L-5 NEWS

A Newsletter from the L-5 Society
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Habitat

UN Conference on Human Settlements

May 18 -June 23

HABITAT REPORT
Norrie Huddle

(Norrie is the organizer of Project America, a traveling future alternatives sideshow. She took some time out this year to raise funds for and attend the United Nations Habitat Forum. It was her second U.N. conference.)

In the early afternoon of the 27th. I bicycled over to the Habitat Forum, a rather harrowing ride through stretches of heavy traffic. The forum, housed in a series of old airport hangers, was still in a state of chaos. . . people pounding nails, setting up exhibits, and generally running around. The location of our exhibit was good, but so far nothing was set up. The next day, Maruyama, Peter and I set it up, while Bob got press releases printed up. The exhibit itself was simple but good, although the models of colonies were unusable. We had a large table on which we spread out literature, attached to a post to the right, in front of the table, a large color photo of an artist's rendition of the large cylindrical space habitation (based on O'Neill's work), and on a post on the other side of the table, a sign which indicated the various languages we spoke. That was a real attention-getter! (Someone scribbled on the sign, "Why don't you asses speak Czech?", but as it was in Czech, we didn't find out what it said until another Czech couple stopped by several days later!) Anyway, at the back of the exhibit, we hung a large photo of the Earth which Peter brought (one of the NASA photos), and over which he had attached a tiny wooden door that actually opened and closed. Inside the door, a photo of the stars, and next to the whole photo-collage, a sign, "Open Door for a Closed World." Peter also built a rack to hold a slide projector and we began showing slides to those who expressed interest.

A thing that bothered me was that although our booth was getting a lot of attention, it was primarily visited by Canadians and U.S. citizens. I asked a few third-world people, with whom I had become friendly, their impressions of our literature. The response was not unpredictable: "It sounds like you're supporting another U.S. attempt to control the third world by advocating space development." They assumed we were merely advocating space development and in no way picked up on how it was relevant to them.

At this point, it became clear that we needed to revise our "strategy" and that I needed to clarify my own feelings. Falling off my bicycle and messing up my knee rather badly provided the necessary hiatus and I began cataloguing the arguments for and against space development, putting them into a force-field analysis. When Peter returned, he worked with me on this. I also wrote up a one-page letter to explain our presence at the Forum, and went through a media list which I had gotten when I became "official press delegate" for the L-5 News I began writing personal notes on business cards that had arrived that day from Tucson; Peter helped in the evening and I continued through much of the next day. We met that evening at a pavilion, a central point near the formal UN conference, and attached these cards to about a hundred press packets, one for each of the journalists representing key newspapers, magazines, and radio/TV networks in other countries. To our chagrin, however, we found we were not allowed to put press releases in the official press boxes. After re-evaluating the situation and getting a second wind, we checked up all the journalists on the media list and found which hotels they were staying in. Two hours later, the Indominable Duo could be seen walking from hotel to hotel, leaving these personalized messages in the boxes.

It is difficult to say what impact these notes had because the only definite feedback we had was from the Japanese journalists we contacted-partly, perhaps, because I had written part of the personal notes in Japanese. The best response came from two journalists representing the two second-largest national dailies *(Sankei* and *Mainichi,* each with a circulation of about 6 million). Although they originally came to talk with me because they didn't speak much English (and wanted to interview me about what I thought of US attitudes towards China!), after answering their questions, I brought the subject around to space. They were totally fascinated with the idea-which I had predicted because of Japan's precarious situation vis-a-vis food, energy, raw materials, population pressures, and pollution-and immediately bought an entire set of materials for their newspapers. I also sent back a set for Dr. Masao Kunihiro, a close friend who is now being journalistically described in Japan as "Prime Minister Miki's brain" and donated a set to another old friend, Jun Ui, who is a professor at Tokyo University and who brought a group of victims of mercury poisoning to Vancouver. Ui, incidentally, is one of the main leaders in the environmental movement in Japan.

Although it is hard to say how much was due to the media packets, the influx of foreign people to our table increased -- I also began walking around and spotting foreign delegates and journalists, giving them the initial rap, and then bringing them back to out exhibit for Peter to talk with. The new letter explaining our rationale (the "Dear Friends" letter) was very useful in approaching them. Of course, their response at the moment and their later memory on the L-5 concept could well be different, so I believe we have to take a wait-and-see attitude. We did, however, collect a large number of 3 x 5 note cards with names and addresses of people interested in learning more; many of these were from different countries.

Clearly, a great deal of planning and follow-up needs to be done. This is especially considering the country fair atmosphere of the Habitat Forum and the wide variety (to the point of overstimulation) of exhibits, free handouts, and so on, combined with the pressure imposed by the short period of time in which all these exhibits were competing for the attention of the public. Given these factors, I believe we had a great deal of initial success and learned a lot. It also clarified a number of the cultural and linguistic difficulties we will face in trying to mount an international campaign. The Habitat Forum *was* an ideal place to make the first step in "going international" and setting up a global spacewatch. In fact, the response to the concept of a global spacewatch was overwhelmingly positive.

Peter and I attended the meeting at which people were attempting to draft resolutions to present to the formal UN

conference. It was pretty disastrous, as most people wanted to get some particular point adopted into the resolutions. A lot of politicking: no one knew who had drafted the tentative set of resolutions, which aroused suspicions, the Latin American lobby had written an alternative proposal which they were pushing to get adopted in lieu of the first set, and they were also insisting on having everything translated/interpreted into Spanish (rumor had it that they were trying to get Spanish to replace English as the main international language). In general, these win-lose situations bring out the worst in people and are, I believe, of questionable value. As I pointed out in the group, what happens to the resolutions? I said that I suspected they just caused a lot of trees to be cut down (to make the paper to print them on), and then gathered a lot of dust till they got thrown out. I suggested that some group (NGO group) might find it interesting to research the follow-up carried out on the resolutions that came out of Stockholm and Bucharest.

So, how do I feel now that I have gotten my feet good and wet in the issues of the L-5 Society? The most honest answer, I guess, is that I really don't know. There are too many unknown factors and enormous problems to solve before the concept could be put into reality. Most of these problems are related to the way that people relate with people and with the environment, and to the economic and political "game rules" we have created-rules which run counter to the basic ecological laws that we must follow to ensure the well-being of our planet.

Nonetheless, the concept of space development definitely does, I believe, merit further investigation. For one thing, the investigation and resulting dialogue *per se* has enormous value because it throws a new light on, creates an entirely new perspective for the whole realm of philosophical, political, economic and social issues which have been under discussion for a long time. What is the role/place/destiny of the human being? What is the purpose of life? What are the ingredients of happiness? etc.

One major example is that going out into space will essentially eliminate (over time) the zero-sum game (this is the concept that is someone wins, someone else has to lose; i.e., the sum of their wins and losses equals zero; both cannot win simultaneously) which dominates our thinking and acting on the earth today. Yet, without education, we will still be caught in a zero-sum *mentality,* and unless *that* changes, people will still fight over what they perceive to be limited resources.

But then again, perhaps more equitable distribution of the world's resources would make it unnecessary to go into space at all. Or would there be enough to go around, particularly with the world's exploding population? Also, how do we ensure that the new worlds of space are any more equitably distributed than those already being maldistributed here on Earth?

It seems to me that those nations who would most quickly realize the benefits to be obtained from developing space are also those most worried by the "gloom and doom" prophets whose message has preponderated in the last decade. These are also the nations (generally speaking) involved in the arms build-up and in the proliferation of nuclear power plants around the globe, two pretty frightening trends. Could the space development program-a new frontier-remove the pressure and sense of impending doom and perhaps reduce the possibilities of global holocaust? Or would the reduction of pressure make the developed countries less willing to change and to begin revising the economic world order? Could space development, which promises enough for everyone over time, be used as a political bargaining tool to effect a more rapid revision of the world order?

Could research on the concept by international groups help bring the earth's people together? I think the possibilities would be excellent, especially if such a forum of investigation were set up properly. At the same time, it is clear that this will not be an easy task and would require enormously skillful organizing by people familiar with intercultural communications and crosscultural experiences.

In sum, the development of space *per se* leaves unsolved the basic problems of how people relate to people and to the environment, and also doesn't address the problem of how the material benefits would be distributed. As Rene Dubos pointed out, technologies themselves are neither good nor evil intrinsically-the morality of technology lies in how we use it. I believe, therefore, we must look at space development in terms of how it will be carried out. Under existing conditions, I think the program would be developed by large US aerospace corporations (or possibly US and USSR, or a small consortium of rich nations), contracted by government(s) and justified primarily by military "needs". The benefits would be distributed first to those footing the bill, with this justified by traditional economic reasoning, and the "trickle-down" theory. Thus, the solar energy would first go to those nations who make the investments. And, if present behavior patterns are indicative, this energy would be used to make appliances that break down after two or three years, do-dads that are surrogates for real happiness, and slowly but steadily to pave over our planet.

Could it be done differently? I like to think the answer is yes, but I still don't know. It depends on who gets involved in carrying out the program. Vancouver was a first step for throwing the concept before the international community. I believe this direction-of encouraging involvement by people of many different cultures-is a very desirable one and should definitely be encouraged. Even if the idea never goes beyond the conceptual stage, it would encourage crosscultural dialogue about a subject that just might have enormous benefits for all of us-if it turns out to be feasible and desirable. But again, that is contingent on the wisdom of the developers. Hopefully, in an international forum, that wisdom might exist somewhere among the four billion inhabitants of our earth.

I also would like to see much more input by informed environmentalists. This is key because this is a group that has tended to dismiss the whole issue as irrelevant before they grasp the concept. To me it is significant, for example, that Paul and Anne Ehrlich were very opposed to the idea initially. Then, Stewart Brand invited the Ehrlichs, Gerry O'Neill, and California's Governor Brown to join him at Tassajara for a weekend of discussion on space colonization. After this, Brown stated that he found the proposal "very interesting" and the Ehrlichs greatly modified their position: "Environmentalists, including us, had a strong negative reaction to the O'Neill proposals when first presented with them. . . but again O'Neill's vision shares many elements with that of most environmentalists. . . . Environmentalists often accuse politicians of taking too short-term a view of the human predicament. By prematurely rejecting the idea of Space Colonies they would be making the same mistake." *(Co-Evolution Quarterly,* Spring 1976)

HABITAT POSTSCRIPT

Peter Vajk

Thanks to generous contributions by members of the L-5 Society and a generous gift from Maryanne Mott Meynet, we were able to send a delegation to Habitat Forum in Vancouver, B.C., bringing the concepts of space colonization and industrialization to a large international audience. More than 2000 English language copies of our official statement "Human Settlements in Outer Space" (published in the May 1976 issue) were distributed, along with 300 copies in Spanish and 200 copies in French.

The Canadian media provided excellent coverage, with 10 minute

interviews on two nationwide television programs, as well as four radio interviews ranging from a 15 minute nationwide program to a two hour discussion on a Vancouver area talk show. Lengthy interviews and background literature were also provided to newspaper reporters from Canada, Japan, and England.

Exhibits at Habitat Forum provided a variety of information of interest to space colony designers. For instance, intensive hydroponic systems under development by several different groups claimed food productivities as high as 4,000 people per acre, substantially higher than the 90 people people per acre assumed in the NASA/ASEE/ Stanford summer study in 1975 at Ames Research Center.

Generally speaking, reactions to the information we presented were positive. The most frequent objection encountered was that abundant cheap energy will lead to further carelessness in our use of non-renewable resources here on earth.

L-5 Society representatives at Habitat Forum were Norie Huddle, Magoroh Maruyama, Aldo Pontecorvo, Peter Vajk, and Robert Wilson. We are also indebted to Total Education in Total Environments (T.E.T.E., Box 297, Bronxville, NY 10708), represented by Henry M. Joels, for co-sponsoring our exhibit booth.

The following statement was widely distributed to news reporters from around the world and to every official governmental delegation to the United Nations Conference on Human Settlements (together with a copy of our statement "Human Settlements in Outer Space" and a selected bibliography):

Dear Friends,

A small group of professionals representing the L-5 Society have come to the United Nations Conference on Habitat to share with you information on recent discussions in the United States regarding the possibility of developing Solar Space Power Stations (SSPS) and space habitats.

Preliminary research suggests not only that these proposals are feasible using existing technology, but that they also promise high long-range investment returns. For these reasons, we believe it is realistic to assume that many will support their development. And if, as research indicates, the SSPS would provide a cheap source of pollution-free solar energy, perhaps the concept merits further research.

However, many questions remain unanswered, and it is to these that we address ourselves. Since this space-development program has vet to receive significant funding, many may feel that our concern is premature. Nevertheless, we feel that now is the time to place these ideas before a broad international forum-and actively seek feedback from the global community. After all, such a space program would greatly affect all of us.

We sum up our specific concerns in the following statements:

(1) *Need to avoid exploitation of any space program by military interests.* The possible misuse of the SSPS by a single powerful nation-or group of nations-is of serious concern. To avoid this, we would like to encourage, early on, the establishment of an international "Global Space-Watch", an organization with the functions of actively guarding against military exploitation of any space-development programs.

(2) *Need to look into the type of management of the program and distribution of energy generated.* Unless such a program is managed by a broadly-based international entity, we are concerned it would be used for selfish political and economic ends.

(3) *Desire to encourage a broadly-based international audience to submit ideas* related to all aspects of the program, as well as criticisms and concerns. We also solicit concrete suggestions of how the program might best be carried out to Serve all the Earth's people, rather than just a privileged few. If a space-development program is carried out in the future, we would like to see it be a truly international effort.

Sincerely,
L-5 Society Representatives
Habitat

SPACE FARM DEBATE

At the May 1975 Princeton Space Manufacturing Facilities Conference, Keith and Carolyn Henson presented a paper, "Closed Ecological Systems of High Agricultural Yield." They proposed that in a space farm plants could be grown in a hydroponic system, and that meat would be provided by alfalfa-fed rabbits, dairy products by goats. A pre-publication copy of this paper is available from the L-5 Society for $4. "Estimates of Crop Areas for Large Space Colonies," I. R. Richards and P. J. Parker, is also available for $1.50.

FROM THE L-5 SOCIETY WEST EUROPEAN BRANCH NEWSLETTER

Soil Culture Versus Hydroponics for Space Farm?

In L-5 News No. 8 (April 1976), L-5 member James Kempf commented on the relative merits of soil culture versus hydroponics for space colony plant production-concluding that hydroponics would allow greater productivity. Dr. Ian Richards, founder-member of L-5 West European branch, has responded to James Kempf's letter, saying that for full growth a plant needs an adequate supply of nutrient elements and a base on which to support itself. Provided that these needs are met and pests and pathogens are excluded, productivity will be the same whatever the method of culture. Soil culture is easy and requires no complex maintenance systems-its disadvantage is the mass of lunar material needed. If large quantities of lunar rocks and regolith are needed anyway for protection against cosmic radiation, this disadvantage of soil culture disappears. Hydroponics requires little or no lunar material but relies on a sophisticated system of maintenance and is, in some ways, less convenient, particularly for root crops. Another point which Jim mentioned and Ian responds to was the effect of reducing atmospheric nitrogen content on nitrogen fixation by legume Rhizobia. Experiments on intact plants and on detached legume nodules have shown that maximum rate of nitrogen fixation is achieved at partial pressure for nitrogen of around 0.1 atmosphere at the site of fixation (Wilson, 1936, J. Amer. Chem. Soc. Vol. 58 1256). The partial pressure at the site of fixation will be somewhat lower than in the surrounding atmosphere but there should be few problems with nitrogen fixation if the partial pressure in the colony atmosphere is kept above 0.15

Illustration from Henson paper.

atmosphere. In the complete absence of the symbiotic Rhizobia bacteria or of atmospheric nitrogen most legumes will take up nitrate-nitrogen from the soil. (Dr. Ian Richards, 15th May, 1978).

Correspondence for the West European Branch of the L-5 Society should be addressed to: Coordinator, 24, Fifth Ave., Kidsgrove, Stoke-on-Trent, ST7 1DA, England, U.K.

ADVANTAGES OF HYDROPONICS IN SPACE

James Kempf

(1) A hydroponics system, suggested by Keith and Carolyn Henson of Tucson,' employing catalytic incineration for conversion of wastes into CO2, nitrate salts, and trace minerals. Initially, in the 2,400 person construction shed, the plants would be supported by Styrofoam boards and their roots would be sprayed with nutrient solution at intervals, to reduce the biomass and supporting mass, both of which will have to be shipped up from Earth. Based on yield figures of hydroponic farms on Earth, the Hensons figured that an area of 32 m^2 per person would be necessary to support the construction workers with a nutritionally adequate diet.

(2) A soil culture system, suggested by Ian Richards and P.J. Parker of England[2], presumably based upon direct farming of the lunar regolith. Although the recycling method was not specified, the productivity figures suggest that farming practice would be similar to that on Earth, with large amounts of organic matter being incorporated into the regolith and intensive fertilization

(continued on p. 6)

SAVE SKY LAB!

This report was turned in by a member who wishes to remain anonymous.

A fantastic opportunity has just been recognized for space colonization. Where theorists were once speaking of ten to fifteen years of planning for initial efforts costing billion, it may be possible to establish the first small permanent American space outpost within *five* years at a cost of well under one hundred million dollars, with potential industrial profits of tens of millions of dollars per year.

The technique would be to save Skylab. It is feasible to revisit the abandoned American space station, send it into a stable orbit, and set up an inhabitable &person space outpost by 1981. One additional Space Shuttle flight would bring auxiliary space power units up for a half-megawatt space complex for industrial and experimental power beaming activities.

Skylab, last visited by astronauts in early 1974, is in a slowly decaying orbit which is due to plunge into the atmosphere sometime in late 1980 or early 1981. This is the unavoidable cutoff date. Several months before then, a Space Shuttle mission must attach a special booster module to the Skylab docking adaptor. The booster module would fire two sets of low-thrust rockets to nudge the space station back into a high circular orbit where it would be safe for another eight to ten years.

On board are ample supplies supplies of water and oxygen. The solar power system, turned off by command from earth, is probably restartable. The pressure hull has probably maintained its integrity, or it could easily be patched. Most of the instruments and equipment are probably still in working order.

On the other hand, the stabilization system (based on massive Control Moment Gyros) is probably shot, so a replacement system of gas thrusters could be built in to the booster module. Also attached to the booster module could be a universal "androgynous" docking adaptor to allow both American and Soviet manned spacecraft to dock at the revitalized Skylab.

The advantages of this arrangement are manifold:

It would allow a space outpost by 1981, with all the special habitability and medical experiments required before detailed planning on very large settlements could begin.

It would allow a space outpost cheaply, at the cost of a booster module (built from a leftover ASTP docking module), several Shuttle flights which could be doing other experiments as well, and other specialized experimental equipment.

It would allow a powerful space outpost, with eight crew people spending six months or more in space, on a permanent rotating basis.

It would allow an international space outpost, with all the political advantages of inviting the Soviet Union, Europe, and Japan to participate with experiments, visits, and crew.

To accomplish this exciting project (which is being seriously studied by NASA in Washington, D.C.) would require a quick commitment. It would require a sense of urgency on the Space Shuttle project, now due to begin orbital flight tests in March 1979 but subject to possible budgetary delays. The orbital decay of Skylab will wait for no budget.

Before leaving crew on Skylab when the Space Shuttle returns to earth, an alternate means of crew recovery is needed. The second Space Shuttle vehicle will not be ready for space flights until well into 1981, so in the event of the unavailability of the sole Space Shuttle, the Skylab crew may need other ways of getting back to earth. These include a docked Apollo command module (possibly very expensive due to the obsolete technology), a new space 'bailout' system (not yet flight proven, and requiring a special development project), or an agreement from the Soviet Union to be ready to provide emergency rescue services on a two week notice (possibly appealing to the USSR's ego, and well within their technical capability for post- 1980).

A proposed scenario could go like this:

Early 1980: one of the first six Space Shuttle test flights makes a rendezvous with the Skylab. Two people conduct an EVA into the laboratory, make an inspection, and retrieve experimental specimens left behind by the last crew in the event of a future visit. The booster module is attached, and the Shuttle pulls off several dozen miles. After the firing of the booster (if the firing is unsuccessful, the Shuttle retrieves the booster module for return to earth), the Shuttle continues the remainder of its week long test program.

Late 1980. As part of a Spacelab science mission with a crew of seven, the Space Shuttle docks with the Skylab. Four astronauts transfer into Skylab and attempt to t-e-establish a 'shirtsleeve' environment. Telescope cameras are loaded with film and the sun is observed on a brief experiment program. Food stocks are left on board during the three to five day visit.

Early 1981: The first new Skylab crew is delivered for a six-month flight, during which a three-person Soviet cosmonaut crew visits the Skylab for several weeks. One American returns in the Soviet Soyuz capsule; one Russian stays on board the Skylab. Space Shuttle flights may occasionally visit the station.

Late 1981: With the laboratory certified for extended habitation, a full crew of eight (transported in two different flights) is put on board. The Space Shuttle normally carries a crew of three and four passengers-in an emergency, it flies with crew of two and eight passengers. On their six-month tour of duty, the space colonists conduct scientific experiments in astronomy, physiology, earth surveys, space power,

and space industry. New power systems and space structures, assembled during extensive EVA work programs, certify the concepts to be used later in the decade on higher, newer space outposts, leading to the foundation of a lunar mining base by 1990.

This American activity will be all the more desirable, coming as it will contemporaneously with the planned 24-person Soviet "Kosmograd" space city of the post-1980 time period. The USSR has never hidden its desire to establish large, long-lived, self-supporting space outposts. The European Space Agency (ESA) free-flying Spacelab concept (mostly paid for by the West Germans, and possibly code-named "Valhalla") will also be in orbit in this same period.

All of these Skylab potentials were described as being done by NASA, but this is not restrictive. In fact, by international law, Skylab is now recognized as a "space derelict" and is eligible for salvage claims by any party which can board it. It is entirely possible that a commercial American or international corporation may pay travel expenses to NASA for rides in the Space Shuttle up to Skylab. If Space Industry promises to be a paying proposition, then Skylab could be the first Space Factory, and whoever takes possession might turn it into a goldmine in the sky.

What can L-5 do? First, publicize the concept (bumper stickers: SAVE SKY LAB). Discuss alternative concepts and potentials. Write to news media, top space scientists and industrialists. Stir up the interest in this immediate, practical, amazing space project possible within 48 months or less!

Furthermore, encourage L-5 members and associates to apply for the new NASA astronaut program to be started this summer. Thirty pilots and scientists - women included - will be recruited during the next eighteen months for Space Shuttle missions, and possibly for a "save Skylab" project. (Bumper sticker: SAVE SKYLAB-GET ON BOARD.)

Space colonies *now!*

$8.5 MILLION APPROVED FOR SPACE SOLAR POWER STUDIES

William N. Agosto

A conference committee of both houses of Congress has appropriated $5 million in ERDA's FY 1977 budget for solar power satellite studies. The $5 million was originally authorized for NASA by the House Committee on Science and Technology after hearings last summer on future space programs before the Subcommittee on Space Science and Applications where Gerard O'Neill presented his proposal for space production of solar power satellites (SPS).

After the Senate version of those hearings last January the Senate Committee on Aeronautical and Space Sciences authorized the $5 million for ERDA to comply with an Administration directive specifying ERDA control of all energy development programs for terrestrial applications. Last month the conference committee switched House authorization from NASA to ERDA in line with the Senate to clear the way for final appropriation.

An additional $3.5 million has also been authorized by the House for space based solar power studies in the FY 1977 NASA budget. Space applications are intended but the SPS qualifies as a power source for space operations as well.

Total funding comes to $8.5 million. New Jersey Representatives Edward Patten and Millicent Fenwick among others supported both allocations as important first steps in developing substantial solar energy sources.

Extensive discussion of the military aspects of Space Colonization in the Newsletter may create the impression that the Society is advocating this possibility. I am sure that most members will not be favorable to this use. I wish to suggest that the Newsletter will not stress this point any further.

Michael Mautner
New York, New York

We'll stop when our under-sand respirators arrive.

MILITARY IMPLICATIONS OF SPACE COLONIES/SSPS

Jack Salmon

An SSPS can supply massive power input for the operation of lasers, electronic signal scrambling devices, radars, or any other electrical or optically-based weaponry. Military men are already interested in space-based ABM lasers, and clearly military implications will play a significant role in SSPS policy decisions whether one likes it or not.

But we miss a point if we consider an SSPS as only a *weapon,* since any major weapon immediately becomes a major target. If a major weapon system would be difficult to defend or use, there is little point to building it-although this does not always stop the project, as military history shows. Would an SSPS weapon be relatively defensible and usable? If more than one SSPS-owning nation has space weaponry, either could turn its armament on the other. Missiles targeted on an SSPS could probably be stopped by a short-range laser ABM system, but a cloud of ball-bearings or some such artificial meteors might be inserted into the SSPS orbit and chew it to bits. No doubt other proposals for SSPS destruction could be invented, but my present point is only that an SSPS may well be so vulnerable to counter-attack that it is useless *military* investment. After all, a massive, delicate, fixed-orbit, 20 sq. mile target does not seem intuitively a good bet for defense.

SSPS defense is probably more significant than SSPS offense: the SSPS system of a nation at war would be a very high-value target for an enemy, since the system would be supplying very large fractions of the nation's basic energy for industrial and military use. Energy centers are often key targets-oil refineries, electrical generating facilities and grids, dams. For a number of years after World War I I the primary target for American nuclear weapons was the Soviet electrical grid. For such a high-value target, militarily there are two critical questions: 1) is the system so important and so vulnerable that it should *not* be built for reasons of national security, because the nation cannot afford heavy dependence on a single vulnerable system; 2) are there feasible methods of either defending the system or alternatively of reducing its attractiveness as a target?

Logically question 2 determines the answer to question 1. Defense of SSPS in the usual military sense may be possible, but does not appear to me a very good bet at this point. There are however a number of ways of reducing the value of the target.

One way would be to build more, smaller SSPSs and rectennas. Although this may be economically and technically the wrong answer, it would decrease the individual target value of each SSPS, increase the probability that several would survive an attack, and thus reduce the incentive to attack them at all-a rationale very similar to the argument for more, smaller ICBMs rather than a few large ones. Nations frequently pay higher economic costs because of such security arguments, counting it part of the national insurance premium.

Perhaps the best way however is also the simplest in a technical, economic and military sense, although much harder politically: internationalizing the SSPS system. If major contending nations all have a share of SSPS investment and power production, if all are significantly dependant upon SSPS power and products, there would be a strong incentive to leave SSPSs off the target list. Further, it would be much easier to maintain national surveillance over each internationalized SSPS, to be certain that no weaponry conversion was being undertaken by an opponent. SSPS thus would become part of the "domestic" structure or alternatively part of the booty in any war and therefore something to preserve rather than to destroy, much as warring kings used to exercise reasonable care to avoid killing peasants or destroying croplands.

Of course, this application of the functionalist theory of international order cannot guarantee the security of any SSPS system: scorched earth policies, Hitler's Gotterdammerung and any number of civil wars and revolutions teach us that people and nations are not

always sensible about things. But emphasis upon inter- rather than independence in space exploration is already accepted as a good thing in principle if not always practiced, and interdependence has become something of a buzzword in foreign policy recently. An SSPS system as an international, nakedly-vulnerable hostage may be far better "defended" than would be a national system bristling with armaments.

Both "active" and more subtle defense methods must be explored. Only when we have a suitable answer to question two may we answer question one-and only when we can favorably answer question one may an SSPS system be built. No project of the magnitude of space colonization can escape military evaluation, but proper and timely analysis and design may minimize the impace of military factors.

Mr. Salmon, in correspondence, has added:

There is a very strong tendency to confuse/combine the ideas of space colonies and space power plants, which makes some economic and technological sense but which is militarily quite separable for several reasons. Colonies at L-5 would be a long way from any Earth launch point for attacks and would have a (comparatively) long reaction time in which to spot approaching missiles and take counter-action. Attacking them with lasers from Earth orbit -- with SSPS-based lasers -- would not now be feasible because of the focus problem at such long range. Besides, they would be at best secondary targets, easily monitored but too far away to be of immediate importance. SSPSs on the other hand are in comparatively close orbit, would have short reaction times, and high value as targets whose destruction would have large and immediate consequences. The colonies would be nice to capture, but-as I see it now, at least-rather pointless as targets. The SSPS is the exact opposite-if it is a national installation.

NEW ASTRONAUT HIRING

This July NASA will request applications for the next generation of astronauts. Thirty will be hired, fifteen being pilot astronauts, and fifteen mission specialists. According to David Garrett the requirements are still being set, but at present they include:

"U.S. citizenship, good health. Pilot applicants must have 1000 hours of first-pilot jet time. We're particularly interested in qualified female and minority candidates. An age limit is illegal now, but probably we'll be looking at people 35 years of age and under. Qualifications for the mission specialists: a bachelor's degree and experience in one or more of the following fields -- engineering, biological sciences, physical science, and medicine. Screening, evaluation, and physical examination of applicants will take place in 1977, with the selection of candidates late in 1977. Then we will assign the candidates to Johnson Space Center in Houston in 1978 for a two-year evaluation period. The astronauts will be selected from among the candidates in 1980."

For details write David Garrett, Code M-N, NASA Headquarters, Washington DC 20546.

ASTRONAUT PLUGS SOLAR POWER SATELLITES AT 1976 INTERNATIONAL MICROWAVE SYMPOSIUM

William N. Agosto

The Institute of Electrical and Electronic Engineers held its annual International Microwave Symposium this year at Cherry Hill, N.J., from June 14 through 16. Over 11O papers were presented in 24 sessions covering a wide spectrum of microwave science, engineering and industrial operations.

In a session devoted to high power techniques, Richard M. Dickinson of Jet Propulsion Laboratory reported the wireless microwave power transmission tests he conducted last year at Goldstone, California. Over 30 kW of power were transmitted a mile across the Mohave Desert and converted to DC line power at a receiving antenna called a rectenna with 82.5% efficiency. The tests are crucial to proving the utility of beaming substantial power to earth from solar power satellites (SPS). Concern is often expressed that birds may be injured flying through the proposed SPS microwave beam. In Dickinson's tests beam power was up to twice what is expected from operating SPSs. Despite that, no dead or ailing birds were found near the test site over months of operation. Birds did damage the rectenna, however.

William C. Brown, the consulting scientist at Raytheon who developed the rectenna reported the latest laboratory microwave power reception efficiency at over 90%. The laboratory rectenna has been operating over 4000 hours at high power densities without significant variations in performance. Life tests are continuing.

Scientist/Astronaut William B. Lenoir was guest speaker at the Symposium banquet. He headed NASA's study team on satellite solar power and addressed a capacity crowd in the Starlite Ballroom on NASA's future aspirations. He described the shuttle in some detail with heavy emphasis on solar power satellite construction as a major shuttle project. SPS questions on radiation hazards and project costs were raised from the floor. Lenoir felt that adequate radiation safeguards would be developed and that SPS cost per kilowatt was competetive with nuclear systems. Somebody asked about the O'Neill space production approach to SPS power. Lenoir took a wait and see attitude. Final SPS manufacturing scenarios can't be decided until after earth-launched prototypes are operating, he said.

The conference wound up with a session on biological effects of microwave radiation. A.W. Guy of the University of Washington, one of the most prominent researchers in the field, reported no adverse effects in laboratory animals irradiated continuously for six months at a power density of 5mW/cm2. The U.S. safety limit for continuous exposure is 10 mW/cm2. Typical microwave oven leakage is 0.5 mW/cm2 and millions of the ovens are now in use. Physicians at the session said no harmful effects attributable to that oven leakage had been reported.

Preprints of the sessions can be obtained from the IEEE, 445 Hoes Lane, Piscataway, NJ 08854. Cost is $25 with a 25% discount for IEEE members.

HYDROPONIC ADVANTAGES

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supplying nitrogen requirements as a supplement to the nutrients provided by bacterial decay. A per person area calculation indicated that 430 m^2 would be necessary to support a worker with a nutritionally adequate and varied diet.

Richards has further defended soil culture[3] on the grounds that soil culture is easy and requires no complex maintenance systems. The disadvantage of soil culture is that large amounts of lunar regolith would be required. Hydroponic systems require little or no lunar material but rely on complex maintenance systems and, according to Richards, are less convenient for root crops.

An immediate comparison of the systems indicates that hydroponics would require about 1/30th the per person area required for soil culture. Since the initial physical plant will have to be lifted from Earth, any savings in area will mean savings in mass, and therefore lift costs. Spraying the roots at intervals will also reduce the amount of water tied up in agriculture and save biomass.

In terms of yield, hydroponics would also seem to be superior. The following table gives a comparison of hydroponic versus field crop yield.[4]

tons per acre

	Field Crop	Hydroponic
potatoes	3.0	62.5
tomatoes	5.0	60-300
oats	.5	1.5
rice	.5	2.5
beet root	4.0	12.0
peas	1.0	9.0
beans	5.0	21.0
cucumber	3.5	15.0

Both the potatoes and beets show superior yields under hydroponic culture, indicating that root crops do not suffer when grown hydroponically and in every other case, hydroponics gives the superior yield.

In terms of mechanization, certainly hydroponics will involve more machinery, in the form of pipes, sprayers, etc. But such material is more easily transported than soil and can be easily assembled in space. Although subject to breakdown, the system could probably be made as reliable as existing agricultural machinery on Earth. Components for commercial hydroponics systems similar to the one proposed by the Hensons already exist[5] and could no doubt be cheaply adapted to space habitat usage, while the tractors and other equipment necessary for soil culture would need substantial modification for use in space.

Perhaps the main problem with hydroponics is the name. In an age when people fear, with some justification, that each new food additive is another nail in their coffins, anything related to food that sounds scientific is suspect. Granted the possibility that certain aspects of human and plant nutrition might not be discovered yet, the uncertainty in nutrition is nevertheless more on the order of clearing up details rather than working out major problems. Hydroponic culture has been around in one form or another since the floating gardens of the Aztecs, so soilless plant growth is nothing new.

Although the methodology used by Richards and Parker to estimate the amount of area need for a space farm is interesting and provides a valuable contribution to the field, hydroponics seems to offer the only technique for satisfying the carbon recycling and nutrition requirements of the initial construction force without incurring a large weight penalty. In the later stages of colonization, when operations of the moon are in full swing, farming of the lunar regolith might be pursued, but, operating under the constraints imposed by importing everything from Earth, hydroponics offers more immediate advantages than soil culture.

1. **Closed Ecosystems of High Agricultural Yield;** H. K. and C. M. Henson, Princeton Space Manufacturing Conference; May, 1975.

2. **Estimates of Crop Areas for Large Space Colonies:** I. R. Richards and P. J. Parker, unpublished paper.

3. **Western European L-5 News;** May, 1976, pp. 1-2.

4. **Commercial Hydroponics;** Dr. Maxwell Bentley, Bendon Books; Johannesburg; 1959; p. 28.

5. "G. E. Electronics Systems Division Hydroponic Greenhouse in Alaska"; **Popular Science;** January, 1976.

Your *fourth-generation Xerox of the L-5 News is barely readable? Tsk, tsk.*

LETTER

I learned from the May news supplement (just arrived) that my "Alternative Geometry" paper was lost in the Atlantic! Just after completing it I learned of O'Neill's "Sunflower" design, a really beautiful design which incorporates many of the same features, and further improvements such as the counter rotating ring. My design used parabolic section mirrors and narrow "solars", giving extra radiation protection and easy night utilisation of solar energy.

One problem not touched on was the rejection of waste heat-the only waste an O'Neill Island should ever produce. O'Neill's original twin cylinders lost infrared 'through the large solars during the day: the "sunflower" sheds heat partly through the solars and partly through the metal endcaps. In both cases valuable colony area is used, and radiation protection sacrificed.

Getting maximum radiation shielding (several meters depth of soil) and heat rejection (outerskin must be above freezing point) seems to put tough constraints on colony design.

Here are some ideas: we can use bare metal, as in the "sunflower" endcaps or in the form of aluminum "walls" running down through the soil to the skin. Water vapour transpired by plants condenses on the cool metal and is channelled back to the roots, while the walls conduct the heat down and even double as structural members. Could larger metal areas be covered in water to the same depth as the soil, and be used for recreation?

The important question now is not which design the first colony will be but how we are going to get it built, and when.

Peter R. Volke
London

BIBLIOGRAPHY UPDATE

Applied Solar Energy: An Introduction, Aden and Marjorie Meinel, Addison-Wesley Publishing Co., Inc., Jacob Way, Reading, MA 01867. This book includes information on solar observation instrumentation, solar flux variation dynamics, comprehensive treatment of the types, methods of preparation and behavior of selective absorbing surfaces, analysis of "thermosyphon", solar saline pond, adverse peaking effects of home solar applications, and zoned thermal storage tanks. Recent developments in optical materials, mirrors, coatings and selective absorbing and transmitting surfaces are summarized and analyzed. Research problems and economic problems are identified and discussed. Twenty appendices offer tables and data not available in any other single source. While this book was written primarily for those interested in Earthbound solar applications, it offers much of value to those considering the use of the sun in space.

"Ecospace: The Economics of Outer Space -- and the Future," Edward R. Finch, Jr., and Amanda Lee Moore, *American Bar Association Journal,* March, 1976, Vol. 62, pp. 332-338.

"The Next Frontier," Isaac Asimov, *National Geographic,* July, 1976, pp. 76-89.

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"Dr. Gerard K. O'Neill-Interview," James Mitteager and Salvatore Napolitano, *Penthouse,* August, 1976. An accurate, careful interview with O'Neill about space colonies and what the future could be if we work for it. Incidentally, *Penthouse* has 5.3 million readers. O'Neill cultists will have to have this one for the color painting of Gerry in a space suit.

"Phased Satellite Power Program Urged," Craig Covault, *Aviation Week and Space Technology,* February 9, 1976, pp. 54-55.

"Overcoming Two Significant Hurdles to Space Power Generation: Transportation and Assembly," R. Kline and C. A. Nathan, Presented at AIAA/ AAS Solar Energy for Earth Conference, Los Angeles, California, April, 1975 (AIAA Paper 75641).

"Escaping the Limits to Growth," Michael A. G. Michaud, *Spaceflight,* April, 1975.

The 1975 TRW Spacelog is out. Relating to Soviet space activity, it is pretty skimpy: e.g., it ignores the April 5th Soyuz failure last year! Order from Public Relations Dept., TRW, One Space Park, Redondo Beach, CA 90278. Free to space-connected people. Give an official address.

Correspondents are also reminded of the heavy concentration of Soviet space articles in the magazine "Space World", $8 per 12 issues, Palmer Publications, Amherst, Wisconsin 54496. L-5 Director James Oberg is the Associate Editor. Articles solicited (send to Ray Palmer, editor).

Illustration by Shusei Nagaoka, Penthouse Magazine

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