

L-5 NEWS

A Newsletter from the L-5 Society
Number 10 * June 1976

A COMMUNITY IN SPACE: STUDY WITH ASIMOV

The idea of space colonization is no longer solely in the domain of science fiction buffs. Eminent scientists, NASA, and the U. S. House of Representatives and Senate are studying the technological feasibility of building a habitat in space.

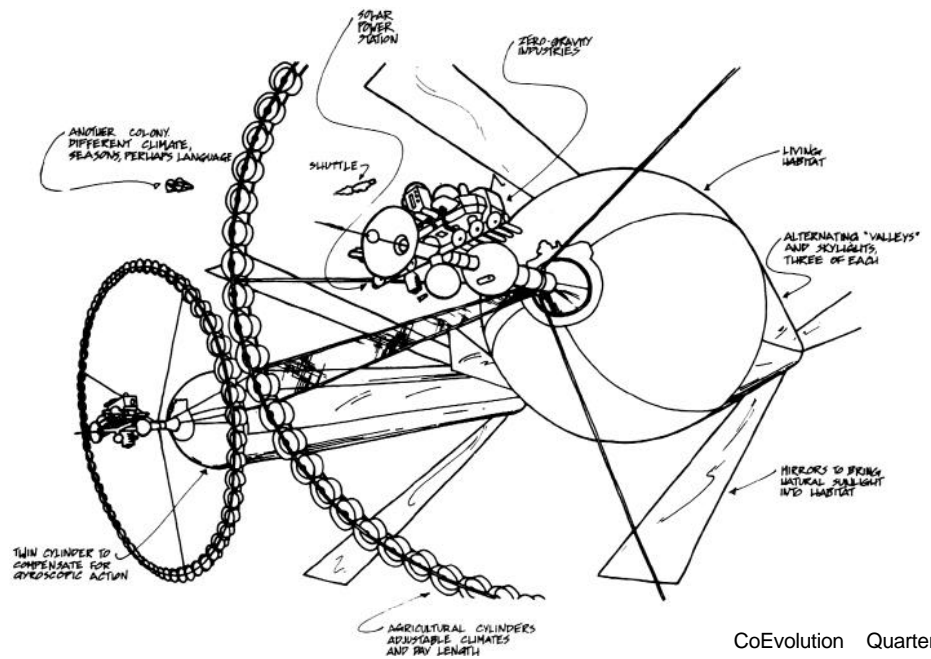
On July 11-15, The Institute of Man and Science will present a public program featuring Dr. Isaac Asimov which will examine the implications of living in space.

The point of entry for the program will be the research and concepts of Dr. Gerard K. O'Neill, professor of physics, Princeton University, and the principal advocate for the development of space colonization: "If we were to start now," Dr. O'Neill has said, "I believe that the first space colony . . . could be in place, with its productive capacity benefiting Earth, before 1990."

That "productive capacity benefiting Earth" is the construction of satellite solar power stations (SSPS). These satellites, built at the space colony, would be placed in geosynchronous orbit and would supply it with solar energy which is cheap, non-polluting, and abundant. Using solar energy could free us from the energy crunch, save Earth's ecology and diminishing fossil fuel resources, and enable the third world nations to develop their technology more cheaply, so that they can close the standard-of-living gap between themselves and the industrialized countries.

The community would be located in a stable orbit, equidistant from the Earth and the Moon, at a point in space called L-5. Ninety-eight percent of the raw materials which will be needed for the first space colony would be taken from the Moon to prevent further depletion of the Earth's natural resources. The manufacturing of the SSPSs gives the project sound justification for its development, and the use of the Moon's materials makes it economically feasible.

Dr. O'Neill has stated, "This is possible, I must emphasize, within the limits of present-day, conventional materials and technology." testimony before the House Subcommittee on Space Science and Applications, Dr. O'Neill underlined this point by noting: the problems of nuclear waste have not been solved, so nuclear reactors are being built against tremendous public opposition which is likely to increase; the problems of hydrogen fusion have yet to be worked out, and it will be quite some time (some estimate as much as 30 years) before fusion power can become competitive



CoEvolution Quarterly

with conventional energy sources, but the space colony and the SSPS are possible now, using the technology that was developed for the space shuttle, which is scheduled to make its first flight in 1980.

The space colony will house about 10,000 people. If they are given the chance, how will they form their community? What kind of community will they form?

The public program this summer at the Institute of Man and Science will attempt to answer these questions. Isaac Asimov, scientist and renowned author of over 170 books, will be returning to The Institute for his fourth consecutive year to chair the program, "A Community in Space."

Joining Dr. Asimov on the faculty will be: Dr. Isidore Adler, professor of geochemistry, University of Maryland, and NASA consultant; Ben Bova, novelist, lecturer, and editor of *Analog Science Fiction-Science Fact* magazine; Dr. Paul Meadows, professor of sociology, State University of New York at Albany.. and author of *The Many Faces of Change*; Paul Siegler, president of Earth/Space, Inc., and editor of *Earth/Space Newsletter*; and Dr. Bert E. Swanson, professor of political science, University of Florida, and co-author of the Woodrow Wilson Award-winning book, *The Rulers and the Ruled*.

The institute invites sixty resident participants and up to an equal number of commuters to join Dr. Asimov and the resource faculty in tackling the economic, social, and political problems associated with planning a community in space. The intent is to form a diverse and informal learning community with teachers, students, business persons: people from a broad range of professions and vocations. The participants will be asked to assume the role of prospective residents of the first space community and will work in

small groups and plenary sessions to answer key questions concerning the topic; feedback will be provided by Dr. Asimov and the members of the resource faculty.

And, while space colonization may not become a reality in the near future, it is hoped that the planning of such a habitat will give a better perspective of communities on Earth and will provide some insight into the reasons for their successes and failures.

The five-day program will be held at The Institute's campus in Rensselaerville, New York, about thirty miles southwest of Albany. The Institute of Man and Science is a nonprofit, independent educational and research center concerned with new approaches to critical social problems. Its new coordinator for public planning is Terri Rapoport; Ms. Rapoport is a graduate of the State University of New York at Albany, where she received a B.A. in English and secondary education in 1973.

For more information and registration materials regarding "A Community in Space," contact: Ms. Terri Rapoport, Public Programs Coordinator, The Institute on Man and Science, Rensselaerville, New York 12147, (518) 797-3783.

MARS SYMPOSIUM TO FEATURE SPACE COLONIES

The Southern California Branch of the British interplanetary Society is sponsoring a symposium on the theme, "Mars and Beyond." It will be held on June 27, a few days prior to the scheduled landing of the first Viking mission to Mars.

The symposium is to be in three parts, and will feature panel discussions between speakers as well as talks by the individual speakers. Among the speakers will be Ray Bradbury, the science-fiction author; Carl

Sagan, author of *The Cosmic Connection*; William Pickering, director of the Jet Propulsion Laboratory; Robert Forward, leading authority on interstellar flight; and Bernard Oliver, proponent of the Cyclops concept for interstellar communication.

In addition, the third session, "2001 and Beyond," will feature the participation of Tom Heppenheimer, frequent contributor to L-5 News. He will be speaking, of course, on the subject of space colonies.

The symposium will be held in the auditorium of La Canada High School, on Oak Grove Drive in Pasadena, California, beginning at 11:00 A.M. This site has been chosen for its convenience to JPL, as well as for the large seating capacity of its auditorium. Admission is free, and interested L-5 members are invited to attend.

SPACE: THE NEXT BATTLEGROUND?

Leonard David

The military use of the Satellite Solar Power Station as a power source for a space-based weapon system is a small part, a drop in the cosmic bucket—so to speak, of what could be, and to some extent already is, our next battleground.

Any discussion of using space for military purposes should begin with an interpretation and investigation of the 1967 "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies."

Article IV of this treaty contains the "control provisions" of locating weapons of mass destruction in outer space. Article IV states:

States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner.

The Moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military maneuvers on celestial bodies shall be forbidden. The use of military personnel for scientific research or for any other peaceful purpose shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the Moon and other celestial bodies shall also not be prohibited.

While the space treaty provides for the use of space for transient ICBMs carrying nuclear warheads, it is clear, according to experts in space law, that an orbiting missile killer or laser weapon would be prohibited, regardless of whether or not it would be intended for offensive or defensive purposes.

However, there have been, consistently, problems in interpreting the rules and regulations of what connotes "peaceful," "military," and "aggressive"

uses of outer space. What the terminology of a certain treaty states rests in the "eye of the beholder."

One only has to look at the vocabulary of whatever SALT document is on the table to realize that technology is continually ahead of vocabulary. By the time the signatures have hit the paper, the hand-shaking and back-patting is over, the vodka has settled in the stomach, the guy in the lab has just invented something that nullifies everything just signed. A new technology, or even an offshoot of an old technology, brings a new vocabulary.

The SSPS system is but a small branch of the much larger picture of the development of a dependence by society on the space industry for its needs. The point should be raised that future dependence on such space-based facilities as space manufacturing, domestic communication satellite networks, as well as space-based power stations, will, in essence, move a country's traditional strategic targets from the Earth into space, requiring protection from aggressive elements.

It is this fact that enforces the hope that these space-based, Earth-assisting, systems will be developed via international cooperation for global use. But can cooperation in space prosper and still provide a competitive market place for goods and services while perpetuating our historical need to be number one in military superiority? Action does speak louder than the words of a treaty, and one should balance optimism, sorry to say, with the apparent "non-cooperative" developments of both the Soviet and U.S. military establishments, particularly in the subject of laser research.

Ronald Pretty, editor of *Jane's Weapons Systems*, has stated that "both the United States and the Soviet Union are probably locked in a race to develop a space-age 'death ray' or high-energy laser weapon." According to Pretty, "such a weapon could be used to knock out an opponent's satellites or to destroy incoming enemy warheads while they are still outside the Earth's atmosphere."

In testimony by Malcolm Currie, director of Defense Research & Engineering, earlier this year, it was noted that the Soviets have a comprehensive program in laser R&D, perhaps leading the United States in several areas. In testimony in March of 1975, Currie emphasized that "We have a strong effort going in RDT&E to improve our space posture. This is very important since we are increasing our reliance on satellite systems to accomplish functions which are vital to the operations of our military forces. Our goal is to protect the functioning of satellite systems critical to our national defense in times of international stress. We have organized our RDT&E efforts into the categories of space surveillance and satellite systems survivability."

To throw more light on the subject. George H. Heilmeier, director of the Defense Advanced Research Projects Agency (DARPA), indicates a "need to protect ourselves from technological surprise that could threaten our security." "Is a space-related use of high-energy lasers possible," asks Heilmeier, "and could it threaten our vital satellite network and its strategic deterrent capability? Conversely, could such a laser serve the United States in some other defensive way?"

To counter all this Soviet activity, the Air Force has been involved in a four-year effort to develop antisatellite technology centering around building a miniature space interceptor capable of deploying a large metallic net to collide with "hostile" satellites. In addition, the Defense Department has increased its emphasis on "radiation-hardening" avionic payloads of its military satellites.

This is necessary, according to the Department, to reduce vulnerability to high-altitude nuclear explosions and attacks from Soviet "killer satellites," already tested and, perhaps, in operational status.

With all this activity, which is only the tip of the proverbial iceberg, it appears obvious that both the United States and the Soviet Union, regardless of any treaty, are involved in developing a space "game plan." This plan is perhaps more extensive than merely taking a peek at your neighbor with spy satellites. Development of space-based lasers appears to be part of that plan, both in order to keep up our "superiority," and, for the U.S., to prevent the Soviet Union from dealing us a "technological surprise" or a space "Pearl Harbor."

Where does NASA and the Space Shuttle fit into all of this? Quoting Lt. General Thomas Morgan, Commander of AFSC's Space and Missile Organization, "I see the 1980s - the time when the Shuttle becomes a proven quantity - as a time of major reappraisal of the role of space in the Air Force future."

Does the Space Shuttle need military backing to keep it alive? Does the civilian NASA mission of utilizing space for peaceful purposes for all mankind include military weapons systems? According to the Department of Defense—and perhaps rightly so—these same systems insure peace.

Will space merely become an extension of our air, land, and sea arenas for fighting wars, or does the vacuum of space offer us a new breath of life—a place where all humankind could breathe a little easier?

MORE MILITARY ASPECTS OF SSPS POWER

T. A. Heppenheimer

In the May L-5 News, there was an article by Keith Henson, "Military

Aspects of SSPS Power." In it, he argued that powerful lasers might be run with the energy of solar power satellites, for use as defensive weapons. Such weapons might make particularly effective antiballistic missile systems, and could also be used to knock down aircraft.

It is easy to imagine the scenarios which could follow from this. The bad guys plot in secrecy to launch an ICBM against the good guys (us). Their preparations are complete; the missile is readied for launch. Five, four, three, two, one (or, to be more precise, pyat, chetery, tri, dva, azhin), liftoff . . . the missile rises. . . then, *ZAP!*

Once again Laser-man with his super-duper space-based raygun has saved the world for Truth, Justice, and the American Way.

In such a world, what would happen to the fond dreams of the bomb-makers? Would the world's nuclear warheads find themselves all dressed up with no place to go? Will missile silos be turned into storage bins for potatoes?

Perhaps the military powers will turn to the development of weapons which can be hidden under clouds, safe from the dread laser beams. Will we see a return to the building of dreadnoughts and railroad cannon of an earlier age?

Happily, the world's militarists need not lie awake with fears of such a bleak future for their trade. It should be quite possible to defend against such laser weapons. One of the simplest devices, to defend against the defensive laser-ray so as to permit a greater freedom of offense, is the corner-reflector. This is an array of mirrors, so arranged as to reflect the laser-ray back in the direction it came from.

An even better weapon would be a ground-based laser, to shoot a ray up to the power satellite. A few hits from such a weapon would soon make the world safe once again for nuclear diplomacy. Other possibilities also come to mind, such as a sunshade to be maneuvered over the powersat, to pull the plug.

The space-based laser may thus be far from a revolutionary device to inaugurate a new era of weaponry. It may well be simply another of the fancy space-based weapons proposed over the past twenty years, which upon examination have been found to be of marginal military utility.

Eric Drexler comments:

Returning the beam with a corner reflector would do no harm to the satellite. A diffraction-limited mirror about thirty meters in diameter is required to form a dangerous beam at geosynchronous range, and a comparable one would be required to return it (hardly a moveable installation to be carried on an ICBM). If returned, the beam would be past focus in any case. Other optical problems exist as well.

A plain mirror surface, unless actively cooled with possibly massive

equipment, would break down under projected power density.

Ground-based laser weapons are possible, but severe questions exist about propagating a beam from the bottom of Earth's (messy) atmosphere and then expecting it to come to a diffraction-limited focus at 23,000 miles (the Scotch-Magic-Transparent-Tape-effect).

The multi-mile-square sunshade should make good target practice for the laser while the shade is being assembled and positioned.

A BELIEVER IN SPACE COLONIES

from The East Hampton Star, East Hampton, N. Y., February 19, 1976

Though he doesn't think he'll live to see it, Dr. Jerry Grey of Bridgehampton, who is 49 years old, is quite sure that people will be living in space habitats within the next 100 years.

Dr. Grey, a space engineer and former Princeton University aerospace science professor who chairs an advisory committee to Congress on solar energy and has been a consultant to the National Aeronautics and Space Administration, is quick to tell you that the prospect of space colonies is by no means science fiction. All the technology for bringing them about exists, he says. "Now it's just a matter of plodding through hundreds of technical details."

As a visitor to his white-walled beach home warned to the idea while it was explained one recent afternoon, Dr. Grey cautioned against overweening enthusiasm, such as had perhaps led people to plunge into expensive solar heating systems before a full demonstration had been made.

While he didn't doubt that solar power would be the answer, perhaps the sole one, to energy problems in the long run, Dr. Grey said that a rash of good publicity, such as the space colony theory was getting at the moment, risked backlash if the initial demonstration weren't satisfactory.

"Everybody is pushing for a demonstration of the ocean thermal gradient power plant," said Dr. Grey. "It's a great idea, but if there is a demonstration now it's going to fail. It's too soon. If we do space colonies too soon, they are going to fail. They've got to work, they can't break down."

The space colony concept, he continued, posited a station on the moon from which mined rocks containing iron, aluminum, and titanium, having been launched by linear electric motor, could be "thrown" to L5 and refined at the "construction shack" there to use as materials for building miles-wide solar energy power plants which would beam low-density microwaves to earth for reconversion into electricity and use in the power grid.

Money from the sale of this cheap energy would presumably be used to

build at L5 commodious, cylindrical space habitats-self-contained, climate-controlled, earth-like environments whose gravity would be produced by rotational acceleration.

And money for the construction of the orbital solar power plants would presumably come from an international consortium of utilities which, faced with finite energy sources on earth and skyrocketing costs, had seen the light.

The concept, said Dr. Grey, originated with a former Princeton colleague, Dr. Gerard O'Neill, who had first tried it out in 1969 as an exercise for students in an introductory physics course.

Dr. O'Neill's "big contribution," he said, lay in finding a way to get around the major problem of having to lift off from earth materials for constructing the solar power plants and colonies.

Now, one may ask, "Why?"

Dr. Grey ticked off three reasons:

1) "Space colonization offers potential relief from energy, food, and population pressures. There's an infinite amount of space in these stable orbits, enough metal on the moon and asteroids to mine forever, and there's an infinite energy supply."

In the debate over whether or not there were limits to growth, Dr. Grey said that as an engineer he preferred to keep his options open. Should The Club of Rome be right and Herman Kahn wrong, he would "want to have a place to go."

"I don't believe, for instance, that the breeder reactor is going to be necessary, but we may damn well need it-that's the kind of option I'd like to keep open. . . . That doesn't mean we have to build 50,000 breeder reactors. . . ."

2) "Space colonization offers a frontier for people-not for astronauts or engineers. The first generation of hard-hats will be pioneers, not old, feeble types, and they'll be followed by home-steaders. And finally will come the timid souls."

There were no more frontiers on earth, Dr. Grey maintained. The Antarctic and the oceans had had their Lewises and Clarks, and they were now the domains of "specialists."

3) It had been established that conditions for operating in space were "fairly benign," contrary to what had first been thought. By now, he said, we had achieved a capability, even familiarity with working in space.

Still, said Dr. Grey, there remained to come the economic impetus, which he thought would develop as the world's utility companies became convinced that solar power plants were a sound investment in the long run, though initially they would serve as a supplement to such "interim" energy sources as fossil fuels and nuclear fission.

The utility companies, he said, had estimated that in the next 30 years they would have to invest \$800 billion in new

plants and equipment. "The prospect of generating energy more cheaply for a smaller investment is certainly worth considering."

"If the capital risk were low, we'd be building solar power stations already, and if it were too high, we wouldn't consider it. We'll probably know more completely what the costs will be in the next five to ten years."

The technology, he reiterated, existed: communications satellites in orbit now were powered by solar cells, every space craft used solar power; a test in California recently had shown the efficacy of beaming microwaves.

Asked what the naysayers' chief arguments were, Dr. Grey replied, "They say it's going to cost a hell of a lot, but they don't say it can't work,"

Jack Graves

NUCLEAR MINING

Eric Drexler

It has been proposed that nuclear explosives will be useful and, indeed, necessary for the large scale utilization of lunar materials for terrestrial benefit.¹ However, the usefulness and the necessity are questionable for a number of reasons, both political and technical.

Suggested underground applications for nuclear explosives in lunar mining are, in roughly decreasing order of importance: oxygen extraction, water production, element extraction, generation of various compounds, isotope production, crushing of large quantities of lunar rock for processing, blasting of caves for underground factories, and tunneling.² These will be considered in reverse order.

There seem to be few reasons for tunneling or blasting caves with nuclear explosives. The initial cavity formed by an explosion in rock immediately collapses, leaving a chimney of crushed rock topped by a smaller cavity or a crater on the surface.³ This is likely to make controlled tunneling difficult. The main reason for going underground on the Moon is to shield against radiation and meteoroids; this shielding could also be accomplished by building in shallow excavations and then burying the structures under several meters of soil.

It is necessary to have crushed lunar rock for many processes, but nuclear explosives are unlikely to produce material much better than that already present from meteoroid bombardment. This material is present in loose, crushed form over most of the Moon's surface to a depth of many meters.

Lunar-produced isotopes seem unlikely to have a terrestrial market large enough to have an impact on the overall economics of space industrialization. Any lunar needs may be easily supplied from Earth.

Proposed chemical products are water, carbon dioxide, cyanide, and metal carbides. All require reactants imported

from Earth. Factors such as reactant loss, process control, product yield, and product contamination would seem to suggest use of conventional or solar furnace reaction vessels rather than nuclear explosive processing. Large scale demand for cyanide and metal carbides is doubtful in projected lunar industries.

The suggested process for producing oxygen, water, and free metals from the oxides of lunar rock is as follows: vaporization of the rock by an underground nuclear explosion and rapid condensation of the metals and silicon in the cooling vapor, followed by pumping off the remaining oxygen (or combination with terrestrial hydrogen to produce water). Twenty to thirty percent yields of oxygen were expected.

Although this process is the main application proposed for nuclear explosives in lunar mining, it appears unfeasible. Vaporization of metal and silicon oxides produces a gas consisting of metal and oxygen atoms, and metal oxides and oxygen molecules.⁴ As cooling and condensation take place, so do recombination of oxygen and metal to form a molten oxide mixture.⁵ No free metal will result. A nuclear explosion in terrestrial granite (containing traces of water and carbonates) produced small amounts of combustible gases (hydrogen, carbon monoxide, and methane). Since these gases survived, oxygen production must have been extremely small; its presence was not reported.⁶ Current work indicates that fairly conventional chemical and metallurgical processes will prove adequate for refining in space.

Use of nuclear explosives for spacecraft propulsion (as in the project Orion study) is proposed for transport of resources from the Moon, planets, and asteroids. For supplying space industry in the Earth-Moon system, electromagnetic launch systems on the Moon seem likely to prove feasible and convenient.⁷ If in the longer run space resources are to be competitive in Earth markets, high-grade ores will be desirable. These are likely to be found in the asteroid belt and in stray objects closer to Earth's orbit.⁸ There is, in fact, a reasonable likelihood of finding objects accessible enough to permit economical recovery with electromagnetic or chemical propulsion systems, rather than nuclear systems.

In summary, the application of nuclear explosives to lunar mining appears unnecessary and in some cases unfeasible. In the current climate public reaction to such proposals (bombs on the Moon!) would be strongly negative. Use of nuclear explosives for propulsion in the Earth-Moon system is unnecessary and risks an even stronger public reaction (bombs in the sky!). Applications in deep space have alternatives and are of less immediate importance in most scenarios.

The above problems are reinforced on an international level by the Outer Space Treaty of 1967, which prohibits any and

all use of nuclear explosives in space. Given the current unorthodox position of large-scale space industrialization proposals, the current climate of public opinion, and the lack of a strong, near term mission for nuclear explosives in space industrialization, use of our limited resources on such studies in the immediate future seems wasteful and possibly counterproductive.

1. Ehrlicke, K. A., "Lunar industries and their value for the human environment on Earth." *Acta Astronautica*. 1:585-622 (1974).

2. *Ibid*, p. 612.

3. Hansen, S. M., and Lombard, D. B., "Completely contained nuclear explosives for mining by caving." *Engineering with Nuclear Explosives, Proceedings of the Third Plowshare Symposium*, U. S. Atomic Energy Commission (1964).

4. Margrave, J. L., ed., *The Characterization of High-Temperature Vapors*, John Wiley and Sons, New York (1967).

5. Brewer, L. "Thermodynamic properties of the oxides." *Chemical Reviews*, 52:1-75 (1953).

6. Pica, J. M., "Study of chemical reactions in the underground nuclear explosion. Incidence of radioactivity." *Symposium on Engineering with Nuclear Explosives, Proceedings*, volume 1: 850-858. U. S. Atomic Energy Commission (1970).

7. Heppenheimer, T. A., and Hopkins, M., "Initial space colonization: concepts and R&D aims." *Astronautics and Aeronautics*, pp. 58-64 (March 1976).

8. Drexler, K. E., "Space colony supply from asteroidal materials." *Proceedings, 1974 conference on space colonization* (in press).

NASA TO FUND STUDY OF SPACE INDUSTRIALIZATION

T. A. Heppenheimer

On May 27, NASA released a request for proposal soliciting bids from interested firms for a study of "Space Industrialization." The study is to be in two parts, each lasting eight months. The first part is to be funded later this summer, and will involve two sections, each representing a contract worth \$100,000. One of these is to go to an aerospace company, such as Rockwell, International or Grumman. The other will go to a non-aerospace company. Among the firms which have expressed interest in this latter section are Science Applications, Inc., and Batelle Laboratories. The study is to be managed by the Marshall Space Flight Center of NASA.

In the words of the request for proposal, "The industrial utilization of space, or space industrialization, will focus on exploiting the economically productive use of space as opposed to space activities undertaken primarily for scientific purposes, for exploration of the solar system, or in support of military needs.

"For the purposes of this study, space industrialization is defined as those space activities undertaken primarily for production of goods and services which play a role in the economic activities of the United States or the world.

"A large number of space

industrialization possibilities have been suggested in the past few years, ranging from producing vast quantities of power in space for use on Earth, to space manufacturing and processing of unique products and materials for Earth use or for use in orbit, to the eventual industrialization of the Moon itself. . . . Recent recommendations by the Hearsh 'Outlook for Space' Committee, Aerospace 'New Initiatives' studies, and various segments of NASA have stressed the need for innovative thinking and long range planning to explore the industrial potential of space.

"This study is a planning activity intended to lay the necessary groundwork for subsequent implementation phases of a space industrialization program and the required support programs, including space transportation systems, domiciliary facilities in space, and space/assembly/manufacturing facilities. . . . This initial study... is expected to provide the supporting engineering data, rationale, and 'road-map' plans for subsequent studies and developmental engineering activities needed to achieve a recommended evolutionary industrialization program commencing in the 1980s and extending into the post-2000 period."

Thus, by this study, NASA intends to recognize the importance of space industrialization as potentially a major theme for its activities in the period 1980-2010. This study focuses particularly upon lunar resources, or on the possibility of using materials from the Moon. Space colonies, per se, are not mentioned. However, the activities envisioned are clearly those which would provide both an economic rationale and a technology base for constructing such colonies.

Because this study lays considerable emphasis upon such topics as use of lunar resources, power satellites, large structures in space, lunar bases, and heavy-lift launch vehicles, its results are sure to be of interest to L-5 Society members. This study will not commit NASA to pursue any of these topics, or even to study them further. Nevertheless, it demonstrates clearly NASA's interest in precisely those projects which would be needed to support a program of space colonization.

SPACE COLONIZATION EVENTS THE WORLD GAME

Design Revolution '76, the seventh annual World Game Workshop, is an exploration into comprehensive planning and design. The conference is based upon the view that the coming decades are a transitional period in which critical choices are going to be made regarding the common future of all humanity and that the problems and prospects facing society represent unprecedented challenges which can only be resolved by a design revolution. New perspectives and

methods will be presented for specific use by individuals in educational, economic, social, and environmental design and planning, and also for general use by others concerned with new directions for change.

The Planning Symposium, July 3-10, will provide an opportunity for the following speakers to present and discuss their views. In addition, lectures, films, video tapes, slides, games and group discussions will aid in introducing design and planning concepts and methods. Speakers will be R. Buckminster Fuller, Ian McHarg, Hazel Henderson, Russell Ackoff, Edwin Schlossberg, Nicholas Georgescu-Roegen, Stewart Brand, John Platt, and Peter van Dresser. Brand, editor of *CoEvolution Quarterly*, and Platt, a member of the Club of Rome, are advocates of space colonization.

The World Game Workshop, July 11-31, will follow the symposium with a three-week workshop in which participants will form a design team to develop a comprehensive energy strategy. The strategy will use the design science process to focus on meeting the long-range energy needs of developing regions while converting developed regions to regenerative energy systems. Participants will learn to assess the life-support needs of a region, inventory potential and available income energy sources and match appropriate technologies to specific needs and conditions. They will then assemble a step-by-step plan of alternative energy policies and strategies.

Participants may register for the one-week symposium only, or for the complete four-week program. The Planning Symposium tuition is \$200; the full Conference program is \$350.

For application, housing, and other information, write or call:

The World Game
Earth Metabolic Design
Box 2016 Yale Station
New Haven, CT 06520, USA
(203) 776-4921

Design Revolution '76 is sponsored by Earth Metabolic Design in conjunction with R. Buckminster Fuller, The Design Science Institute, and The University City Science Center of Philadelphia, and is hosted by the University of Pennsylvania and the University Museum.

ENVIRONMENTAL SYSTEMS CONFERENCE

The Fifth Intersociety Environmental Systems Conference will be held July 12-15 in San Diego, California. The keynote address, "Outlook for Space," will be given by Professor Gerard K. O'Neill of Princeton. It will be followed by a panel discussion on "Outlook for Spacecraft Life Support Systems."

Papers will be presented on the topics of aircraft environmental and thermal control systems, marine technology application; thermal control systems, life

sciences shuttle laboratories and experiments, environmental protection systems, chemical engineering applications in life support systems, advanced technology for spacecraft, personal protective systems, municipal and industrial effluent control and waste management, European Space Agency Spacelab and Space Shuttle and technology transfer.

The conference is sponsored by the AIAA, SAE, ASME, AIChE, and ASMA. Registration begins at 8:00 A.M., July 12, in the Towne Room of Town and Country Hotel, 500 Hotel Circle, San Diego, California 92138. Registration is \$35.00 for members of the sponsoring organizations and \$50.00 for non-members.

WRITERS OF TECHNICAL ARTICLES-TAKE NOTE

Mr. R. C. Parkinson, of the British Interplanetary Society (BIS), has stated his interest in receiving technical articles on topics related to space colonisation. Mr. Parkinson is editor of the blue-cover space technology issues of the Journal of the British Interplanetary Society (JBIS).

The London-based BIS is one of the oldest and best known of the technical societies in the field of astronautics. The JBIS, which appears monthly, is published in sequence as a series of issues devoted to specific topics of space technology (blue covers), space applications (green), space science (orange), and interstellar flight (red). It is received by most technical libraries and its articles are abstracted in International Aerospace Abstracts.

Mr. Parkinson states that he wishes to receive technical articles, written with comprehensiveness and depth, that would be suitable for a technically proficient readership. Among the topics which may be treated are as follows:

Engineering-Problems of space transportation, ore processing, chemical technology, space construction, space agriculture and life support, power systems, and systems optimisation.

Economics-Cost benefit analysis, economic scenarios, productivity estimates and work force requirements, problems of management, and the implications of space colonisation in national policies.

Social-Space colony societies, legal aspects, relations between colonies and Earth, architecture and community planning, population distributions, and demographic considerations.

Authors are referred to recent issues of the JBIS for manuscript style and format. It should be particularly noted that the JBIS follows the British style of spelling, e.g., centre, programme, etc., and that the JBIS uses metric units throughout. Authors will be furnished with galley proofs and up to five copies of the issue in which their paper appears. There are no page charges.

Mr Parkinson states that he hopes to receive, initially, four new papers of quality suitable for publication. This will permit him to produce a blue-cover issue devoted entirely to space colonisation studies. Further issues of this nature may then be forthcoming, depending upon the volume and quality of contributions.

Authors are invited to submit copies, in triplicate, to Mr. R. C. Parkinson, Editor, JBIS, 33, Langdon Avenue, Aylesbury, Buckinghamshire, England, U.K.

In addition, the L-5 Society would appreciate receiving copies for distribution at the request of its members. These are to be sent to L-5 Society, 1620 N. Park Avenue, Tucson, Arizona 85719 (U.S.A.), and to Phillip J. Parker, AFBIS, L-5 Society, (W. European Branch), 24, Fifth Avenue, Kidsgrove, Stoke-on-Trent, ST7 1DA, England, U.K.

POWER SATELLITES AND THE ENERGY LAB

The article in the March L-5 News about an institutional agreement between ERDA and MIT may have misled readers. The fact is there are no plans at present for funding research on SSPS's through the program. Dr. James W. Meyer, Program Director for Special Programs at MIT's Energy Lab, explained that the contract is primarily "an institutional arrangement to facilitate the flow of money, and eliminate the need for individual contracts with ERDA."

He indicated that "any good proposal has a good chance" of being included in the arrangement, provided a faculty member sponsors the proposal and finds someone at ERDA to accept the need for the study. No SSPS research is being done by the Energy Lab, and it is unclear whether any faculty member at MIT plans to propose any.

Dr. Meyer, on of thirty in a Solar Energy Working Group which was funded by MIT's Cabot Fund to produce a report on the prospects of solar power, was asked why the report (which was issued March 1, and which has become an authoritative reference among "policy-makers") totally omitted any reference to extraterrestrial solar collection or micro-wave power transmission. Although the Working Group was aware of a report on the SSPS by Prof. McCarthy's design course at MIT in 1973, as well as the work of Peter Glaser and Raytheon, no word was mentioned of it because, at the time of the study, no work was being funded by MIT, according to Dr. Meyer.

This explanation is, perhaps, less than satisfactory, since the report, which covered virtually every area "under the Sun" and which concluded that the problem of storage may be the most limiting factor in large-scale electric power generation from solar energy should have at least referred to the

concept of putting collectors and relays in geosynchronous orbit.

Jonah Garbus

ERDA SOLAR CELL RESEARCH

Contracts totalling \$990,000 for 46 kilowatts of solar cells have been awarded to five firms in the largest single acquisition of solar cells to date for terrestrial electrical power generation.

The awards were announced by the Energy Research and Development Administration (ERDA) and the Jet Propulsion Laboratory (JPL), which manages this aspect of the photovoltaics program for ERDA. JPL is operated for the National Aeronautics and Space Administration (NASA) by the California Institute of Technology.

The contracts call for delivery of groups, or "arrays," of the cells over a period of six months. The prices range from \$14 to almost \$30 per watt with an average of \$21 per watt.

The arrays will be used in a testing and evaluation program that is a part of the government's effort to reduce the cost of photovoltaic power generation to the point that it would ultimately become practical for widespread residential, commercial, and industrial use. The program objective is to foster by 1986 an industrial capability to produce solar cell arrays at a rate of 500,000 kilowatts per year at a market price of less than \$.50 per watt. Today's production, at an average price above \$20 per watt, is estimated to be about 100 kilowatts annually.

"Thirty kilowatts of the modules from the current procurement will be used to begin a series of ERDA-funded tests in cooperation with the Department of Defense," said Dr. Henry Marvin, Director of ERDA's Division of Solar Energy. "These tests will range from battery-recharging to purifying water and operating mobile telephone vans. The purpose is to establish the technical feasibility of using photovoltaic power systems for a wide range of military applications. A later procurement of solar arrays will be used to provide a significant fraction of the power supply for a remote military installation. These uses, in turn, will help lower prices and encourage further domestic uses," he predicted.

"A significant additional market for cost-effective photovoltaic energy systems may exist at or somewhat below current prices of solar cells for both military and civilian uses," Dr. Marvin said. The remainder of the modules from the current procurement will be used in a testing program aimed at promoting additional domestic uses. This portion of the program will be managed for ERDA by the NASA Lewis Research Center in Cleveland, Ohio.

The contract awards were based not only on cost but also on a number of technical and managerial factors, Dr. Marvin said. These factors include the

ability of the selected firms to meet the specified production schedules.

The contracts were awarded as follows:

3 KW, \$84,000, M7 International, Arlington Heights, Illinois.

8 KW, \$160,000, Sensor Technology, Inc., Chatsworth, California.

10 KW, \$298,000, Solarex Corporation, Rockville, Maryland.

15 KW, \$205,000, Solar Power Corporation, Wakefield, Massachusetts.

10 KW, \$252,000, Spectrolab, Inc., Sylmar, California.

ERDA SPEAKERS BUREAU

The development of adequate energy technology options to meet the increasing energy demands of the nation is an issue of prime importance to concerned citizens. The Energy Research and Development Administration was established in January 1975 to direct the national effort to provide those options through an extensive research, development and demonstration program. ERDA pursues work in such areas as fossil energy-including coal gasification and liquifaction; nuclear fission and fusion; solar, geothermal and advanced energy systems; energy conservation; environment and safety and national security.

The ERDA Speakers Bureau will make arrangements for qualified persons to discuss energy issues before national, regional and local organizations and groups. Speakers are available from ERDA headquarters in Washington and from the various field installations located throughout the country.

General topics for discussion include:

- ERDA-its organization and objectives
- Creating energy choices for the future: the national plan for energy research, development and demonstration.
- International cooperation in solving the energy crisis.
- Cooperative roles of government and industry in energy development.
- Synthetic fuels development and commercialization
- The nuclear energy option
- Uranium resources and the nuclear fuel cycle
- Controlled fusion development
- Environment and safety aspects of energy development
- Conservation and improved efficiency in energy development and use
- Energy research and the university
- Fossil fuels-improving technologies
- The broad range of solar energy development
- Geothermal energy development
- National security and nuclear safeguards

Other more specific and technical subjects can also be addressed by ERDA

speakers, and organizations are encouraged to request information on the availability of speakers for particular areas of interest. Slides can supplement presentations and films and publications are available as well. ERDA also has at headquarters and various field locations computerized electronic simulators which depict energy-environment trade-offs and which can add an interesting dimension to programs on energy.

To request the services of ERDA speakers, contact the ERDA Speakers Bureau, Office of Public Affairs, 20 Massachusetts Avenue, N.W., Washington, DC 20545. Telephone 202 376-4075 or 202 376-4066.

SSPS FUNDS

In response to a letter from Sen. Frank E. Moss (D-Utah) and Sen. Wendell Ford (D-Kentucky), Sen. Henry M. Jackson, (D-Washington), Chairman of the Interior and Insular Affairs Committee, has authorized five million dollars for satellite solar power station research, to be added to the ERDA Authorization Bill for fiscal year 1977.

Due to an administrative slip-up, ERDA solar power officials had not been aware that responsibility for the research had been transferred from NASA to ERDA by the Energy Reorganization Act of 1974, and had failed to include the sum in ERDA's budget request to Congress.

The next step is for the bill to be passed on by Senators John C. Stennis (D-Mississippi) and Mark Haffield (R-Oregon) in the Public Works Subcommittee of the Appropriations Committee. The ERDA Authorization Bill is then expected to be sent to the floor by June 15.

In the meantime, the House Science and Technology Committee has attached funding for the same solar power satellite research projects to the NASA Authorization Bill. The question of which agency will end up with the funding will

be determined in conference between the House and Senate, assuming the power satellite funds remain intact as the bills go through the process of being considered by committees and voted upon.

COSMIC PERSPECTIVE

Cosmic Perspective is a series of non-technical educational supplements published by the Astronomical Society of the Pacific. Each supplement examines the relationship between astronomy and another discipline in an attempt to provide a unique extraterrestrial view of traditional areas of activity and thought.

Richard Reis is editor, and Penny Anderson is associate editor.

For further information on how to obtain copies, write to *Cosmic Perspective*, Astronomical Society of the Pacific, 1244 Noriega Street, San Francisco, California 94122.

FANTASY/FORECAST 2010

from the Houston Harbinger, *newsletter of the Houston chapter, World Future Society*

Significant breakthrough in longevity research has merged with the spectacular success of early space colonization to bring about a new phenomenon: a space colony for the aging rich. It is advertised as an oasis of programmed nostalgia, a space island in which irritants are filtered out and pace is slow. Life is comfortable, fulfilling, serene.

Would-be residents are listed on the waiting list while still teenagers to allow for accumulation of the necessary advance deposit. They diet, exercise, and meditate for years to pass the stringent physical, mental, and psychological tests that screen out misfits. They strive to evade the rejection of experts at the Geriatric Referral Institute of Medicine, sometimes known as the GRIM reaper.

The colony provides escape from strident voices, peevish relatives, turmoil, and crowding. The schedule is replete

with optional learning, entertainment, and social events. The colony's official title is Habitat Enrichment: Alternative Values for Elderly Nabobs. Most just refer to it by its acronym: HEAVEN.

CORRESPONDENCE

If I may comment on Jesco von Puttkamer's remarks in the April *L-5 News*: space colonization can be accomplished on a significantly more rapid time scale than presently projected *if* enough people, or people with sufficient influence, decide that they want it. The primary obstacles right now are economic and political, not technical. If it is done more rapidly, however, it will likely be more expensive rather than less so (as is usually the way of crash programs). Even if the total cost is the same, it will *feel* more expensive, because, for a time, money will be spent at a more rapid rate.

I myself would favor the more rapid time scale, even if it is more expensive; I cannot speak for anyone else.

On Carl Marcy's report: let us remember that the conflict between the U.S. and Western Europe and the U.S.S.R. since World War II is not primarily economic in origin. The West has feared (with, I believe, considerable justification) that its liberties have been in danger. The U.S.S.R. has sought world domination (why its leaders have sought power may be open to debate, but I believe that their behavior since World War II has consistently shown that they *do*).

If joint efforts toward space colonization can divert effort from this conflict, I will welcome the fact, but I would like to caution that it may not be easily put aside, since it is based on a fundamental difference of philosophy on the value of liberty and the worth and rights of the individual human being.

I may be attending MidAmeriCon, this year's World Science Fiction Convention, in Kansas City, this Labor Day Weekend.

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

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Some members of United for Our Expanded Space Programs are also scheduled to attend. We may have the opportunity to talk about space colonization to people at the Con. If we do, I suspect we'll have sympathetic listeners

Larry Friesen
Webster, Texas

To equate nature buffs with "the settled, the affluent, the satisfied, the smug" does more to hurt your case than any of the technical problems anticipated so far. It is also a very poor policy to imply that those who disagree with your ideas are somewhat less than American and lack the frontier spirit of our forefathers. Government and industry have been using that approach too long.

You also speak as if the main argument used by nature buffs against space colonization is the psychological harm that will result from living in an artificial environment. Nonsense. The main argument against space colonization is the well-founded fear that another frontier will go the way of all our frontiers on Earth: mindless exploitation for profit and growth under the guise of national and human needs.

Don Miller
Sitka, Alaska

This letter refers to "Astrolling the Astroturf," in last month's L-5 News. The point is well taken, if overstated; in fairness to Heppenheimer, the author, it should be pointed out that the letter exaggerates the tone and implications of his article.

Are you aware that you can see L-5? Since it is a stable point, quite a bit of dust has collected there. To see it, calculate when the moon would be full if it were at L-5. Then, shortly after sunset you will see a brighter area in the eastern sky at the ecliptic. You need a

clear night. (cf. Trojans and Jupiter.)

Sherman E. DeForest
Assistant Research Professor
Department of Physics
University of Alabama
Huntsville, Alabama

CULTURAL FUTURISTICS CONTEST WINNERS

Winners in the American Anthropological Association's Contest in Cultural Futuristics (see L-5 News No. 2) have been announced. Four of the six winners were L-5 Society members - Michael Michaud of Bethesda, Maryland, with his paper, "The Consequences of Space Colonization," Shirley Varughese of South Somerville, New Jersey, for "The Island in Space," A. Harlan, K. Henson, and C. Henson of Tucson, Arizona, with "Ezekiel's Wheel," and Peter J. Vajk of Walnut Creek, California, "To Comfort Her Suffering."

Nonmember winners were James W. Herrick of Utica, New York, "Penumbra," and Susan Shatanof of Staten Island, New York, with "The Future has been Cancelled."

The winners will be awarded a \$100 prize, and the papers will be published in book form at a later date. The winners also have been invited to speak at the Symposium on Speculative Anthropology and Cultural Alternatives, which will be held as part of the American Anthropological Association's 1976 meeting, November 17-21, in Washington, D.C.

BIBLIOGRAPHY UPDATE

The following papers of interest to L-5 Society members can be ordered from ASME. The price is \$1.50 for members of SAE/ASME/AIAA/ASMA/AICHE, and \$3.00 for non-members, plus postage and handling charges. Address: ASME, Order Department, United Engineering Center, 345 East 47th Street, New York, NY

10017. All papers must be ordered by paper number and not by title.

"Development Testing of a Self-Contained Heat Rejection Module," M. L. Fleming, 76-ENAs-33.

"Planning for Life Sciences Research in Space." Kenneth-M. Mallory, Jr., and Stanley Deutsch; 76-ENAs-52.

"Microbiology Studies in the Space Shuttle," Gerald R. Taylor, 76-ENAs-23.

"Organism-Support for Life Sciences Space Lab Experiments," George L. Drake and Dennis B. Heppener, 76-ENAs-7.

"Life Sciences Laboratories for the Shuttle/Spacelab," Louis D. Schulte, Herbert B. Kelley, and Terry C. Secord, 76-ENAs-28.

"Biomedical Experiments Scientific Satellite (BESS)," W.E. Berry, John Termor, and Ted Aeppli, 76-ENAs-57.

"Environmental Parameters of Shuttle Support for Life Sciences Experiments," James M. Waligorn, 76-ENAs-24.

"Development of an On-Board Oxygen Generating System," P.D. Thornley, 76-ENAs-9.

"A Dispersion Model Approach to the Preliminary Design of Adsorber Beds for Trace Contaminants," R. Madey, M. Czayka, R. Forsythe, J. Poulis, and K. Yin, 76-ENAs-34.

"Monitoring Complex Trace-Gas Mixtures by Long Path Laser Absorption Spectrometry," B.D. Green and J.I. Steinfeld, 76-ENAs-8.

"Development of a Preliminary Design of a Method to Measure the Effectiveness of Virus Exclusion during Water Process Reclamation at Zero-G," A. S. Froser, A.F. Wells, H.J. Tenoso, and C.D. Linnecke, 76-ENAs-32.

"Development of a Water Quality Monitor for Spacecraft Application," Steven J. West, Martin S. Frant, and James W. Ross, Jr., 76-ENAs-10.

"Electrolytic Urine Treatment," Barbara M. Greenough and N.T. Thomas, 76-ENAs-19.

"Design, Fabrication, and Testing of a Spacecraft Wet Oxidation System, Including Trash Pulverization Studies," R.B. Jagow, 76-ENAs-15.

"Spacelab Environmental Control System," K. L. Mitchell, B.W. Sessions, and R.D. Turner, 76-ENAs-58.

"A Mature Bosch CO2 Reduction Technology," CD. King and R.F. Holmes, 76-ENAs-14.

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