaving the LDEF and its hitch-hiking experiments alone in the vacuum of space.

Planned exposure time will be from six to nine months, with an altitude decay of about 20 nautical miles, after which a subsequent Shuttle flight will capture the LDEF for the trip back to Earth. Upon return, the LDEF trays will be shipped to the various experimenters for analysis

Wide Range of Possible Experiments -- Experiments for LDEF can be developed for a passive or active mode while in space, although the first LDEF will involve only passive experimentation. These experiments would require data measurements taken before and after space exposure. Active experiments, for later LDEF flights, which require such systems as power, data storage, must be provided by the experimenter and be an integral part of the experiment assembly. Each LDEF experimenter will be responsible for establishing the criteria necessary to ensure that the experiment is safe to fly and will not adversely affect the other experiments on board LDEF.

LDEF -- An Equal Opportunity Program -- For those of you with eyes that are now "space-glazed," please note that LDEF is not exclusively a high school or college program. Also, LDEF is not a program to make a student or teacher “the first one on your block” to fly an experiment in space.

The LDEF is, however, designed to serve as a meaningful interface between NASA and the academic community. Experiments will be chosen on a selective basis, by a panel review and evaluation of specific proposals from those wishing to participate in the LDEF program. Experiments will come from numerous groups, including education, government and industry.

Under sponsorship of NASA, the Universities Space Research Association (USRA) has been contracted to be the prime focal point for involvement in the LDEF concept. Both experienced and inexperienced space researchers can seek assistance from the USRA, including possible sources of funding for your space experimentation.

The chances appear good that students and teachers, perhaps one of you reading this article, may participate in the LDEF program. The range of possible experimentation is limitless, from effects of zero-gravity on plants, to solar and cosmic radiation studies. It looks as if LDEF may provide the simplest, most inexpensive way of developing high school and college participation in space. The missing ingredient is you, a creative idea and a willingness to get involved!

To get involved, contact Bill Davis, LDEF Program office, Universities Space Research Association, P.O. Box 3006, Boulder, CO 80303.

FASST is developing student and teacher awareness of the potential of LDEF. At present, FASST is in the process of cataloging student experimenter interest, hoping to insure a smooth flow of student participation in the LDEF and other Shuttle programs. For those wishing to be included in such a catalog, notify the Washington headquarters of FASST: 1785 Massachusetts Avenue, N.W., Washington, DC 20036, Attn. Shuttle Student Experiments.

PROFESSORS DEBATE THE “HONORABLE” FUTURE OF NUCLEAR POWER

(FASST News Service, Washington, D.C., 11/22/76) -- Two of the most prominent names being called upon by university groups interested in the discussion of nuclear power are Dr. Barry Commoner and Dr. Norman Rasmussen. At a recent international meeting in Washington, D.C., sponsored by the Atomic Industrial Forum and the American Nuclear Society, these two energy gladiators treated a standing-room-only crowd of over 900 to a lively “debate” on what this country should be doing in regards to nuclear energy development.

Speaking first, Dr. Commoner, a professor of environmental sciences at Washington University in St. Louis, presented his opposition to nuclear power on economic grounds. He does not believe that nuclear power can survive the tension that is being generated between the financial costs and the actual benefits. Because of our “technical immaturity” in determining all economic factors related to nuclear plants, he pointed out that things such as legal fees, security costs, and costs of waste disposal are not always included in the price of producing nuclear energy. For this reason he believes that “the economic costs of nuclear [energy production] are high, rising, and uncertain.”

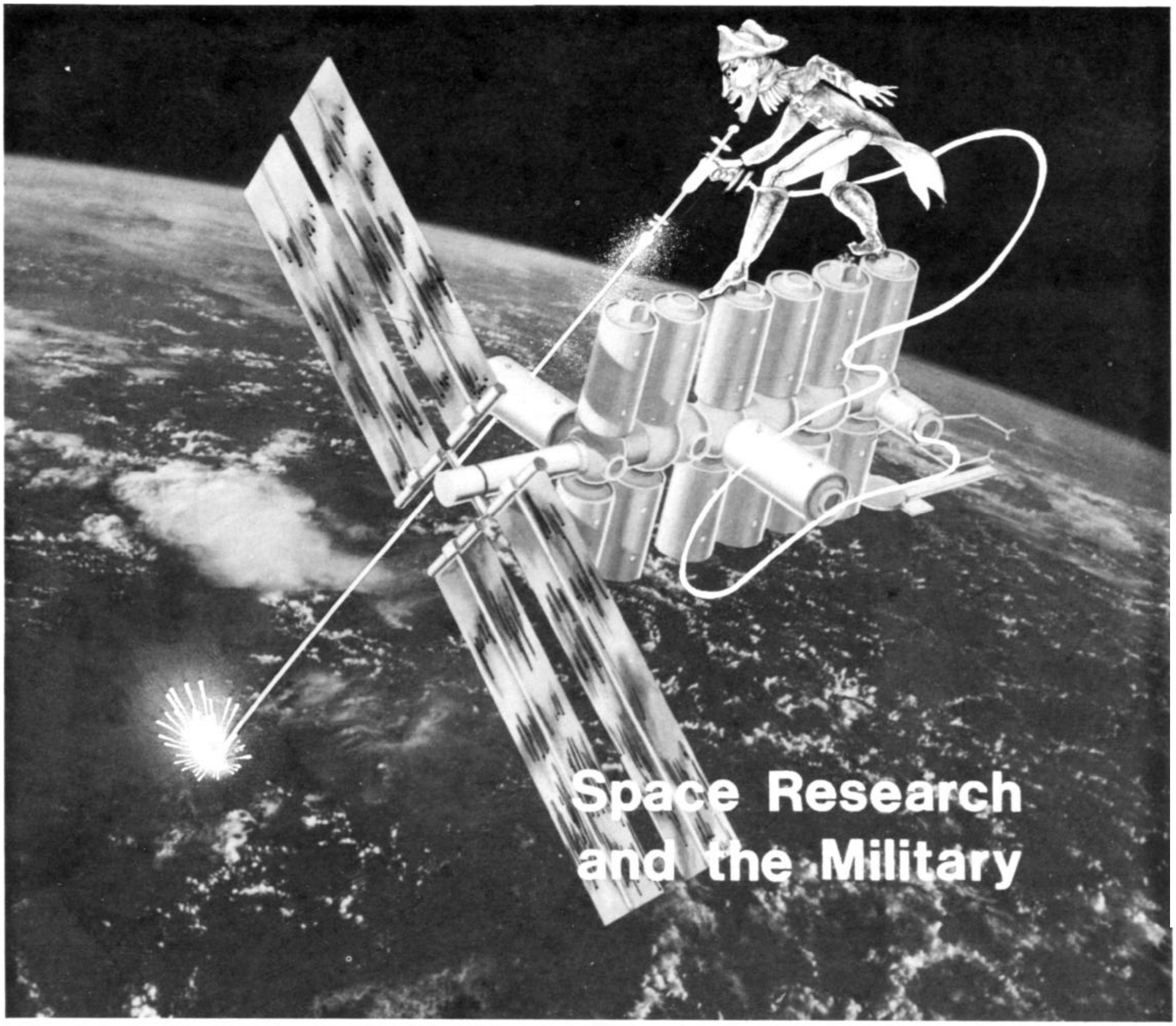
Dr. Commoner also argued that the cost of nuclear power would increase exponentially as the price of uranium increases with dwindling ore supplies. Much of his argument was based on comparisons of nuclear costs to that of coal, which he claims would be cheaper, and not escalate as quickly as nuclear. (I n the question and answer session, member of the audience angrily disagreed with Commoner’s graphs and statistics which gave this comparison, claiming that the information was over a year old and inaccurate.)

In closing, Commoner contended that nuclear power has not been able to sustain itself as an ongoing energy source and as a viable alternative to fossil fuels. He interpreted President Ford’s recent call for a “delay in reprocessing nuclear fuel until nonproliferation can be assured,” as a signal to the end of the entire nuclear program. He turned the arena over to his opponent with the charge that “The only honorable thing to do now is figure out how to begin the shut-down of nuclear power in the U.S.”

Chairman of the nuclear department at the Massachusetts Institute of Technology and author of the nuclear reactor safety report which bears his name, Dr. Norman Rasmussen did not directly challenge Commoner on the economic arguments. He preferred to leave that approach to those with more expertise in economics. Instead, Dr. Rasmussen focused his remarks on the consequences of not utilizing nuclear energy.

Rasmussen stated that Commoner had “omitted to tell you where we’re going to get power without going nuclear.” He mentioned that there were several ways that we could help to relieve some of our energy problems-the most obvious being to practice conservation. “Any country that does not implement a strong conservation program is unethical,” the MIT professor stated. However, he also noted that even with a strong conservation program, there will still be a need to increase our capacity to generate electricity. In reviewing energy alternatives, Rasmussen believes that it will take a combination of all available sources to meet our energy needs. He found it ironic that Commoner, a strong environmentalist, would advocate the extraction of coal over further development of nuclear power.

Rather than criticizing the fact that after 30 years nuclear power is producing only 10% of the U.S. electrical needs, Rasmussen challenged the opponents to recognize that this is equal to the total output of hydroelectric power generation. He proposed that Commoner come up with another energy source that could develop more rapidly than nuclear power has, while filing environmental impact statements on each plant site.



Space Research and the Military

Excerpted from an article by John Holt in Skeptic *No. 17, Jan/Feb 1977.*

A great danger of space research is that it will sooner or later be turned to military purposes. It is military research in disguise, a hawk in dove's clothing. I don't claim that the Space Salesmen *want* this to happen, only that it is certain to happen whether they want it or not. One of the reasons why science is too important to be left to the scientists is that they have been so poor at foreseeing what life-destroying uses the military would find for their clever inventions. When the laser was first described to the public, it took me only a few minutes to realize that science had at last made into a dreadful reality the death ray of the comic strips. But it was not until some years later, when there began to be reports of intensive American and Russian military research on lasers, that scientists began to express any public concern about this possibility.

Let us take another example. The *New Scientist* of September 30, 1976, describes the latest American cruise missile: about 20 feet long and a little over a foot and a half in diameter, it can be launched from submerged submarines, surface ships, land vehicles or aircraft and can travel almost 2,000 miles and deliver a one-megaton warhead to its target with an error of less than 100 yards. Flying very low, it is almost undetectable by radar and there are now no effective countermeasures against it. When in production, each of these will cost only about half a million dollars, one-thirtieth of the cost of a modern fighter. Since all new weaponry finds its way quickly into the international arms market, we can expect that soon many of the nations with sufficient nuclear materials to make bombs will have some of these little devices to deliver them.

The connection between the cruise missile and space research is this. The missile is guided to its target by matching radar signals from the ground over which it flies with a very accurate contour map of the terrain programmed into it beforehand. These extraordinarily accurate maps were obtained from satellites. Without such maps, this missile could not work. Moreover, the extremely accurate knowledge we have of Russian territory has encouraged our military leaders to consider seriously and plan for a *first-strike* strategy, in which we would bomb all of Russia's missile launching sites before they dropped any bombs on us. No doubt they have similar maps and similar plans.

In spite of all we have learned about the horrors of science misapplied, the scientists just don't seem able to ask themselves, as they work away busily on this or that magic toy, "What might some bad person do with this?" So we must ask the question for them. When we ask this question about space research, we get some very disquieting answers. One of the things the Space Salesmen tell us is that by using materials mined on the Moon or the asteroids, we can very easily (there being no gravity) build out in space huge solar generating stations. These would trap large amounts of sunlight in collectors or reflectors, use it to generate electricity, turn that electricity into microwave energy and beam that energy down to collectors on Earth, where it would be turned back into electricity, thus (so they say) solving all our energy problems. At first blush, it sounds quite attractive. But suppose someone used the enormous output of these multi-megawatt electric generating stations to power a laser or group of lasers aimed at the Earth's surface. This would be an ultimate weapon indeed. The nation that owned it could deny access to space to any other nation; destroy any missiles launched on the Earth's surface; destroy a nation's nuclear or other power plants, or anything else they wanted to destroy; or even use it as a weapon of political assassination. (Who, without going underground, could escape such a Finger of God?).

When nuclear power was first developed, the military played for a while with the idea of a nuclear-powered airplane that could stay up for months without the need to refuel. On Earth, in Earth's atmosphere, it proved impractical; to protect the crew from nuclear radiation they needed so much shielding that the plane would have been too heavy to get off the ground. They gave up the idea for aircraft, though as we know, it worked fine for submarines. Why not then, for space "submarines?" Suppose we did learn how to mine, refine and process metals on the Moon and in space, and to make in space massive human habitations. Suppose we then developed a nuclear or hydrogen propulsion system for some of these space subs. Suppose we put enormous nuclear- or hydrogen-powered electric generators in these ships and used them to power the kind of superlasers I have just talked about. The nation or group that could put a few of these ships in space would have the means to rule, or at least destroy, the world.

As far as we know, which may not be very far, the military is not doing this sort of research now, for the very practical reason that these possibilities are too remote and risky to be worth spending money on. As rich and wasteful as they are, the armed forces of the world's nations are not so rich that they can afford to spend many tens or even hundreds of billions of dollars on projects which might have only a very small chance of being successful and which would in any case take a generation or two to complete. However, if space technologies should become perfected enough to be militarily useful, the military will then take them over. One thing we ought to have learned by now is that anything that can be used for military purposes will be. If there is military advantage or wealth to be had in space, nations that are fighting on Earth for wealth and military advantage will fight for them in space as well.

The rest of the article is much like the above. The L-5 staff would appreciate it if our readers would comment on this article in letters to the L-5 News, *and to* Skeptic, *812 Anacapa St., Santa Barbara, CA 93101.*

THE CONSEQUENCES OF EXTRATERRESTRIAL COLONIZATION
A Paper Presented to the American Anthropological Association, November 20, 1976

Michael A. G. Michaud

"The most profound effect of extraterrestrial colonization may be on humanity's self image."

Until now, the study of humanity has been limited to this biosphere-a thin veneer of earth, air, and water on the surface of our planet. During recent years, we have become conscious of the finitude of that biosphere, and of the limitations it might impose on the human future. But now we are on the edge of a new dimension of human existence, of new settings for human behavior and social interaction; we are about to expand the human sphere beyond the Earth into that larger environment we call space. Already, humans have lived in small artificial biospheres in space-Skylab and Salyut -- for as long as three months. Within the next ten years, we will see permanent inhabited space stations in orbit around the Earth, with groups of three to twelve humans residing there for months or longer.

Space stations will lead, perhaps unintentionally, to the colonization of space. As humans stay longer and longer in orbit, and as they make these artificial biospheres safer, more comfortable, and more self-sufficient, some workers and their families will become long-term residents, no longer returning periodically to the Earth.

In that expansion to new biospheres lies a potential discontinuity in human affairs, a change of scale, new access to energy, resources, and living space, and new visions of possible human futures. In it also lies opportunities to explore new ways of organizing human societies, to study humans in new environments, and to understand better what humans really are.

In each stage of extraterrestrial colonization, there will be a first, pioneering generation which is likely to be tied closely to Earth by memory, culture, training, and, for geolunar colonies, occasional travel. That generation will carry into space the values of Earthbound societies. Yet it will be different in motivation, for these humans will have chosen to leave the familiar Earth for new opportunities and new challenges. Originally, many may be assigned by governments or other organizations to staff stations, or work in factories which may be like company towns, but many may go to seek higher incomes, adventure, a test of their abilities, or new beginnings to their lives. Such motivations would shape the social values -- and perhaps the social structures -- of the first colonial generations.

Other colonists may want to escape the limitations, frustrations, and inadequacies of Earthbound societies, and may hope to create utopian societies in space. But this may be too optimistic. The first extraterrestrial colonies will not be paradises, but places of work; space colony proponent Gerard O'Neill said that they might be more like a construction camp on the Alaskan pipeline than laboratories for sociological experiments.

Self-selection will be limited by the selection processes of the governments and other organizations which send up the colonists. Since their investment in the first wave of colonization will be very large, and since they may have purposes other than colonization in mind, these governments and organizations will insist that the first colonists be chosen in such a way as to increase the prospects for success and, in some cases, economic return. The colonists and their performance will be watched from Earth; there will be a public demand for accountability, and a low tolerance for waste or failure. There will be pressure on the colonists to meet the expectations of non-colonists. Those who finance the colonies will expect loyalty and a certain degree of discipline, and will expect the colonists to demonstrate values esteemed by the originating society. There may be little patience with unconventional values or behavior.

The influence of the sending societies on the colonists is likely to be greatest during the first generation of each wave of colonization. The earliest colonization ventures at each stage of the human expansion will tend to be the most uncertain, and the most in need of support from and contact with the Earth. Earthside societies will control the selection of the first generation of colonists, thereby determining the composition, educational and cultural backgrounds, values, and loyalties of the initial colony populations. However, these Earthside influences will tend to attenuate as the colonies produce, acculturate, and train their children, as the colonies achieve a greater degree of economic and technological self-sufficiency, as the time/distance/energy factor grows in importance with increasingly remote colonization, and as the colonies generate new colonies themselves. Early residents in space biospheres may see them only as jobs, but this attitude will tend to change as stations become colonies by acquiring permanent populations. Later residents may identify increasingly with the success or failure of their colonies, and may come to regard them as permanent homes.

Extraterrestrial colonists will not easily escape their evolution, the natural forces that have shaped humans, or the social influences that affect us on Earth. Extraterrestrial colonization will be a test of human individual and social adaptability, as well as of compensatory technology. The design of extraterrestrial habitats will have to draw on anthropological knowledge to ease that transition to new environments by giving artificial biospheres the qualities most needed for human psychological and social well-being, as well as physical survival.

The colonies will be influenced by their natural environments, which are likely to be hostile to life. Colonists on natural bodies beyond the Earth will have to protect themselves against unbreathable or non-existent atmospheres, and against radiation, and may spend most of their time within closed artificial biospheres. Space colonies will be surrounded by the near vacuum, extreme cold, and powerful radiations of space. Colonists will be sensitive to the fragility of their human-made biospheres, and their dependence on human technology and closed ecological cycles. Colonists may feel the psychological effects of confinement, with a sharp distinction between a hospitable inside and a dangerous outside. They also may feel a sense of physical isolation from other humans and their concerns. They will recognize the need to be as self-sufficient as possible. These new environments, this isolation, this sense of vulnerability, may encourage closely knit societies, with a sense of identity and shared purpose.

Individual colonists may need, more than on Earth, the reassurance of role definition and purposeful work, and peer approval. Early colonies may have specific tasks to perform, such as manufacturing, research, or exploration; those tasks may define roles and behavior. There may be no easy escape from social pressures within a closed artificial biosphere, especially in more remote colonies. Therefore, we should be cautious about creating utopian expectations for the first generations of extraterrestrial colonists.

Early colonies may put a high value on reliability and technological competence. Selection may emphasize technical skill, stable personalities, self-discipline, and some degree of altruism over extreme individualism and self-satisfying behavior. The establishment of experimental forms of social organization may have to wait for later generations, and may be limited to the most hospitable and least vulnerable biospheres.

Extraterrestrial human colonies, composed of skilled persons in new and often difficult environments, may prove to be among the most rapidly changing societies in history after the first generations. The first generation in each colony may be firmly rooted in Earthbound societies and cultures; later generations, born in the colonies, may increasingly follow separate social and cultural evolutions, diverging from the Earthbound and from other colonies.

The response of the colonial society to its environment will lead to growing social, behavioral, and value differences between the colony and the originating society. The demands of living in a closed artificial biosphere in space or on a harsh new planet will require different social interactions, and perhaps new belief systems, forms of political organizations, legal systems, and loyalties. Each colony will develop its own approach to the socialization of new generations, and its own ways of defining and assigning social roles.

The first wave may require the pioneering and work-oriented values of a frontier society; later generations may have more latitude for diversity in attitudes and behavior, and a lesser degree of discipline. As the sense of shared risk and task orientation lessens, colonists may become more concerned with personal, social, and political problems, and divisions within the colony may begin to grow. The growth and evolution of a colony may reduce the self-evaluated significance of the role of the average colonist at the same time that the task of survival and self-sufficiency seems less urgent, encouraging latent tendencies toward alienation and divisiveness. The colonists could create threats to their own survival by dividing a society which must work together for survival and economic viability, or by acts especially dangerous in a closed biosphere, such as the use of weapons.

There may be growing divergences between colonies on natural worlds and space colonies. Those on natural worlds, especially a planet like Mars, may have vast frontiers before them, room for growth, and a sense of expansiveness, and perhaps a situation more conducive to individualism and social mobility. Closed artificial biospheres, without an explorable "outside," may be more likely to encourage tendencies toward hierarchical social structures, role assignment, and cultural and ideological conformity. These differences may lead to different values and different forms of social organization.

Extraterrestrial colonists eventually will begin to diverge from the Earthbound in the physical sense due to the demands of new environments, particularly as new generations are born in space or on other worlds. At first, this will be a minor problem, as the inhabitants of geolunar colonies may be able to return to Earth easily and frequently, and to intermarry with the Earthbound. However, travel and intermarriage may become more difficult and less frequent as the sphere of colonization grows and distances lengthen. Low-gravity worlds such as the Moon, Mars, and the asteroids may encourage such extensive adaptation that colonists will not be able to live comfortably in Earth gravity; they may become permanent exiles from the Earth.

The more that later generations of colony populations are isolated from the Earth and from each other in new environments, the more we will see gradual genetic drifting in response to environmental pressures, including low or zero gravities, different exposures to natural radiations beyond Earth's magnetosphere, and perhaps different natural chemistries or alien biota on other worlds. For interstellar colonies in particular, genetic pooling with Earth and other colonies may be rare or nonexistent, producing isolated gene pools. In some cases, there may be deliberate selection of colonists for certain genetic characteristics, based on values or interpretations of needs in new environments. Eventually, genetic drifting may become so great that interbreeding with Earthbound *Homo sapiens* will no longer be possible; new and divergent species may emerge, better adapted to their new environments.

Scientific arid technological advances might open up new options, allowing us to exploit environments that otherwise would be uninhabitable. Surgical or chemical techniques might be used to prepare colonists for exotic atmospheres or alien biota. The development of genetic engineering may coincide with the colonization of space, allowing more purposeful pre-selection and pre-adaptation to improve the colonists' prospects for survival. Advanced colonies may be able to do their own genetic engineering after arrival, propagating particular genotypes in accord with needs and values. And there is the possibility of cyborgs, linking humans with machines in cybernetic organisms with enhanced toughness and capabilities. Such changes could lead to situations in which the colonists could not return to their originating biospheres.

In short, the coincidence of extraterrestrial colonization and advances in biotechnology could make the human design of human beings both more feasible and more desirable than it is now. Whatever options are pursued, the possible environments and biotechnological solutions are so varied that different futures seem likely for different parts of the expanded human species. Such divergences will increase the sense of difference between colonists and the Earthbound. Judging by the history of racism on this planet, we must expect that physical differences among human communities will be reinforced by prejudice and ideology.

Some colonies will respond to challenges better than others. Those that succeed, especially in other star/planet systems, may be destined, singly or collectively, to become new civilizations. Those that fail may range along a continuum from indefinite dependence on the originating society to extinction. But all will be affected, in varying degrees by pressures different from those that have influenced the evolution of human societies on Earth.

These factors lead to one general conclusion about the future of the human species if it colonizes our solar system and others beyond it: there will be growing divergences among the colonies, and between the colonies and Earthbound societies. That divergence will find expression in cultural forms, modes of social interaction, preferences for shaping the future, and eventually in biology. It also will find expression in a growing desire for independence from the Earth, its cultures, its economic, political, and military systems.

From the beginning of our planning for the expansion of the human sphere, we must recognize that extraterrestrial colonists will come to believe that they are different from Earth-bound humans. They will have different experiences, different dangers, different joys; they will find it annoying, frustrating, and eventually inevitable that the Earthbound do not understand. This sense of separation, and the deepening concern of the colonists with the success or failure of their own biospheres and societies, will lead to growing resistance to dependence on, or interference from, originating societies. Sooner or later, independence movements will become a fact of life for the expanded human species.

Originating societies may attempt to prevent the independence of their colonies through a variety of means, ranging from a threat to withdraw financing to the use of force. These methods may succeed within our own solar system, where communications and travel times are relatively short. But they probably will fail at interstellar distances; star colonies will be decades away, and must be self-sufficient from the beginning.

The prospect, then, is for a diversity of human societies spread throughout this solar system and a growing number of others, enjoying different degrees of independence. The eventual result may be a scattering of star-states separated by light years of time/distance, each remembering a common origin, but each so engrossed in its special concerns that the origin slips farther into the mists of legend with each generation. If interstellar travel remains a difficult, time-consuming, and costly project, the only links between human civilizations may be the great radio antennas that listen for voices from other stars.

The colonization of frontiers has affected the development and culture of many societies, including our own; so it will be with extraterrestrial colonization. There will be continuous feedback from the colonies to Earthbound societies; colonial experiences, perceptions, styles, values, ideas, and innovations will influence Earth cultures. The space economy will feed new inputs into the global economy, allowing it to grow beyond the limits that now concern us. The colonies may prove to be more vigorous, optimistic societies than those left behind, and may even produce leadership figures for the Earth. Eventually, the growth of human population and technological capability off the Earth may tilt the balance of influence in favor of the colonies, and Earth may decline in relative importance within the larger complex of human civilization. The planet might some day be governed or reinvigorated by remote descendants of the original colonists who left it to go into space. If warfare, biospheric disaster, or a terminal laboratory experiment on Earth should destroy its remaining human population, recolonization from space would vindicate the original colonization effort.

The most profound effect of extraterrestrial colonization may be on humanity's self-image. Colonizing this new frontier may stir hope among the Earth-bound, and create new perceptions of humanity's possible futures. Humans may regain the self-confidence that sometimes seems to be in decline in Western societies, creating an essential underpinning of a new human civilization. Humans may be freed of an impending sense of limitation on their future. They may see anew the virtues of diversification, of tolerance for different societies and cultures, and of intelligent growth. In new colonial societies, humans may regain a sense of community, of mutual dependence, and of social purpose.

The colonization of space and other worlds will so change human perceptions and abilities that future generations will look back on our time as the beginning of a new era, a new dimension of human existence. But humans will remain, in many ways, humans, and not idealized creatures out of science fiction. They will suffer from their limitations, their frailty, their lack of wisdom, and from the tension between individual and society. Humans beyond the Earth can no more escape the need to confront themselves, their needs, and their weaknesses than can humans here.

But we can improve their prospects by designing these new biospheres to be as hospitable as possible. We can strive to include adaptive variety as a factor in the selection of colonizing populations, both genotypically and culturally. We can recognize divergence before it leads to unnecessary conflict, and ease the transition to independence. We can, if we have a long enough perspective on species survival, seek an early crossing of two thresholds in extraterrestrial colonization:

1. Establishing the first self-sufficient colonies off the Earth, creating alternative, survivable biospheres, and alternative societies.
2. Human interstellar flight and colonization, drastically reducing the danger of terminal conflict within the human species, ensuring its diversification, and improving its long-term prospects for survival.

To summarize: sending humans to permanent habitations in space or on other worlds will change both the colonists and those who send them. These changes will grow in scale and importance as colonization proceeds outward and new generations are born off the Earth. The alien and often hostile environments surrounding extraterrestrial communities, and the human-designed artificial biospheres that will be necessary for human survival, will test human adaptive potential, creating new strains on individuals and societies. However, the experiences, perceptions, and capabilities of extraterrestrial societies also will open up new possibilities for individual and social evolution, and new scales of human existence and achievement, making us larger in every sense than we were before.

These changes in the human condition are just beginning. Our judgments about them must be speculative at this time. But it will not be long before social science is able to study humans in new environments, removed from the Earth. And social science skills will be needed in our designs for extraterrestrial biospheres. Eventually, whole alternate societies in exotic environments will allow comparisons with our Earthbound conclusions about the nature of humanity. And, someday, we may encounter an intelligent extraterrestrial species, requiring us to develop a science of intelligent beings in addition to a science of humanity.

LUNAR UTILIZATION ABSTRACTS PUBLISHED

Lunar Utilization, abstracts of papers presented at a special session of the 7th Annual Lunar Science Conference, 16 March 1976, is now available from the Lunar Science Institute. This special session on the utilization of lunar materials and expertise for large scale operations in space was organized by Dr. David R. Criswell (LSI). The 188-page volume, edited by Dr. Criswell, can be obtained by sending a check for $1.00 U.S., $6.00 foreign, to cover mailing costs, to Ms. Carolyn Watkins at the LSI, 3303 NASA Road No. 1, Houston, TX 77058.

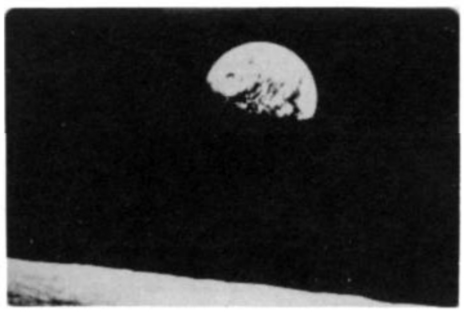
L5 SOCIETY

SLIDE SHOW

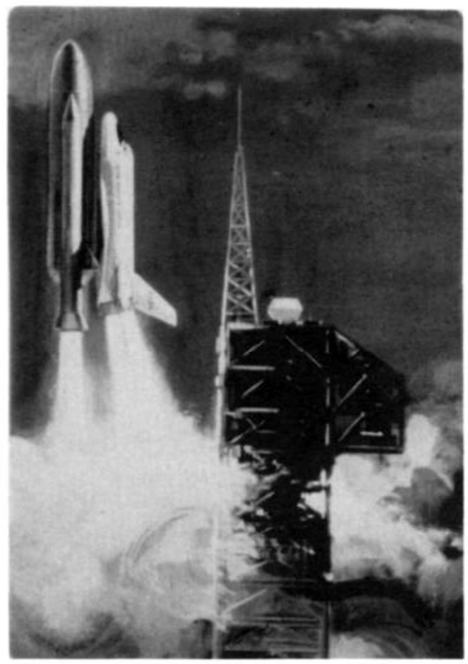
The following images are in four sections: INTRODUCTION TO THE L-5 CONCEPT (101-118), SPACE INDUSTRIALIZATION (201-228). SATELLITE SOLAR POWER STATIONS (301-312). and SPACE HABITATS (401-418). If you wish to order any of these images as slides or sets of slides, see the order form at the end of the slide show.

INTRODUCTION TO THE L-5 CONCEPT

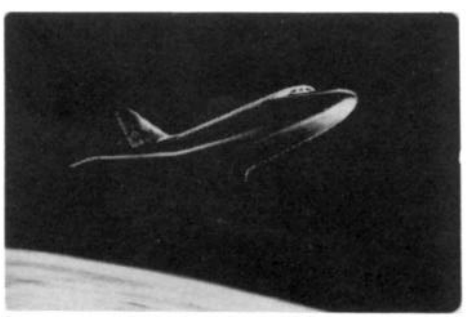
101 The Moon, source of most of the materials for space colonization.



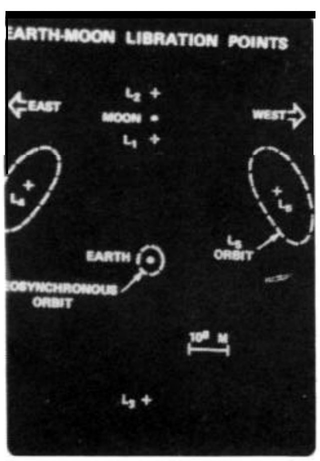
102 Apollo 8 view of the Earth seen from the Moon (NASA photo).



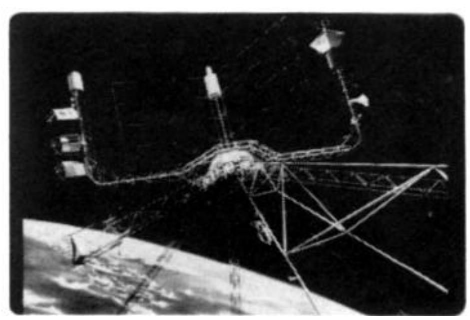
103 The space shuttle takes off from the Earth, carried by the lift vehicle.



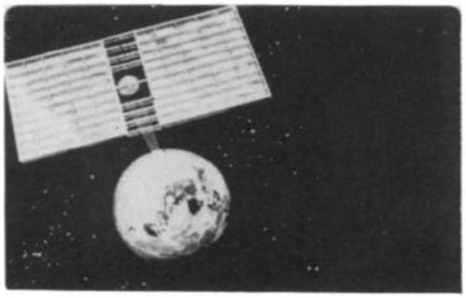
104 NASA space shuttle entering the atmosphere.



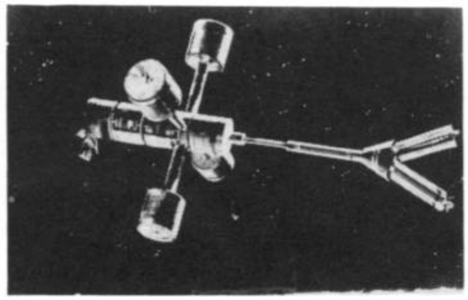
105 The geography of space, showing some points significant for space colonies.



106 Part of a power satellite under construction in low Earth orbit (Boeing).

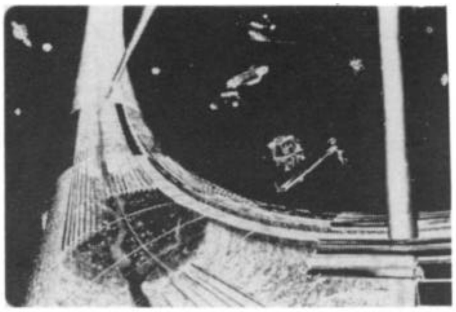


107 Power satellite of the photovoltaic type (Arthur D. Little).

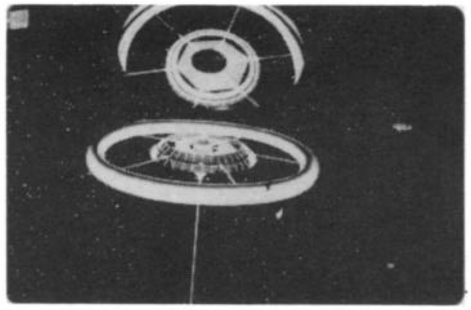


108 Space base "construction shack" for space industrialization.

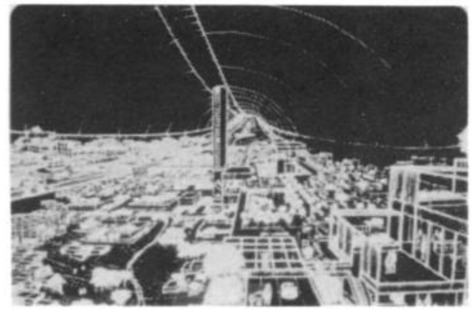
109 Space farm-interior of the space base "construction shack."



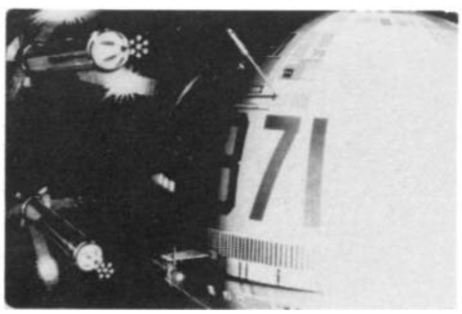
110 Construction in space of a space colony (toroid design).



111 A completed colony (toroid design by 1975 NASA/Ames Summer Study).

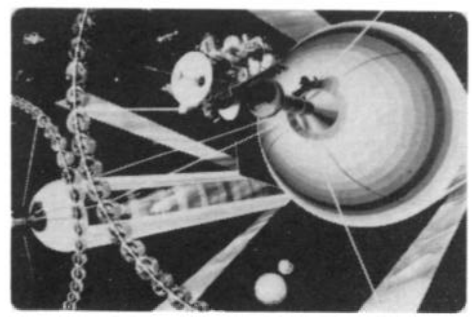


112 Interior of a colony (toroid design by 1975 NASA/Ames Summer Study).

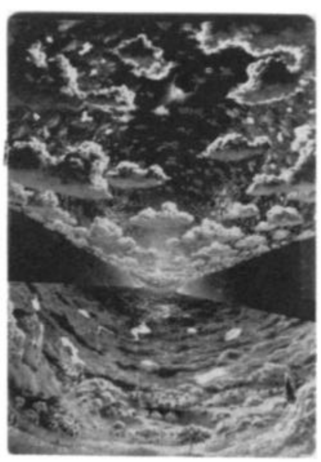


113 The spaceliner *Robert H. Goddard* brings in a new group of immigrants (Courtesy *Science Year).*

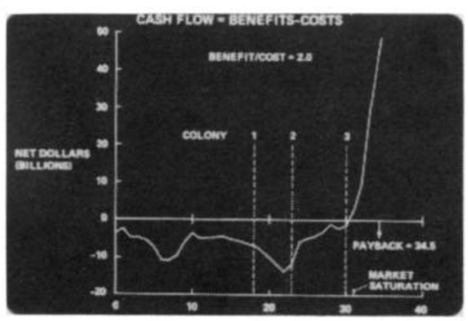
114 Interior design of a colony founded by a group of expatriate San Franciscans.



115 An advanced colony. Two cylinders in tandem, each with a four mile diameter and twenty mile length.



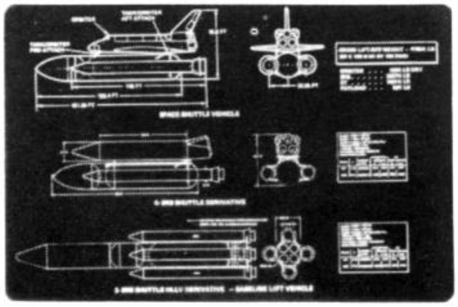
116 Solar eclipse in a colony. Cylinder interior is viewed along its axis.



117 Net revenue graphed over time (number of years from start of project).

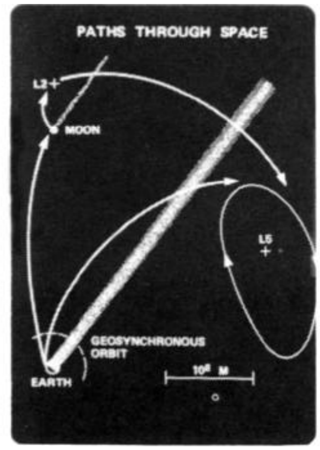
118 Humanity moves from the Earth to space in less than 100 years.

SPACE INDUSTRIALIZATION

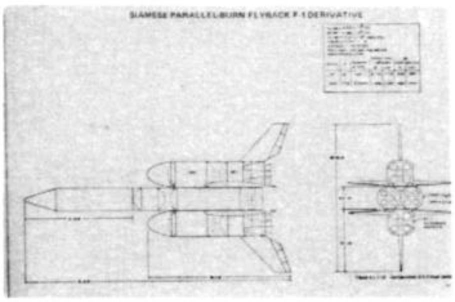


201 Schematic diagrams of the space shuttle, derivative, and lift vehicle.

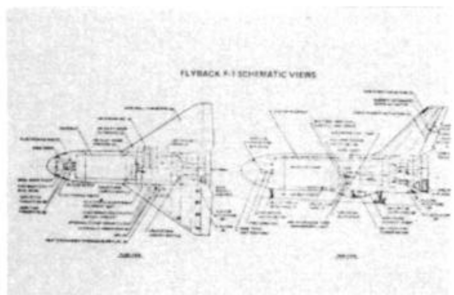
202 Space shuttle leaving the Earth via lift vehicle.



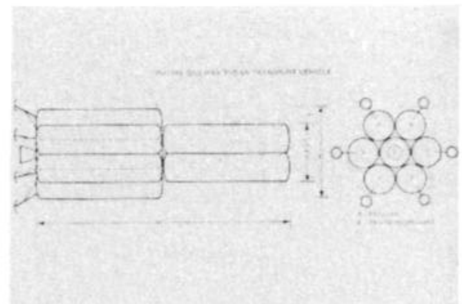
203 Paths through space from the Earth's surface (to scale).



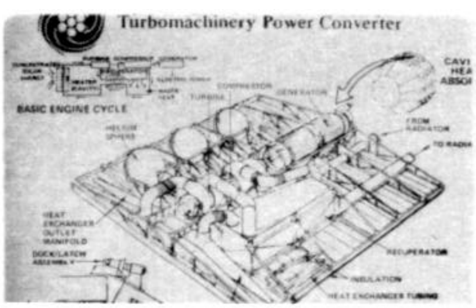
204 Design for carrying two reusable shuttles.



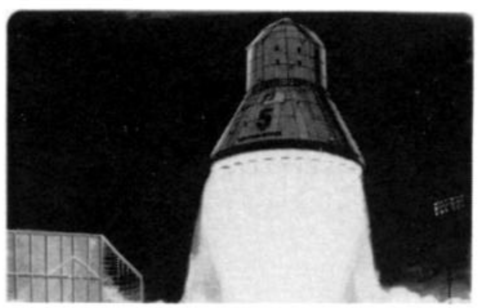
205 Design details of space shuttle (Flyback F-1).



206 One way lunar transport vehicle design.

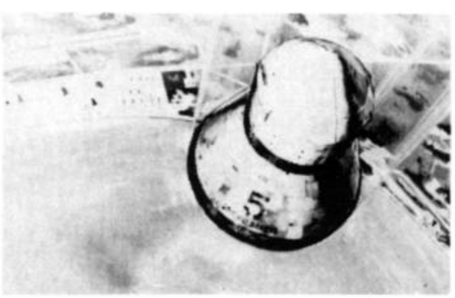


207 Design for Turbomachinery Power Converter.

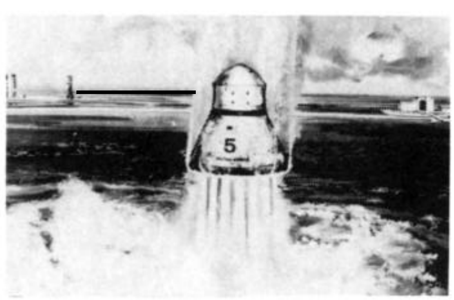


208 Heavy lift rocket takes Earth materials for construction to satellite solar power station (Boeing).

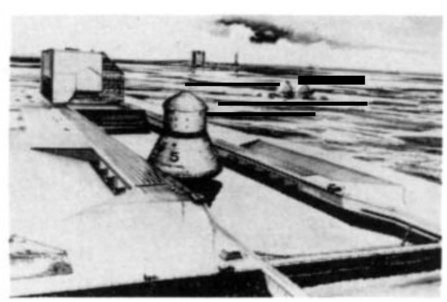
209 Cape Canaveral in the future, with landing basin and power receiving antenna (Boeing).



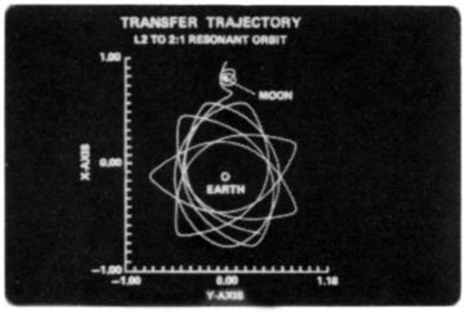
210 Heavy lift rocket re-entering and heading for landing basin (Boeing).



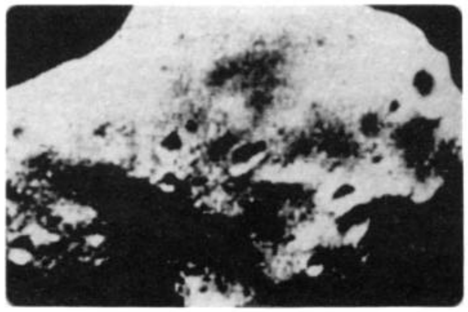
211 Heavy lift rocket landing after delivering Earth materials to construction site (Boeing).

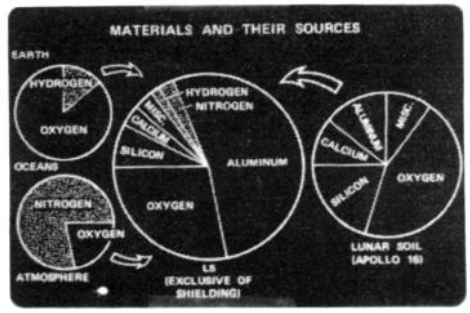


212 Heavy lift rocket docked and ready for next trip to construction site (Boeing).



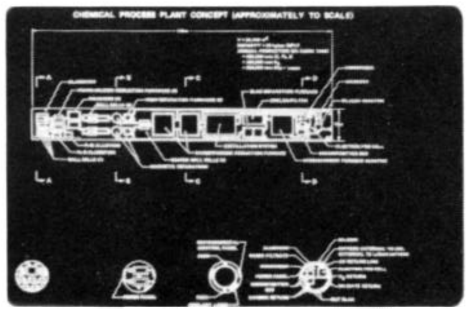
213 A possible location for space habitats -- 2:1 resonant orbit (14 days).


214 Phobos - asteroids are believed to look like this.

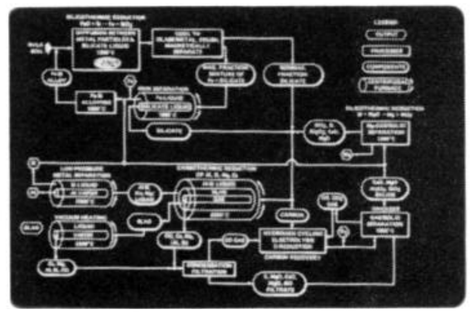


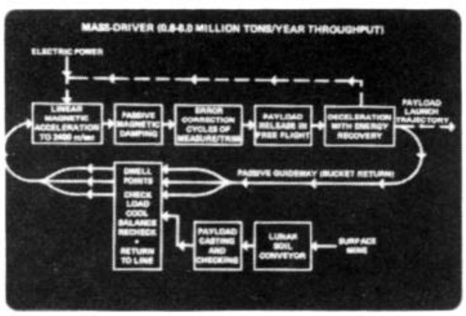
215 Summer study slide showing that almost all of the materials can come from the Moon.


216 Lunar mine to obtain materials for construction in space (Field Enterprises).

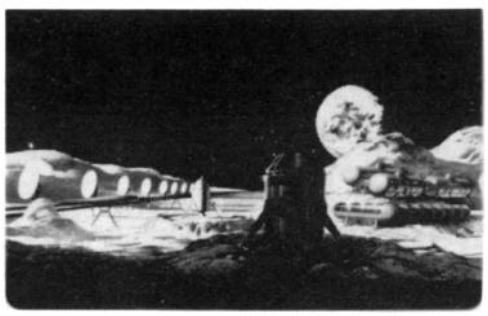


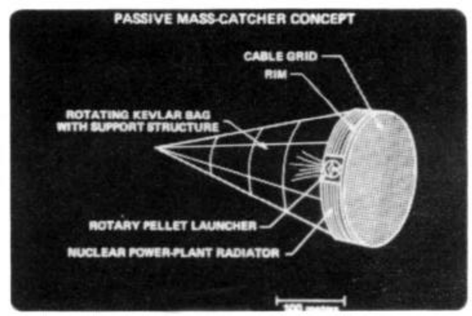
217 Mechanical layout of chemical processing plant.


218 Flow diagram for chemical processing plant.

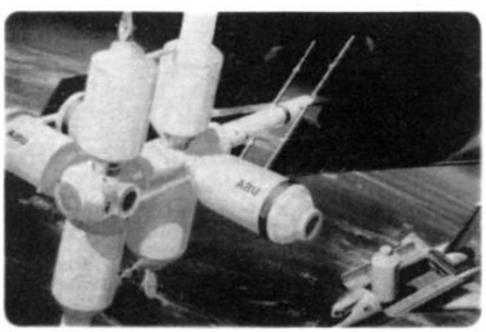


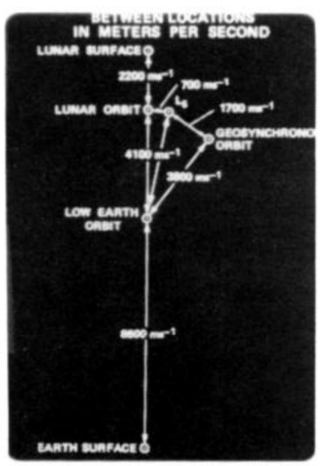
219 New version of the mass-driver (summer '76).


220 Lunar base with mass-driver launch track and habitations for crew (Field Enterprises).

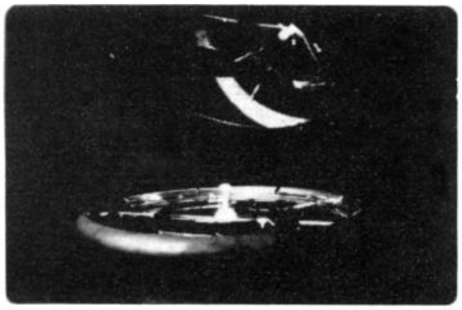


221 Early mass catcher design now superseded because of much greater accuracy by the TLA on the lunar surface.

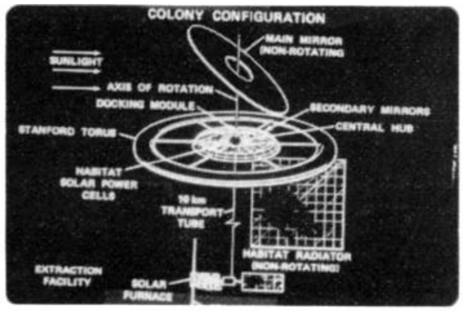

222 Space base used as habitat for construction crews.



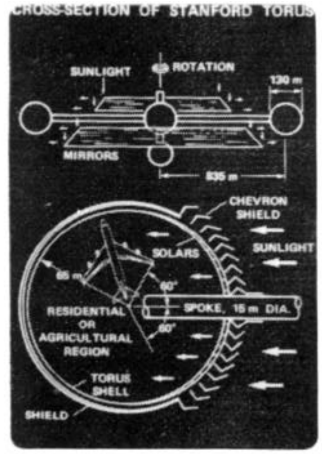
223 Distance between significant points in meters per second.



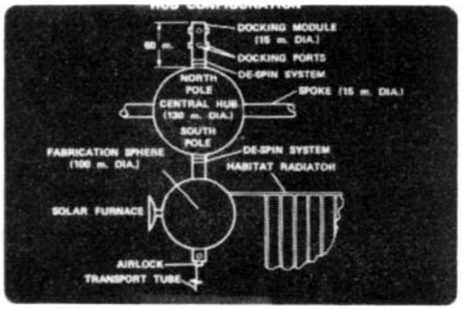
224 Model of the Stanford Torus design (NASA).



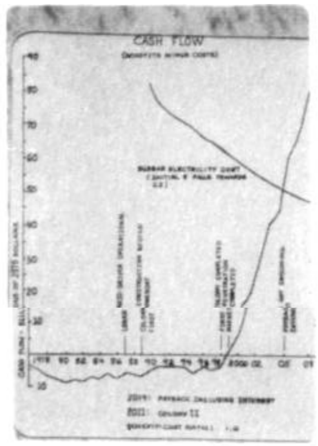
225 Details of the Stanford Torus design -- colony configuration.



226 Details of the Stanford Torus design -- cross-section.



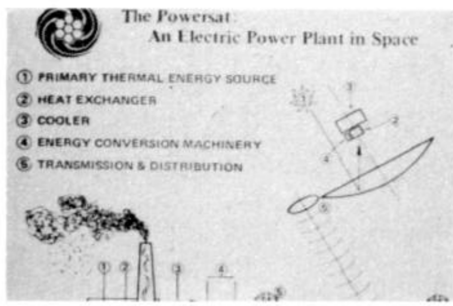
227 Details of the Stanford Torus design -- hub configuration.



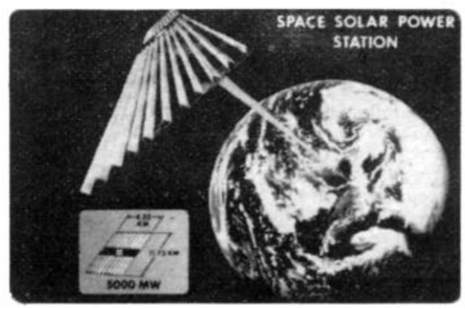
228 Results from an early economic study.

SATELLITE SOLAR POWER STATIONS

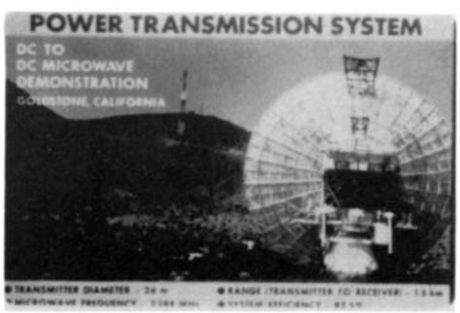
301 A view of the Middle East, present focus of energy discussions.



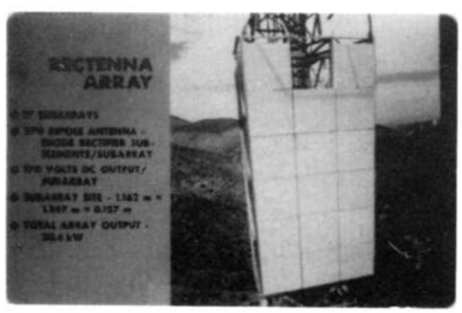
302 The Powersat: An Electric Power Plant in Space (Boeing design).



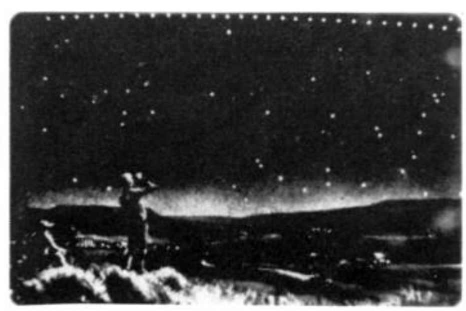
303 Photovoltaic type of solar power satellite with one km. diameter transmitter/antenna in center (Arthur D. Little design).



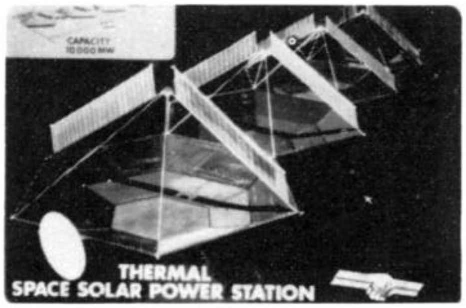
304 Microwave power transmission test (summer of 1975).



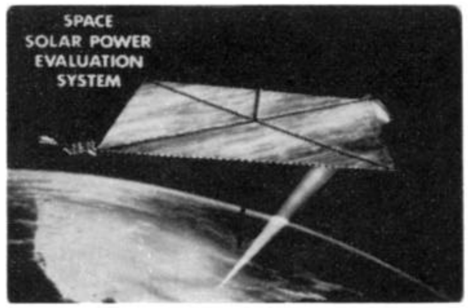
305 Microwave power transmission test (summer of 1975).



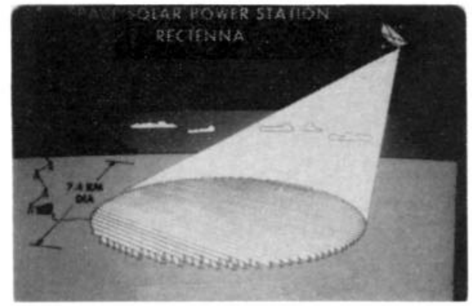
306 Power satellites in geosynchronous orbit as seen from Washington State (Boeing).



307 Photo-thermal type of solar power satellite, white disk is the transmitter/antenna (Boeing).

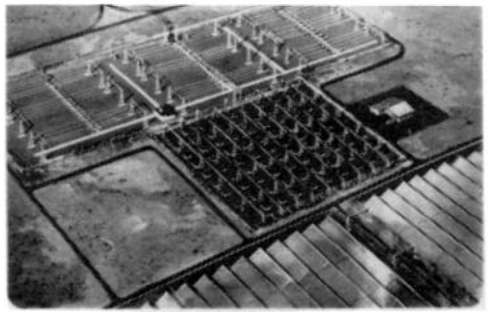


308 An early small test SPS built using the shuttle.

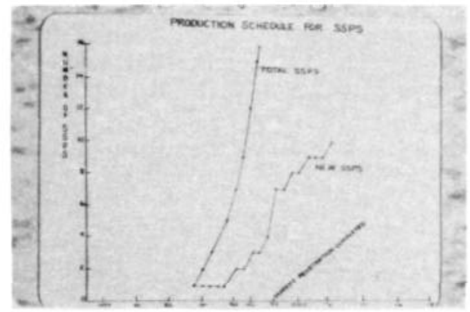


309 Rectenna configuration for receiving microwave transmission from SPS.

310 Rectenna array over farmland for receiving microwave transmission from SPS.

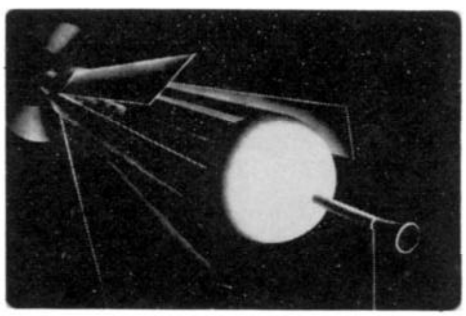


311 Inverters and standard power grid at the edge of the rectenna array over farmland.

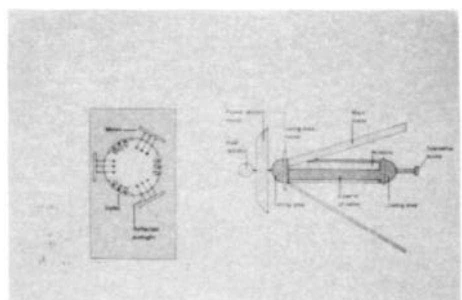


312 Production schedule for satellite solar power stations.

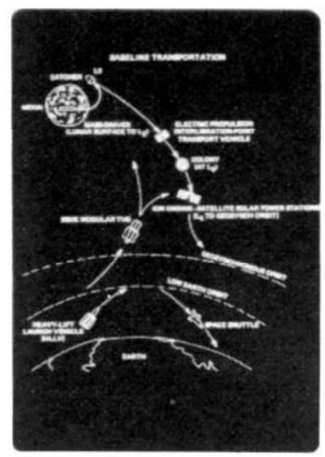
SPACE HABITATS



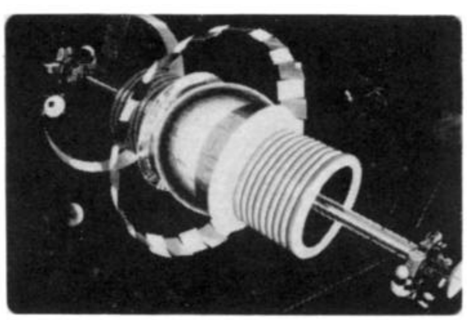
401 First painting of a space habitat -- four by twenty miles in size (cover of *Physics Today,* September 1974).



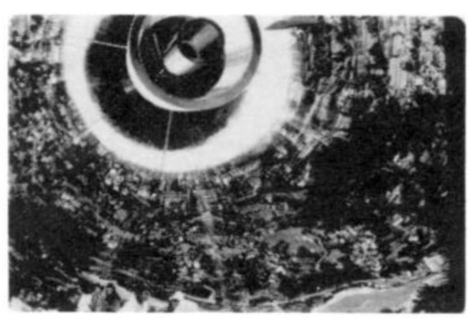
402 Diagram of Model 1 space habitat indicating living areas, valleys, and energy source.



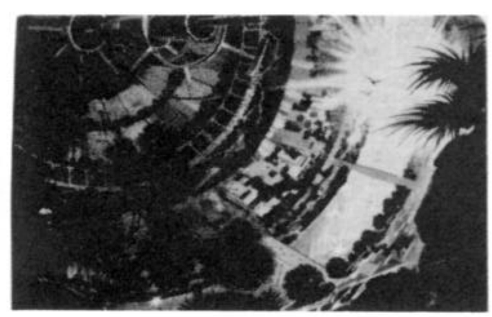
403 Baseline transportation diagram: Earth, Moon, colony at L-5.



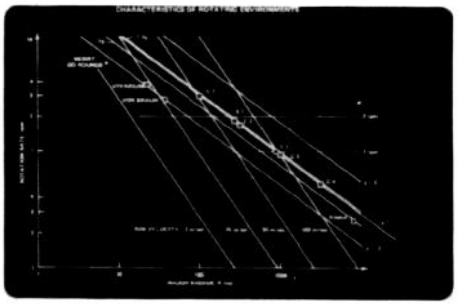
404 “Bernal Sphere” design for an early space habitat -- accommodating about 10,000 people.



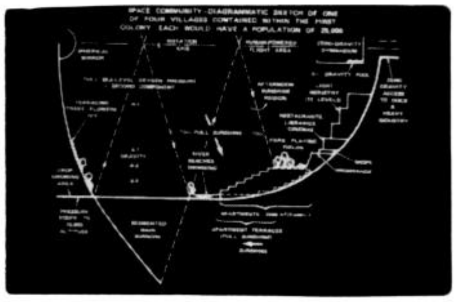
405 Interior of a “Bernal Sphere” space colony.



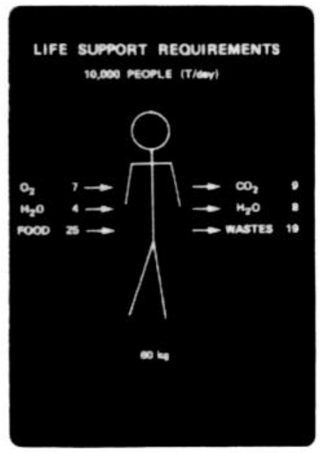
406 Detail of the interior of a space colony (Field Enterprises).



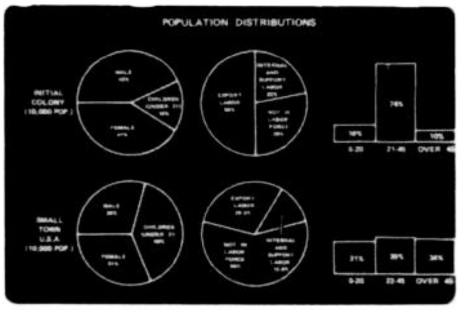
407 Design considerations for rotating space habitats.



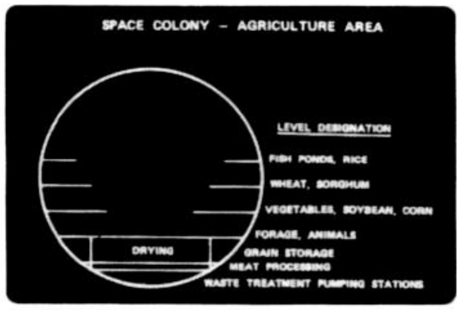
408 Early design of space colony (May 1975), now outdated.



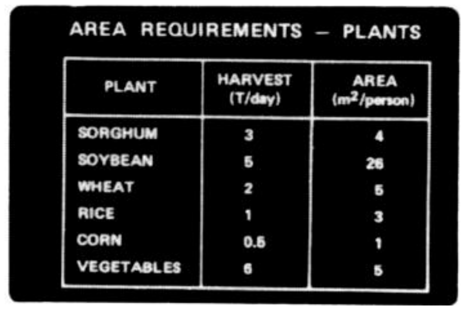
409 Life support requirements, taken from the Stanford Torus study.



410 Population distributions, taken from the Stanford Torus study.



411 Cross-section of the agricultural area of the Stanford Torus design.



AREA REQUIREMENTS – PLANTS

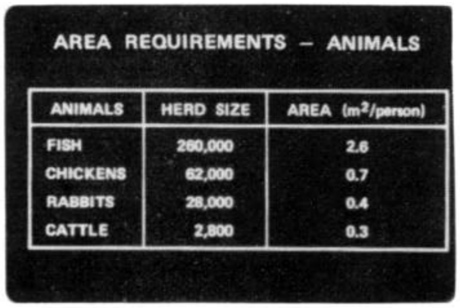
PLANT	HARVEST (T/day)	AREA (m^2/person)
SORGHUM	3	4
SOYBEAN	5	26
WHEAT	2	5
RICE	1	3
CORN	0.5	1
VEGETABLES	6	5

412 Area requirements for plants, taken from 1975 NASA/Ames summer study.

A NOTE ABOUT THE SLIDES

We recommend the slides be used for lectures or other presentations explaining the L-5 concept and the possibilities of space industrialization and settlement.

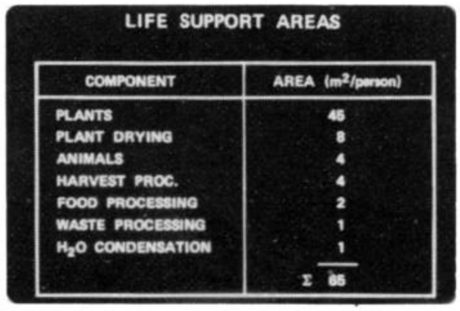
We wish to add more slides to the catalog in the future. We would welcome receiving slides from members who would like to have them made available to others through the L-5 Society.



AREA REQUIREMENTS — ANIMALS

ANIMALS	HERD SIZE	AREA (m^2/person)
FISH	260,000	2.6
CHICKENS	62,000	0.7
RABBITS	28,000	0.4
CATTLE	2,800	0.3

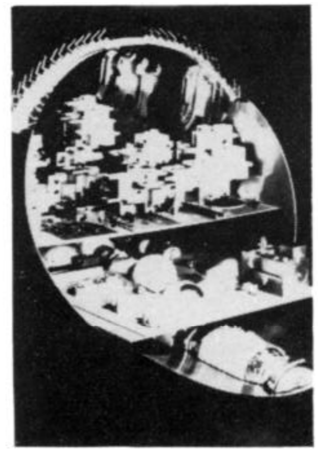
413 Area requirements for animals, taken from 1975 NASA/Ames summer study.



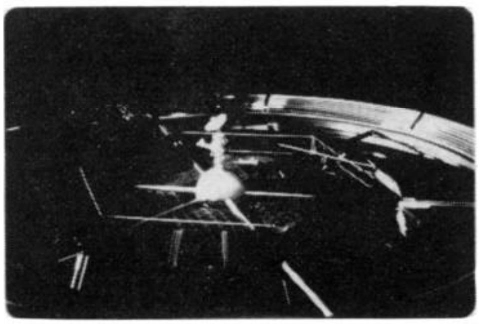
LIFE SUPPORT AREAS

COMPONENT	AREA (m^2/person)
PLANTS	45
PLANT DRYING	8
ANIMALS	4
HARVEST PROC.	4
FOOD PROCESSING	2
WASTE PROCESSING	1
H_2O CONDENSATION	1
	Σ 65

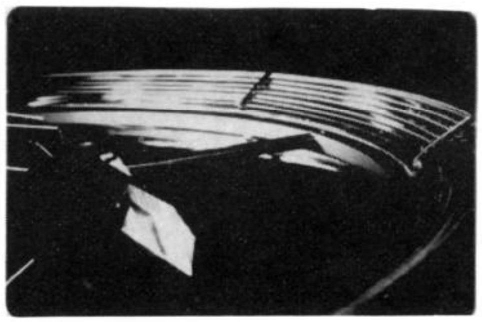
414 Life support areas, taken from 1975 NASA/Ames summer study.



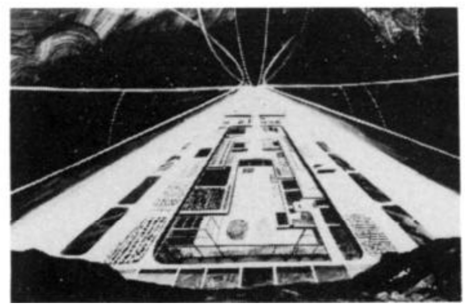
415 Cross-section of a model of the Stanford Torus, showing habitat, and other areas.



416 The Stanford Torus: a wheel-shaped habitat with spokes rotates within a tire of cosmic ray shielding.



417 Closeup of Stanford Torus exterior.



418 Agricultural area of the Stanford Torus, situated between two parks.

THE L-5 SOCIETY SLIDE SHOW
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- SPACE INDUSTRIALIZATION (28) 0201-228
- SATELLITE SOLAR POWER STATIONS (12) 0301-312
- SPACE HABITATS (18) 0401-418

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0106	0117	0206	0217	0228	0306	0406	0417
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STUDY TOPICS LIST (continued from page 1)

A) Effects of Partial G on Bone Calcium Loss, etc.
B) Effects of Rotation in Range Appropriate to Small Structures (2-4 RPM)

Experimental Studies (resulting in Concept verification or new scientific knowledge);
1) Mass-Driver (unique opportunity Kolm/O'Neill/MIT only during 9/76-5/77)
2) Model Lunar Soil (needed for all processing experiments)
3) Ionospheric Effects of Microwaves (cooperation with ERDA LASL proposal 12/76)

II. Material Resources

Lunar Soils Modeling (simulation) :
(less difficult)
Chemical Equivalence
Particle Size Distribution
Trace Elements
Volatiles
Radiation History
(last 2 affect chemical leaching)
Needed for experiments on :
Chemical Processing
Payload Formation
Agricultural Methods and Yields
Direct Formation of Low-Density Blocks/Structures

Develop Computer-Correlative Inventory for Lunar Surface :
Topography Suitable for Particular Requirements :
Launching- Downrange Correction
Solar Energy Utilization
Communications
Regolith Depth
Chemical Composition from
Apollo
"Prospector" (Lunar Polar Orbiter)
Geological Prediction
Samplers
Proximity of Permanently-Shadowed Areas
Velocity Intervals for Soft-Landing
Proximity of Boundaries Between Differing Mineralogical Areas
Needed for:
Chemical Processing Studies
Study of Materials Local-Transport methods
Study of Materials Launching Methods
Evaluation of Excavation Techniques

Develop Computer-Correlative Inventory for Asteroids :
Minerology
Mass
Orbital Elements and Velocity Interval to Reach
Launch Windows
Escape Velocity
Rotation Rate

Other Research :
Extend Theoretical Studies on Lunar High Latitude Volatiles
Integrate Lunar-Polar-Orbiter ("Prospector") Launch Schedule into Critical-Path Analyses
Study Slope Stabilization
Study Deep Drilling Techniques
Study Lunar Soil Sampler Missions
Intensify Search for Asteroids of Low Velocity Interval (Apollo-Amor Class). Correlate with Spectral Analysis
Study Dedicated Schmidt Telescope (Ground) + (Space)
Intensify Study of Asteroidal Flyby Missions
Study Asteroidal Sampler Missions

III. Transport

Study Conventional Vehicles and Methods :
Shuttle-Derived HLV
Shuttle/OTV Passenger Compartment Module
OTV (Orbiter Transfer Vehicle)
LTV (Transfer Vehicle Orbit to/from Lunar Surface)
Tanker or Tank Module for Early Use of Lunar Oxygen
Fuel Depots and Warehousing
Orbital Refuelling Techniques
Shuttle Uprating

Lunar Materials Launch/Guidance :
Methods :
Mass-Driver
Gas-Gun
Encourage Search for Other Alternatives
Evaluation Criteria :
Stress
Wear
Reliability
Maintainability
Repairability
Fail-Safe Design
Uprating Capability
Efficiency
Accuracy
Related Studies :
Orbital Mechanics Moon / Space
Materials Collection in High Orbit
Raw Materials Preparation/Packaging
Canisters for Special Payloads:
Liquid Oxygen
Stored Information
Electronics
Medical Supplies
Silicon Wafers

High Specific-Impulse Engines :
Methods :
Mass-Driver
Ion Thruster
Solar Sails
Micropellet Electrostatic Thrusters
Other
Evaluate :
Thrust Capabilities
Specific Impulse Capabilities
Efficiency
Thrust/Mass Ratio
Utilization of Non-Terrestrial Reaction

Size Scaling

Environmental Effects Studies :
Consider :
Lunar and Geosynchronous Environment
Van Allen Belts
Ionization Layers
Ozone Layer
Troposphere
Land and Water

In Environmental Effects Studies, Evaluate vs. Traffic :
SRB Effects
Liquid-Fuel Rocket Effects
Mass-Driver Engine Reaction Mass Choices :
Liquid Oxygen
Powder
Pellets
Slugs
Ion-Thruster Reaction Mass Alternatives :
Mercury
Cesium
Nitrogen
Other
Orbits, Impacts, Hazards of Uncollected Lunar Material
Atmospheric Entry Effects (Nitrogen Dioxide Formation, etc.)

Other Transport Studies :
Lunar Surface Material Conveyors
Lunar Surface Transport Systems (with or without crew) :
Magnetic Levitation
Wheeled
Other

IV. Processing
(* indicates Shuttle)

Oxygen Processors
Oxygen Liquefaction*
Dry Bulk Separation*
Process Study Evaluation
Yields (for Carbothermic Silicon Reduction + All Other Processes)
Reaction Rates
Equipment Inventory
Throughput/Equipment-Mass Ratios
Suitability for Automation and/or Process Flow
Utilization of Zero-Gravity or Centrifugation*
Utilization of Solar Energy*
Utilization of High Vacuum
Non-Solar Energy Needs
Solar Furnace Design*
Search for New Process Techniques*
Use of Volatiles (Sulfur, Nitrogen, Hydrogen, Helium)
Magnetic Separation
Eddy-Current Separation
Containerless Processing
Concept Studies of Chemical Engineering Unit Operations

V. Industrial Operations

Handling Machinery
Rolling
Milling
Blooming
Casting
Welding
Hot/Cold Working
Extrusion
Coating Techniques (Thin Film)
Vapor Deposition (Structural Thicknesses)
Alloying
Wire-Spinning into Cables
Foamed Metals
Foamed Ceramics
Structural Glass
Optical Glass
Insulator Manufacture
Powder Technology
Analogs to Cement (Sulfur-based, etc.)
Composites not Requiring C, N, H
Solar-Cell Manufacture
Industrial Mass Spectrometry
Sealants
Catalytic Effects of Dispersed Fine-Grain Lunar Soils
Search for Undiscovered Manufacturing Techniques
Modern Spacesuits
Enclosed vs. Vacuum Environments
Manufacturing Machinery Evaluation/Design vs.
Elements Required
Mass Required
High Complexity, Low Mass (from Earth)
Low Complexity, High Mass (Yokes, Frames, Bases)
Static/Dynamic Loads
Vibration
Fatigue
Zero Gravity or Rotation
Materials/Assemblies Traffic
Quality Control
Personnel Shielding
Repair by Humans vs. Automated/Telemetered Repair

VI. Structures

Categories : RP; RN; NP; NN
(R = Rotating; P = Pressurized)
Types
Plate Structures
Truss Structures
Cable-Wound Structures
Vapor-Deposited Structures
Special Components
Window Areas
Bearings
Airlocks/Seals
Radiators
Heat Pumps
Blowers

Heat Pipes
Structure
Light Concentration

Human-Rated
- Lunar Bases
  - Ground Properties
  - Civil Engineering
  - Energy Utilization
  - Personnel Shielding
- Space Habitats, Deep-Space Vessels, Orbital Laboratories
  - Geometries
  - Energy Utilization
  - Atmospheric Dynamics/Weather
  - Personnel Shielding
  - Sound Propogation
  - Norse Control

Universal Considerations
- Structure Design Calculability
- Mass Required
- Atomic Elements Calculability
- Optimization for NonTerrestrial Materials
- Oscillations and Damping
- Nutation and Precession
- Fatigue Life
- Fail-Safe Design
- Safety in Use
- Evacuation/Rescue
- Inspection
- Maintainability
- Repairability
- Productivity to Build

VII. Human Parameters

Biological Parameter Tolerance Distributions (Percentages Accepting) All as Functions of
- Age
- Sex
- Pregnancy Condition
- Time of Exposure
- Cycle of Exposure
- Previous Personal History

Quantifiable Variables :
- Oxygen Pressure
- Nitrogen Pressure
- Trace-Gas Pressures
- Humidity
- Toxic Substances
- Water
- Food
- Temperature
- Gravity/Acceleration
- Rotation Rate
- Diurnal Cycles/Circadian Rhythms
- Sunlight Spectrum/Intensity
- Radiation (Minimum lonizing, Heavily lonizing, Gamma)
- Vibration
- Shock
- Noise
- Sound Propagation
- Magnetic Fields
- Microwaves

Variables Less Easily Quantified :
- Personal Space/Privacy
- Variety/Availability of Clothing
- Variety/Availability of Foods and Beverages
- Isolation
- Sexual Needs
- Opportunities for Recreation/Exercise/ Creativity
- Cultural Needs (Books, Tapes, Radio/TV, Cultural Events)
- Opportunities/Ease of Communication
  - Other Local Points
  - Earth
- Sense of Personal Value/Independence vs. Exploitation
- Overwork
- Psychology of Personal Relationships
- Sense of Security from Personal Threat (Disaster-Security)
- Societal Desires (Community Size, etc.)
- Legal Desires
- Economic Desires
- Opportunities for Travel
  - Other Human Locations in Space
  - Earth
- Religion

All Affecting :
- Habitat Overall Design
- Internal Design
- Landscaping
- Decorative Art
- Personnel Transport Design
- Communications Systems Design
- Societal/Legal/Economic Structure
- Personnel Selection Criteria
- Personnel Tasting
- Personnel Equipment (e.g., Voice Amplifiers)

VII I. Ecosystems

Components : (Crops for Consumption; Seed Crops)
- Food Plants
- Decorative Plants/Trees
- Animals
- Birds
- Scavengers
- Bacteria/Viruses
- Machinery
- Humans
  1) As Ecological Components
  2) For Human Intervention to Maintain Ecological Stability or Force Change

Main Parameters
- Soil Type/Depth
- Water Balance
- Nitrogen Balance
- Oxygen Balance
- CO_2 Balance
- Trace Element Balance
- Sunlight Spectra and Angles
- Diurnal/Circadian Cycles
- Gravity
- Rotation
- Radiation
- Seeding and Harvesting Techniques
- Atmospheric Flow Patterns

All Affecting (1) Utilization of Non-Terrestrial Materials; (2) Need for Materials from Earth
- Main Habitat Design
- Agricultural Area Design
- Special Agricultural Atmospheres and Circulation Systems
- Waste Recycling Systems
- Plant/Animals/Bird/Scavenger/Bacteria Selection Criteria
- Ecological Stability Studies (Mathematical Modeling)
- Food Marketing/Distribution Techniques
- Human Tolerance Selection Criteria and Skills Selection
- Scaling With Unit Size
- Isolation/Monitoring/Inspection
- Productivity

Special Ecosystem Challenges :
- Lunar Bases
- Orbital Stations
- Local-Space Vessels
- Deep-Space Vessels

IX. Energy

Electricity Generation/Transmission Methods: (Component Development; Systems Integration)
- Solar Cells
- Turbogenerators
- Other?
- Microwave Generation and Beaming
- Microwave Rectification
- Conductor Transmission Lines
  - (On Lunar Surface, or Near/In Space Habitats, etc.)
- Laser and Other Energy Transmission Methods
- Nuclear Energy Generation

Direct Thermal Uses :
- Solar Furnace Designs
- Control of Spectrum by Windows and Mirrors

Direct Utilization of Solar Spectrum :
- Photoionization as Part of Chemical Processes

Special Energy Challenges :
- SSPS
- Lunar Electric and Thermal Power Sources
- High-Efficiency DC to Audio-Frequency Power Transfer
- Synthetic Fuels Production
- For Terrestrial Applications
- For use in Space
- Deep-Space Vessels
- Electrically-Powered Space-Probes
- Synthetic Fuels Production
  - For Terrestrial Applications
  - For Use in Space
- Deep-Space Vessels
- Electrically-Powered Space-Probes

Special Research Issues :
- Environmental Effects of Microwaves :
  - lonospheric
  - Atmospheric/Weather (Absorption in Rainstorms, etc.)
  - Human Tolerances
  - Effects on Aircraft
  - Effects on Birds
- Testing of Transmission Systems :
  - On Earth, Between Mountains (~100 km)
  - Earth to/from Space
  - Up/Down Differences in Microwave Transmission Tests
  - Optimization of SSPS Design for for Utilization of Lunar-Available Materials

X. Products

Quantifiable :
- Satellite Solar Power Stations
- Solar Power for Use in Space
- Space Engines (High Thrust, High Specific Impulse)
- Reaction Mass for Engines in Space (Oxygen, Rock Dust, etc.)
- Components of Main Regenerative Loop :
  - Lunar Materials Launchers
  - Solar Power Systems for Lunar Surface
  - Chemical Processing Equipment
  - Manufacturing Equipment
  - Workforce Habitats
- Large-Aperture Radio-Telescope Arrays
- Specialized SETI Antennas
- Large-Diameter Optical Telescope Arrays (Synthetic Optics)
- Communications and Observation Satellites
- Space Laboratories
- Unmanned Space Probes
- Orbital Laboratories for Location Around Other Planets
- Landers for Other Planets
- Space Vessels for Asteroidal and Other-Planet Research

Quantifiable but Not Itemized Products :
- Removal of Earthbound Limits to Growth
- Environmental Conservation and Protection
- Productivity (the Most Important Quantifiable Product)

Less-Quantifiable Products and Added Values :
1) Satisfaction of Human Needs for Hope and New Frontiers.
2) Satisfaction of National Needs for a Sense of Civilization-Leadership and of Place in History
3) De-Escalation of Conflict Through Partial Replacement of International Military Rivalry by Joint Response to a Common Nonmilitary Extraterrestrial Challenge

XI. Value Relationships

Identify Ordering Parameters ($, $/kg, Throughput/Installed Mass, Lunar/ Terrestrial Materials Utilization, Doubling Times, etc.)

Cross-Correlate Research Items with Priorities on :
- Probable Location on Critical Path
- Adequate Starting-Information to Initiate Research Immediately
- No Long-Lead-Time Prior Technology Development Required
- Fortunate Coincidences of Research Personnel, Facilities, Time and Place (Serendipity Factor)
- Likelihood of Large Return of Information or Technological Risk-Reduction from

Modest Research Investment
Likelihood of Synergism with Research Applicable Near-Term on Earth
Commonality to Any Plausible Long-Range Industrialization Effort
Chance of Later Cooperation with Other Agencies or Industry
Probable Existence and Availability of Competent Researchers for the Item
Research Building on and Reinforcing the Shuttle Program
Research Leading Naturally to Shuttle Experiments and Experiments at the Space-Industrialization Complex

General Needs :
- Develop Economic Analysis Methods Applicable to the Use of Non-Terrestrial Materials Sources
- Develop Economic/Research Status/Critical Path Analyzing Techniques for Space Manufacturing Program Permitting Rapid Correction and Updating
- Explore Historical Analogs (Westward Movement, Mining, Oil Exploration, etc.) for Lessons on Successes/Failures
- Reinforce and Build on Synergistic Education-Avenues Originating Both in and outside of Agency (Articles, Books, Radio and Television Interviews/ Panel Discussions, Documentaries, Professional Society Meetings)
- Explore Investment Scenarios and Probabilities:
  - U.S. Private
  - U.S. Public
  - Combined
  - Multinational
  - Non-U.S. (Drooped-Ball Effect)
- Quantify Non-Monetary Products and Values (Environmental, etc.).

STUDENTS LEARN LESSON IN SPACE ECONOMICS

From FASST Tracks

With the blessings of NASA being bestowed upon a high school and college level student payload program for the Space Shuttle, the first forms of the concept are taking shape from the NASA paperwork and rearing, along with this reality, the ugly head of the dollar mark.

In the November 8 issue of *Aviation Week and Space Technology* magazine the student Shuttle program was likened to an “orbital counterpart of the scheduled airline youth fare.” Payloads which are self contained and less than 200 Ibs. will be handled on a “space available basis,” and, according to NASA, will be flown for a “nominal amount”-between $3,000 to $10,000 in 1975 dollars. Additional fees will be negotiated if orbiter or crew support is needed.

FASST has learned that one high school student payload program, with a price tag of over one-half million dollars, has been turned down. The idea was generated internally at NASA, but the “powers-that-be” determined that the program was too expensive. That proposal is now being scaled down to an amount which should be more palatable to NASA budget watchers. The question that should now be raised is: How meaningful can a cheap student payload program be?

It is obvious that students can’t be expected to pay thousands of dollars to fly an experiment in space, and from the NASA viewpoint money is also tight. Most of the Shuttle program officers are very supportive of student involvement in the Space Shuttle, however, they quickly follow-up their show of enthusiasm with, “but I’ve got no money here!” It appears that new sources of funds will be needed to keep a student space experiment program alive and well.

FLASH! O’NEILL LEAVES FOR SAUDI ARABIA

Gerard K. O’Neill, space settlement proponent and author of *The High Frontier,* has just left for Saudi Arabia to give a lecture at the invitation of Aramco and the Saudi Arabian government.

His lecture, purely informational, will be the second of three lectures: the first was by Clark Kerr, former president of U.C. Berkeley, and the last will be by the president of the American Association for the Advancement of Science.

O’Neill informed the *L-5 News,* “There is no plan for and no reason for any expectation that the Saudis would be interested in putting up money toward the High Frontier.” Intermediate technology is the present focus for developing the country, according to O’Neill.

SPACE HABITAT STUDIES

The University of Illinois at Urbana-Champaign is offering a course this spring entitled: *Extraterrestrial communities: human considerations in design.* Psychological effects of various macrogeometry: large vista to avoid theatre-stage artificiality and solipsism syndrome; visibility of plants and animals which grow, and are independent from predictability; existence of “other towns beyond horizon” (in Torus). Two principles of heterogenization: localization; and interweaving. Four different principles of community design: homogenistic; individual insulation (privacy, self-sufficiency, uncoordinated random heterogeneity; hemostatic heterogenism (static harmony of diversity); morphogenetic heterogenism (interactions which generate heterogeneity, symbiotization, new elements, new patterns).

LUNA 24 SAMPLES INSPECTED BY U. S. LUNAR SCIENTISTS

Three U.S. lunar scientists, Dr. Michael B. Duke, NASA/Johnson Space Center; Dr. G. J. Wasserburg, California Institute of Technology; and Dr. Charles H. Simonds, Lunar Science Institute, visited Moscow on December 13-15 to examine lunar materials returned by the Luna 24 mission last August and to arrange for the transmission of samples for study by U.S. investigators. Luna 24 returned a 2 meter long, 8 millimeter diameter core from southeastern Mare Crisium, which has not been sampled previously by U.S. or Soviet missions. The site may contain material from nearby highlands and material from the ray crater Giordano Bruno some 1200 km away.

A Soviet-American space cooperation agreement provides for the exchange of samples from each of the lunar returns. The U.S. has provided 3 grams of sample from each of the six Apollo missions; the Russians have reciprocated with 3 grams of Luna 16 and 2 grams of Luna 20 samples, plus two small fragments of Luna 20 rock provided separately. Considering the fact that the Russian return has been 100 and 50 grams, respectively, for Luna 16 and 20, their cooperation in this exchange has been exceptional.

It is hoped that the samples will be transmitted to Houston to be available for distribution in the Spring of 1977.

SETI: Knocking at Heaven’s Door?

The Jet Propulsion Laboratory in Pasadena, California has announced that a search for extraterrestrial intelligence will get underway in October of 1978. At that time, scientists will begin to scan the heavens using a new signal processing technique that analyzes millions of frequency channels, simultaneously, in search of extraterrestrial civilizations.

Designed and developed in cooperation with the National Aeronautics and Space Administration’s Ames Research Center, which is located near San Francisco, the JPL Search for Extraterrestrial Intelligence (SETI) program is described as a “modest” but serious beginning. This initial step, using existing Earth-based radio telescopes, may lead, in time, to a SETI program involving construction of large antennas in space or, perhaps, on the Moon-away from radio interference from the planet Earth.

The announcement comes in the wake of an appeal from Nobel Laureate Sir Martin Ryle, a prominent astronomer from Great Britain, to refrain from making known the existence of intelligent life on the planet Earth, for fear that we could be invaded by hostile beings.

Sir Martin has taken his plea that radio astronomers should not beam out powerful signals to distant stars and galaxies to the International Astronomical Union and the American Astronomical Society. SETI scientists argue that the emphasis of their programs is on listening, with no thought, at this time, of transmitting. However, Sir Martin points out that such has not been the case as powerful radio signals have already been sent from the Arecibo Radio Telescope in Puerto Rico, and from a project designed to map the planets with strong radar pulses.

Inside the L-5 Society

L-5 SOCIETY FINANCIAL INFORMATION

income and expenditure figures for the first and second quarters of the current fiscal year (beginning July 1, 1976) follow:

Income		**1st Quarter**	**2nd Quarter**
Memberships		$ 2,490	$ 4,356
Sales		868	2,627
Donations:	O'Boyle	5,500	3,566
	other	61	248
Income Totals		8,919	10,797
Expenditures			
Management Services		1,819	3,454
Printing & Copying		1,705	3,673
Conferences		752	1,013
Telephone		765	511
Postage & Shipping		697	765
Publications & Slides		472	1,268
Office Supplies & Expenses		51	395
Miscellaneous		294	191
Expenditure Totals		6,556	11,270

The expanded nature of current Society activities, in particular the improved quality of the newsletter, has been made possible by the generosity of William B. O'Boyle, of New York.

However, it is necessary for the Society to operate from a broad base, and Bill's period of funding is now over. Current income from memberships and sales is not quite adequate to maintain our present level of operations. We can effect some short-term economies without noticeable damage, but about $1,000 per month over our usual income will be necessary to do a proper job.

If every one of the nearly 1000 L-5 Society members sent us a dollar, we would have another month to allow our income to catch up to expenditures through growth in Society size. You get what you pay for, *monumentum aere perennius* (translation sent to those who donate $1 or more during the next month).

L-5 DIRECTOR WINS GODDARD AWARD

The National Space Club in Washington has announced the name of the winner of its annual Robert H. Goddard Historical Essay Contest Competition for 1976. He is James E. Oberg, 32, an aerospace engineer at NASA's Lyndon B. Johnson Space Center in Houston, Texas.

The annual contest is devoted to encouraging research into historical questions in the development of rocketry, astronautics, and space exploration. Entries are solicited by November 1 of each year, with the judging to be completed by the following January. A distinguished panel of space experts from NASA, the Smithsonian institute, the Library of Congress, and the university community evaluates all of the entries without knowledge of the identity of the authors. Only when the winner is selected is a sealed envelope opened which contains the author's name.

A certificate and a $500 cash award are presented to the winner at the annual Robert Goddard Memorial Dinner in Washington which is customarily held each April. Numerous other awards and scholarships are presented to other winners in different competitions.

The subject of Oberg's winning historical paper is "Korolev, Khrushchev, and the Sputnik." It deals with the behind-the-scenes political maneuvering in Russia which led to the Kremlin decision to proceed with the launching of the first Sputnik in 1957. Oberg drew on numerous Soviet, American, and West European sources, including Khrushchev's memoirs, official Soviet biographies of top Russian space engineer Sergey Korolev, interviews, letters, defectors' reports in English, Russian, and Ukrainian, and other obscure but vital leads.

Oberg, an Air Force Captain detailed to NASA for the Space Shuttle program, is a computer software analyst in the Spacecraft Software Division, where he prepares estimates for on-board software support for payloads. He has been at NASA since July 1975, having previously served at Kirkland AFB in New Mexico and as an instructor at the Department of Defense Computer Institute in Washington. He has two graduate degrees in astrodynamics and in computing sciences. He and his wife live in Alta Loma in rural Galveston County.

Besides his Air Force and NASA duties, Oberg is a free-lance science and space writer/lecturer. He is Associate Editor of *Space World* magazine and is a Contributing Editor to *Astronomy* magazine. His articles frequently appear in other journals such as *Science Digest, Spaceflight, Technology Review, Sky and Telescope, Aerospace Historian, Flight international, Analog* and New *Engineer.* He often lectures on space science and space colonization and is a member of the Board of Directors of the L-5 Society.

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.
- *L-5* News, back issues $1 each (Volume included 16 issues).
- Bernal Sphere postcards (interior; exterior). 15¢ each; 50 of one kind, $3.
- Bernal Sphere 14" x 17" posters (interior, exterior). $3.50 for one, $3 each for two or more, $2.10 each for 10 or more, $1.75 each for 50 or more.

NOW AVAILABLE!

- *The Fourth Kingdom,* William J. Sauber, Aquari Corp., 1975, $6.00.

Note: Postage and handling per order, add $2.

IN THE L-5 OFFICE

Thanks to the staff and several volunteers (a tip of the hat to them), we succeeded in sending out a double mailing of the January issue and the Index, as well as sending out 500 answers in response to requests for information.

The posters (in full color) hopefully will be done and ready for shipment on the first of March.

* L-5: A POINT TO REMEMBER *

News from ERDA

ERDA SEEKS NOMINATIONS FOR NEW ENVIRONMENTAL ADVISORY COMMITTEE

The Energy Research And Development Administration (ERDA) has set up an Environmental Advisory Committee to increase public involvement in defining the goals and setting the policies of ERDA's environment, health and safety programs.

The Committee will advise the ERDA Administrator through the Assistant Administrator for Environment and Safety, Dr. James L. Liverman.

The new panel will provide advice on social, economic and institutional impacts of ERDA's energy programs; the preparation of environmental impact assessments and statements; biomedical and environmental research and planning; and occupational health and safety matters within ERDA facilities.

In addition, the Committee is expected to provide advice and counsel to ERDA's technical staff on natural and social science aspects of new and continuing programs.

"ERDA was established as the first agency with a clear mandate to give environmental concerns equal consideration in the development of energy technology," Dr. Liverman said.

"I believe the Environmental Advisory Committee will help us achieve a balanced approach to solving the problems which arise from the interactions of scientific, engineering, economic, social and institutional factors related to energy technology."

The Committee's 21 members, who will meet at least four times a year, will be drawn from the fields of science, medicine, engineering, industry, state and local government, and environmental protection, as well as from the general public.

Committee members will be selected by the ERDA Administrator from recommendations submitted by the Assistant Administrator for Environment and Safety.

Those wishing to submit names for consideration or desiring additional information should contact Dr. Joel B. Stronberg, Office of the Assistant Administrator for Environment and Safety, ERDA, Washington, D.C. 20545.

ERDA STUDIES UNCONVENTIONAL WIND ENERGY CONCEPTS IN 1977

Three advanced and innovative wind energy concepts are being explored in 1977 by the Energy Research and Development Administration.

Under research contracts issued late in 1976, the Grumman Aerospace Corporation of Bethpage, New York is studying and developing a vortex tower wind energy system; the University of Dayton Research Institute is analyzing a Madaras rotor power plant concept; and the South Dakota School of Mines and Technology, Rapid City, South Dakota is exploring the feasibility of extracting energy from humid air.

These projects are part of an overall ERDA program to develop wind energy, and they represent an examination of innovative concepts quite different from the conventional windmill. The ERDA-funded studies involve investigations of the feasibility of these concepts and examinations of their potential for significant improvement in energy cost over conventional windmills. The contracts resulted from the evaluation of over 50 unconventional ideas received in response to a request for proposals announced early in 1976.

Letters

I had a class in Community Services last semester [Fall 1976], and they became deeply involved in working on the alternative social structures for L-5. We were all very surprised at what appears to be a dearth of such planning in the materials we have received from NASA. The technology is carefully worked out, with tremendous amounts of research and reports. However, there is very little we are aware of that has been done in actually working out the possible social structures, and that is *as important* as the technological element. This is an unprecedented opportunity for planning, and there is enough research now that definite organizational systems can be created that will facilitate life in the space community! Not to do so would be such a vast mistake that one can hardly conceive of it. What this first colony does, the patterns it sets up, will have a major impact on the following communities-if and how they organize. Of course the research possibilities in such a closed environment are a sociologist's dream!

The students are going to continue working on the project, even though the semester and the class is over. Thus, they, and I, have an interest in all the materials we can find on the plans and development for the Space Colony. The whole area of space colonization was totally unknown to all of them, and I have been amazed at the interest they have shown, and the impact their work has had on themselves and their friends and families!

B. J. Bluth, Ph.D.
California State University
Northridge, California

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

NL 702

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 opened up the paper this evening *[Kansas City Star)* and looked through the editorial page as I usually do when I stumbled across the following statement: ". . . President Carter's budget experts are looking at the proposed fiscal 1978 budget for the National Aeronautics and Space Administration as a likely place where cuts can be made and the money diverted to social programs."

ARGH!! I don't know if we can mount a letter-writing campaign in time to stop this madness, but I think we'd better try. We're not going to get space colonies or anything else up there unless we can demonstrate that the people of this country (or at least a sizeable fraction thereof) are in favor of the space program, and the bigger the better! The Space Shuttle is absolutely vital to everything we believe in.

I don't know how you (the L-5 Society) feel about this, but if it were up to me I'd give it top priority and tell as many of the members as possible to write directly to the President, 1600 Pennsylvania Ave., Washington, D.C., and let him know how we feel about this matter.

Is it possible to send a letter or postcard to all the members of the L-5 Society and inform them of the fact that the NASA budget might get cut? You don't have to tell them to write and protest this abominable idea, but you might suggest that Mr. Carter might react positively to a couple of hundred letters on the subject. We might also want to get in touch with the Star Trek people and anyone else who shares our views about the importance of space to our future, and get a massive letter-writing campaign started.

Robert G. Lovell
Shawnee, Kansas

[The Society can't get involved in lobbying, but we will print letters from members on relevant subjects.]

If the Viking results indicate that Phobos and Deimos are really carbonaceous chondrite material, then we have a deep space source of volatiles such as carbon, nitrogen, and hydrogen, without having to drag it up from Earth or snag a passing comet. I'd like to see a study of the transport of such materials from Mars orbit to L-5, or even better, the emplacement of Deimos or a large hunk thereof at L-4.

Mining the asteroids sounds neat, and raiding Saturn for volatiles also is exciting, but the delta-V requirements alone become prohibitive, not to mention the trip times. Of course, who says we have to build the colonies near Earth anyhow, except perhaps because we may hug close to the Sun to draw its power. Out past Mars we may set up new manufacturing sites but might need alternate sources of energy.

The Earth-crossing Apollo asteroids are more bits and pieces of available resources, but since their periods are very close to that of the Earth, the resulting synodic period may be measured in decades. While the theoretical delta-V to get to 1976-AA and back is the lowest for any other object in the Solar System, the launch window does not recur until the early 1990s.

Recall that we once thought Phobos might have been a spacecraft but everybody said that ten-mile-wide space vehicles were a thousand years beyond human technology. Now, of course, we will build satellites of that size in a few decades. We will build Phobos-sized artificial worlds a thousand years sooner than experts had estimated twenty years ago. Of course, we have an advantage over the Martians: we will do it with natural lunar materials, which more than makes up for the Martian advantage of lower primary gravity. Well, forget the fantasy; Phobos is a natural object. If we ever expect to find ten-mile-wide spacecraft in the Solar System, we will have to build them ourselves.

James E. Oberg
Dickinson, Texas'

I would like to thank Mr. Aldo Pontecorvo for his letter in the November issue, in which he points out something of which I was unaware. This is that it is food technologists, and not chemists, who would have the responsibility for development of food products from sources such as soybeans, TVP (textured vegetable protein). Mr. Pontecorvo may rest assured that now that I am aware of this, I would certainly advocate that people from this discipline, food technology, should consider the contributions they might make to a colonization program, in which no doubt they would be entirely welcome.

As for the *L-5 News* in general, as one who has received every issue since the first, I too am impressed by the recent improvements in its quality. To me, what is most noteworthy is your use of major articles in such areas as NASA's space-station program, von Puttkamer's advanced planning activities, and Criswell's analysis of space-resource economics. These articles have been entirely on a par with articles appearing in such journals as *Aviation Week* and *Astronautics and Aeronautics.* Insofar as such topics have not yet been treated in these journals, however, it is evident that *L-5 News* is becoming a valuable resource for the aerospace professional and a useful reference for work in management or advanced planning.

Many have speculated as to the future of *L-5 News.* May I offer a modest suggestion? Late in 1945, Eugene Rabinowitz and his colleagues, at the University of Chicago, founded the *Bulletin of the Atomic Scientists.* At first it was just a mimeographed newsletter, but it soon grew to become a leading journal of viewpoint and opinion, and of interest to many people outside the nuclear community. May I predict a similar future for *L-5 News?*

T. A. Heppenheimer
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