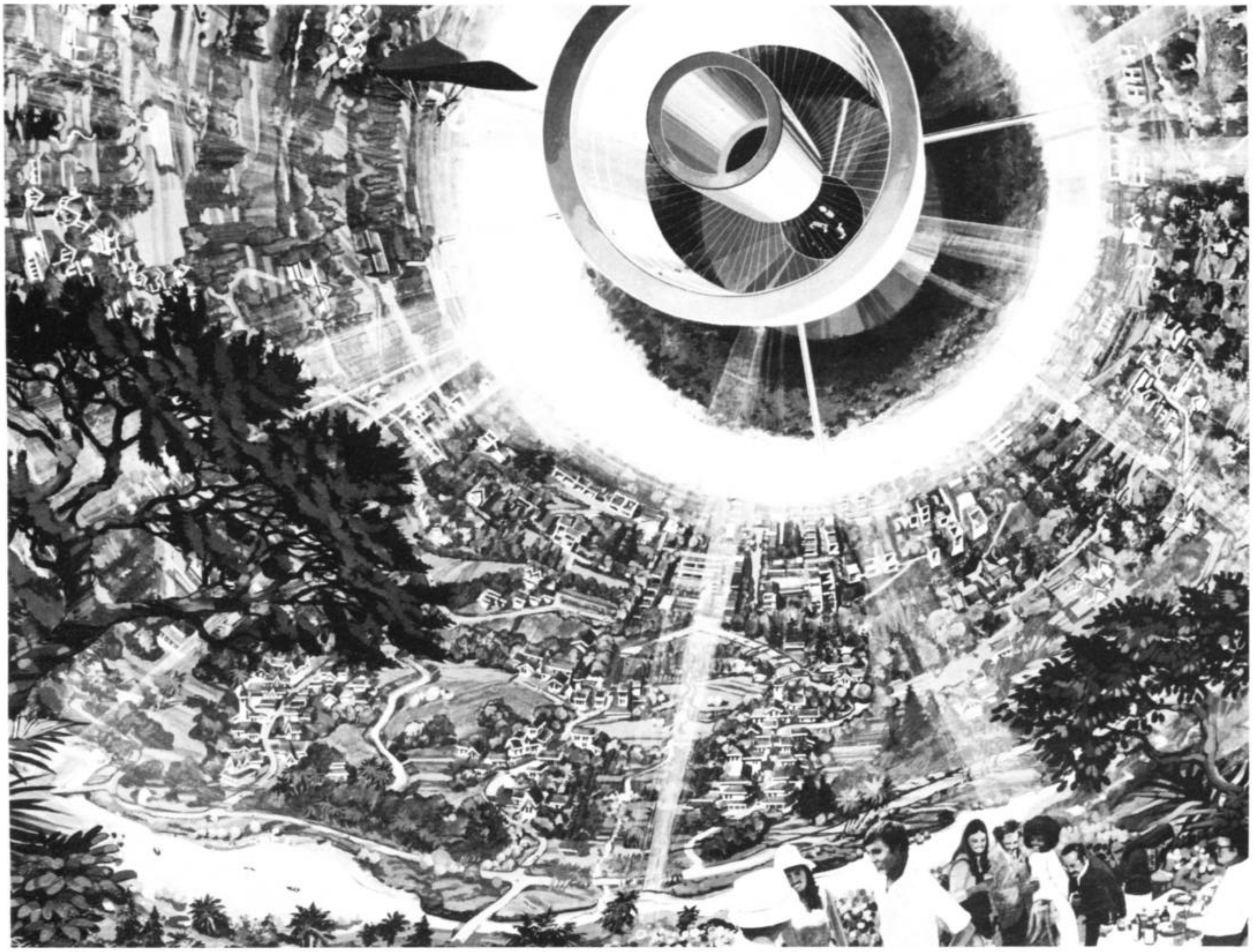
L5 NEWS

Volume 1, Number 13 September, 1976



On the Cover: A NASA artist's conception of the exterior of the "Bernal Sphere" space colony, a space-habitat for some 10,000 people. The inhabitants, members of the workforce of a space manufacturing complex, would return after work to homes on the inner surface of a large sphere, nearly a mile in circumference, rotating to provide them with gravity comparable to that of the Earth. Their habitat would be fully shielded against cosmic rays and solar flares by a non-rotating spherical shell, accumulated from the slag of industrial processes carried out on lunar surface material. Outside the shielded area agricultural crops, far less sensitive to radiation than are humans, would be grown in the intense sunlight of space. Docking areas and zero-gravity industries are shown at each end of the space-community, as are flat surfaces to radiate away the waste heat of the habitat into the cold of outer space. In the 1976 NASA Study on Space Manufacturing, just completed, habitats of this type, very efficient in their use of materials for shielding, are thought of as possible next steps beyond more utilitarian structures. These would be shielded versions of the agricultural areas shown here.

1620 N. Park Ave., Tucson, AZ 85719
(602) 622-2633

This Page: Interior of the "Bernal Sphere." In this year's NASA Study on Space Manufacturing, habitats of this kind, efficient in their use of materials and structurally strong, are thought of as possible next steps beyond earlier, transitional structures of a more utilitarian design.

The "equator" of the rotating habitat is nearly a mile in circumference, and near it wanders a small river whose shores are made of lunar sand. Natural sunshine is brought inside through external mirrors. Rotation of the sphere at about 1.9 RPM would produce gravity of Earth-normal intensity at the equator, gradually diminishing to zero at the "poles," where human-powered flight and other low-gravity sports would become easy. For the short distances within the space-habitat, automobiles would be unnecessary, and transport would be on foot or bicycle. A climb from the equator past the small villages on the hillsides, to the rotation axis where gravity would be zero, would take about 20 minutes. A corridor at the axis would permit floating in zero-gravity out to the agricultural areas, the observatories, the docking ports, and the industries.

In the economics of space-manufacturing, the provision of attractive living areas of this kind appears to be worthwhile relatively early in the program, because families so located could remain for several years at a time, rather than coming for short tours of duty at high cost for transportation.

CONTENTS

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

L5 NEWS

NUMBER 13 A NEWSLETTER FROM THE L-5 SOCIETY SEPTEMBER 1976

NASA Ames

1976 SUMMER STUDY

J. Peter Vajk

On July 30, NASA Ames Research Center in Mountain View, California, hosted a press briefing to present a summary of the results of this year's summer study on space manufacturing, sponsored by NASA, Stanford University, and the American Society for Engineering Education. Gerry O'Neill presented a brief overview of the project, and then introduced, in turn, the other four speakers.

Frank Chilton discussed the new design for the Mass Driver which would launch packages of lunar soil from the Moon for use as raw materials in space manufacturing. Basic design parameters included a capacity of 600,000 metric tons per year in 20 kilogram packages accelerated up to escape velocity, 2.4 km/sec, with tolerances in velocity components at release of less than 10 cm/sec longitudinally, 1 cm/sec laterally, and 0.1 cm/sec vertically.

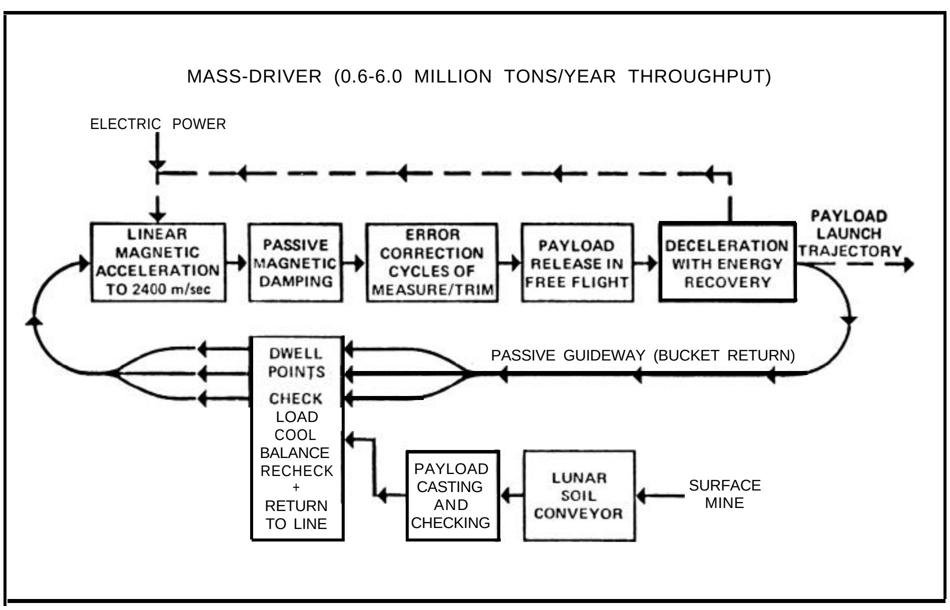
Each "sled" would be subjected to a thrust somewhat smaller than the thrusts required for magnetic levitation train systems planned for terrestrial use, but since these sleds are much lighter than railcars, much higher accelerations would result. Chilton said his team would have designed the system to provide 1000 G acceleration with total confidence that it would work, but O'Neill told him nobody would believe it, so they stuck to only 100 G! (It should be remarked that the Sprint ABM missile accelerates at well over 50 G). The sleds contain superconducting electromagnet coils, with the entire liquid helium system completely sealed tight; the sleds are never exposed to sunlight. Total tracklength is about 4 kilometers.

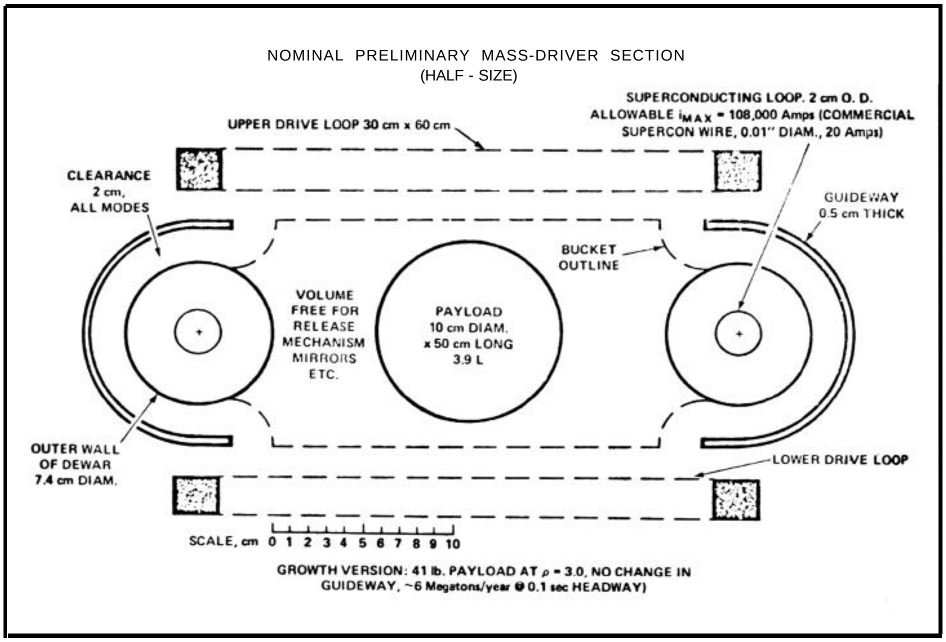
Since the dispersion between consecutive payloads on arrival at the Catcher, 60,000 km away, must be quite small, the dispersion is still minute only 150 kilometers downrange from launch. If the payloads are initially aimed slightly below horizontal, then final guidance can be provided by letting the payloads fly through a l-meter diameter "tunnel" about 100 meters in length placed on a suitable plateau or mountain 150 km away from release. Fine-tuning to 1mm/sec in all three axes could be provided by zapping the payload with an electron beam and then using electrostatic plates to adjust the velocity. Chilton did not expect, however, that it would be necessary to go to such extremes, as initial release velocities should be within that level of precision anyhow.

Total mass for the launch system (including the Rube Goldberg downrange "tunnel") is down 40% from previous estimates. Based on present solar energy technologies or small nuclear reactors, the mass needed would be 4067 metric tons; with extrapolated values for solar energy sources, the mass would drop to 3067 tons. About 100 workers would be needed initially to assemble and align the system, but only about 20 would be needed to maintain and operate it.

Brian O'Leary then discussed the extensive computer calculations which were done to pin down the launch precision required for the Mass Driver. Precision needed depends on the location on the Moon of the launch point. The dispersion in payloads is least sensitive to velocity errors at release if the launcher is placed at about lunar longitude 33.1°. (Looking up at the Moon in the sky, that means the launch point would be about half-way from the middle of the Moon's face to the right limb of the Moon.)

Extensive calculations were also done to define the Catcher's orbit. Because the





Moon's revolution around the Earth each month does not keep perfectly in step with the Moon's rotation on its own axis, the launch site does not stay in a fixed position relative to the Lagrange libration points. To minimize the work the Catcher has to do to follow the stream of payloads coming up from the Moon, it turns out that the Catcher should make a once-a-month orbit around L-2 with a radius of about 10,000 km, with the Catcher's orbit standing on edge relative to the Earth-Moon orbital plane. Thus the Catcher would always be visible from the Earth.

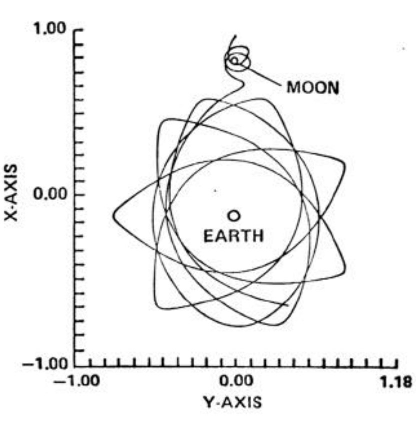
Keeping the Catcher accurately on this orbit requires a "delta-vee" of about 150 m/sec per month, with a peak acceleration of less than 0.2 mm/sec/sec (20 millionths of one-G). To transfer the Catcher and its cargo of lunar soil to L-5 would require an additional "delta-vee" of 440 m/sec and would take about 14 days. Alternative locations were also considered for the Space Manufacturing Facility (SMF) which would be the destination for this cargo. One interesting possibility turns out to be the "two-to-one (2:1) resonance orbit" and transfer there from the Catcher's orbit would require only 9 to 31 m/sec and would take about 65 days.

The "2:1 resonance orbit" is a solution of the restricted four-body problem (Earth, Moon, Sun, and satellite), as are the kidney-shaped orbits around L-4 and L-5 shown in the L-5 Society literature. The orbit is roseate-like, and can be thought of as an elliptical orbit which precesses around the Earth every rapidly, with a satellite in such an orbit returning to the same location relative to the Earth and the Moon every two months. Such an orbit is relatively stable, requiring nominal station-keeping, and has the advantage of a relatively small "delta-vee" to transfer completed power satellites from the SMF to geosynchronous or lower orbits. O'Neill suggested in jest that the L-5 Society might have to rename itself the "Two-to-One Resonance Orbit Society."

William Phinney then discussed the problems of chemical processing in space to extract metals, oxygen, silicon, and calcium from the lunar soil, with some preliminary description of lunar soil composition variations among the six Apollo landing sites. For example, soils from the lunar highlands were relatively more rich in aluminum than were soils from the maria; the converse held for iron.

The kinds of reactions, catalysts, and temperatures needed to separate lunar soil into the desired elemental fractions have been worked out in sufficient detail to think about building a pilot plant to work out chemical engineering bugs. This could be done here on the ground for starters, then in zero-G in low-Earth orbit with the Space Shuttle. Since the processes all begin by melting everything, the physical texture of lunar soils is irrelevant to testing. Pilot plants could be adequately debugged using synthetic lunar soil samples containing appropriate mixes of terrestrially available minerals. Total power requirements for processing

TRANSFER TRAJECTORY FROM L2 TO A 2:1 RESONANT ORBIT



600,000 metric tons per year will be about 500 megawatts, corresponding to about one square kilometer of solar collector area.

Gerry Driggers concluded the presentation with a discussion of fabrication, logistics, timetables, and costs. A careful analysis of what parts of power satellites could be easily fabricated in space at an early stage of space industrialization showed that about 91% of the mass of a silicon photovoltaic cell power satellite could be built in space, with only 9% shipped up from Earth. For a turbogenerator-based power satellite, however, only 68% of the mass could be readily fabricated in space, so that the photovoltaic system appears to have a very strong advantage, at least initially, even if the total mass required for it is significantly higher.

The chemical extraction plant could be housed in a more or less cylindrically shaped "factory" about 50 meters in diameter by about 140 meters in length, while the fabrication machinery would require about a 100 meter extension of that same cylinder.

Three different scenarios were developed for a Space Manufacturing Facility/Solar Power Satellite program. The most conservative was based on "minimum concurrency," that is, development of each part of the system is undertaken only after other parts on which it depends have been fully developed and tested in orbit. The fastest scenario was based on an Apollo-style program, where various logically dependent parts of the system are concurrently developed. By the slowest of these timelines, the first solar power satellite would provide 10,000 megawatts of electricity for the Earth in 1999; by the fastest timetable, in 1992.

To establish the lunar base, operating at 11,000 to 22,000 metric tons per year, well below design capacity, and to establish a prototype orbital manufacturing facility with 300 workers would cost, according to the estimate Driggers considered most reasonable, $30.2 billion. By a highly conservative estimate, the cost might be as high as $63.9 billion.

Working up to a full-scale Space Manufacturing Facility with 6,000 workers, with annual productivity of 5 power satellites of 10,000 megawatts generating capacity, the cost of the project up to the point at which 20 satellites are in operation (total generating capacity 200 gigawatts) would be (reasonable estimate) $102.5 billion to (conservative estimate) $207.4 billion. (All figures are in 1976 dollars.)

Instead of last year's estimate of two years for a SMF to replicate itself, Driggers' team now estimated 2 months; productivity for power satellite construction is ten times higher than last year's estimate. If the entire project were abandoned at the point of 20 powersats in operation, the program would already have proven competitive with conventional ground-based generating plants: the 200 gigawatts would have cost between $500 and $1000 per kilowatt, which is the present cost of powerplants!

L-5 Review: 1975 Study Report

"SPACE COLONIZATION: A DESIGN STUDY"

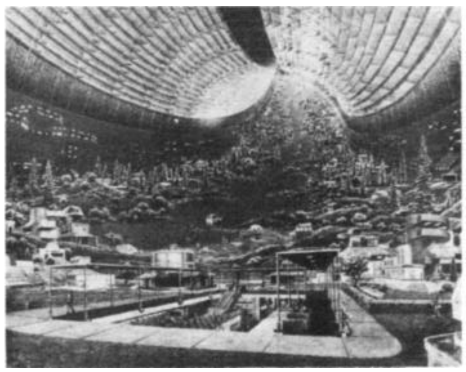
C. H. Holbrow

Where is the long expected report of the 1975 summer design study of space colonization? Well, it's coming. In fact, I recently held in my hand all eight chapters and most of the figures set in galleys with headings, captions and all. But it will be a while vet. The large color figures prefacing each chapter have still to be put in place; the figures need close proofreadings; and then the document has to go through a GPO printing schedule.

I think it will be worth the wait. Representing some six person-years of effort by a team of scientists drawn from economics, sociology, anthropology, biology, aerospace engineering, planetary science, civil, sanitary, electrical, chemical and industrial engineering, physics, and architecture, the report provides the most detailed and circumstantial exposition of the possibility of colonizing space published to date. In eight chapters and many appendices it gives a design for living in space, a program for achieving that design, a number of alternatives, and a wealth of background material useful to those who wish to make their own design.

Except for the wheel shape of the habitat, the design of the summer study draws heavily upon O'Neill's concepts, and so by now the basic proposal is probably well-known to the readers of the *L-5 News.* The plan is thoroughly outlined in the first chapter so that the reader can more easily follow the rest of the report. The 1790-meter-diameter torus is described; it rotates at 1 rpm, at the Lagrangian libration point L-5, and 10,000 colonists live inside the 130-meter-diameter tube of the torus raising their food and living normal lives in a simulated earth-normal gravity. Brief mention is also made of the manufacture of satellite solar power stations for sale to Earth. All this is to be done with millions of tonnes (that's the way we write a metric ton these days) of material brought up to the colony from the Moon in two stages-an electromagnetic launch from the Moon to L-2 where the material is caught, and then by ferry to L-5.

The next three chapters lay out a rationale for the design choices of the summer study group. Chapter 2 describes basic properties of space such as vast distances, gravitational topography, weightlessness, vacuum, intense sunshine, cosmic ray fluxes. Chapter 3 considers their impact on human needs-physiological, psychological, and economic. These needs are defined (e.g. normal gravity, atmosphere, familiar foods, openness of the habitat but with hidden views and variety, a means of earning a living) and various ways to meet them are considered with the aim of achieving a conservative credible design within the limits of "near-term" technology. Anyone concerned about alternatives will find Chapter 4 especially interesting.



Those whose interest focuses on the overall system of the colony and what life in it might be like will be most interested in Chapter 5. Here the reader is taken on a tour through the system. Starting on Earth the reader travels to L-5 and tours the Stanford Torus, its residences, factories and farms. After a visit to the Moon to see the 150 people there mining the lunar soil and maintaining the electromagnetic launcher, you return to Earth. The conversational narrative sticks to the facts of the design. Mention is made of the tedium of life in space, of the long hours and hard work in what is really a small, isolated community narrowly focused on a very few productive tasks. The colony is definitely a frontier community and as such not to be romanticized.

In Chapter 6 schedules and plans for realizing the proposed design are laid out. These naturally lead to the questions of cost and funding. A schedule of funding that would go on over 20 years is presented; the payouts would average about $10 billion per year. By the time the first colony is built, solar power should be producing income, and, about fifteen years later, Earth's initial investment can be fully repaid. All this would be accomplished while building more colonies, more satellite power stations, and paving an annual interest rate of 10% on the investment.

A longer view is taken in Chapter 7. It considers possibilities of using asteroidal material, developing multiplicities of cultures in space, and examines the ultimate limitations on colonizing space.

The final chapter sets out the conclusions of the summer study and recommendations for further research and study. The conclusions are enthusiastic and advocate that the United States, possibly in cooperation with other countries, take definite steps toward colonizing space. Five specific items are mentioned in this connection: (1) continued development of space transportation, in particular the Shuttle; (2) start of development of a heavy-lift launch vehicle; (3) the establishment of a space laboratory in low Earth orbit; (4) the setting up of a base on the Moon where the needed lunar technology can be tested out; (5) an unpiloted, sample-return mission to the asteroids to determine their composition.

There are several assertions of humility in the report to which attention should be called. The actual length of the study was only ten weeks. There was no time for optimization of the design, and in fact the design had to be frozen fairly early on in the process with the result that good ideas with large potential for improving the overall system could not be incorporated. I do not think that any of the participants would recommend building the "proposed" design. By the completion of the study each member could see very radical departures from the proposed design that seemed quite promising. A principal recommendation of the group is that a major systems study be undertaken of space industrialization and colonization.

But even within the terms of the report itself there are some difficulties that should give the careful reader pause. The radiation problem was much greater than expected. To make a habitat safe for long-term living led to a brute force solution of piling 10 million tonnes of lunar slag around the rotating wheel of the torus to protect the inhabitants from cosmic rays and solar flares. Other more elegant possibilities such as magnetic shielding were considered but rejected as unfeasible or beyond "near-term" technology. The colonists end up living in a "cave" built at great expense of effort and resources; they cannot easily look outside the habitat.

There was initially a desire to make the environment as earthlike as possible, but the result is not particularly earthlike. The atmosphere is at half earth-normal pressure; the recycling is almost entirely artificial because natural means are too slow for such a small system; there is no weather; day and night are controlled artificially; the gravity of the system comes from rotational pseudo-forces which produce small effects different from those experiences in a genuine gravitational field. Considerable thought was given to the use of architecture and environmental design to alleviate the artificiality, but there can be no denying or obscuring that colonists would live in city-like surroundings.

Also the engineering problems are very great and stretch technology to its limits. On the Moon cryogenics and superconducting magnets are to be operated near a system pumping megawatts of power into the launching of payloads. All these devices are to be maintained by small crews. There are new designs of transit vehicles, the rotating pellet launchers which each year propel themselves and a million tonnes of lunar material through space by throwing rocks. Their energy is derived from nuclear reactors which power rotating arms. Of even greater engineering difficulty is the catcher which with radar detects and tracks the individual 10 kg payloads coming from the Moon. They are each 40 m apart and moving 200 m/s. A mechanically driven net in one of several large frames about 1 km across must be activated and aligned with each incoming package. The packages arrive .2 sec apart. It's a kind of trap shooting in reverse, collecting together the pieces of a giant clay pigeon.

Another subsidiary goal of the design was to base the transportation on relatively simple extension of existing Space Shuttle technology. In principle the proposed design achieved that goal, but the Table 4.18 which presents expected launch rates shows that the achievement is only in principle. To lift the needed materials and fuels would require about a launch per day with a very heavy environmental burden. Clearly a new generation of lift vehicles is needed for the project to be practical.

Despite a valiant effort to overcome deficiencies of expertise, the report has some serious omissions. There is a complete absence of any consideration of microbial ecology. The report acknowledges this weakness and calls for a strong program of research into the subject. The political problems of founding and organizing a colony get little attention. In general, although there is discussion of the problems of the impact of space colonies on the environments of the Earth and Moon, the demography of a space colony, the esthetics of life in space and the likely attendant cultural shock, the engineering concerns are dominant. Much more needs to be thought about the social and political organization and institutions necessary to foster a good life in space.

The wary reader will surely find other gaps of consideration and treatment, but that should be a large part of the pleasure of reading through this document's riches of fact and conception. There can be little doubt that despite the omissions and potential flaws which are on the whole brought candidly to the reader's attention, this report will serve for a number of years as the principal focus for further creative consideration of the exciting prospect of colonizing space.

ANOTHER VIEW

K. Eric Drexler

In reading and publicizing "Space Colonization: A Design Study" one should know what it is and what it is not. The 1975 summer study suffered from limitations of time, organization, and expertise. The study group favored breadth over thoroughness; the report reflects this by omissions and inaccuracies.

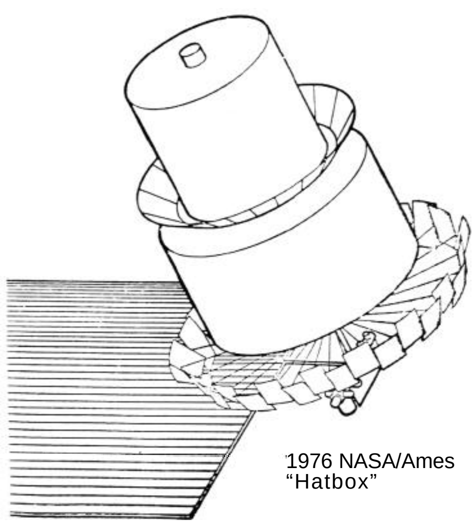
Because of its breadth and starting point, the report can serve as a good general introduction to space colonization. It presents the needed system elements, the motivations behind the project, and the magnitude of the endeavor. Its discussions touch on virtually all the major design considerations of work in the space colony field. As an introductory text, however, it is not as smooth and engaging as some other books now nearing publication. This may be the price of writing by committee.

The report's usefulness as a starting point for future work is questionable. While it contains many ideas, some both new and useful, it has shown many flaws.

As is usually the case, the writings on social and psychological aspects are more opinion than fact. They deal with the uncertain effects of still unconstructed human environment.

The full impact of the design assumptions on space colony economics is not made clear. By lowering esthetic standards slightly (see last month's L-5 News for an artist's conception) and increasing rotation rate (to where an estimated 95% rather than 100% of the population would feel no adverse effects), this summer's study reduced colony structural mass by a factor of four and shielding mass by a factor of three. This affects the sizing and economic profitability of the whole system.

As was shown by the MIT study last spring, the stressed-skin structural design of the Stanford Torus is unsound. The design presented in the report would split like a dropped melon when pressurized due to growth of undetectable flaws in the metal and welds.



1976 NASA/Ames "Hatbox"

The mass driver design has been superceded by this summer's work, which demonstrated that all performance parameters could be improved without significant pressure on current technical abilities. A side effect of this is elimination of the complex active mass catcher through reduced payload dispersion. A further side effect is the replacement of rotary pellet launches by low-throughput mass drivers for space propulsion.

The metal refining system has also been superceded by this summer's work, which demonstrated that the system's mass payback time could be reduced by a factor of four while recovering a greater fraction of lunar rock as useful materials. Partly as a result of the above considerations, the estimated program cost has dropped by roughly a factor of four.

The agricultural system was subjected to a detailed mass balance, but the underlying assumptions approach the ridiculous. A goal was dietary diversity; a sub-goal was provision of a variety of meats (in addition to eggs and milk). While omitting whale meat and lizard meat, the study diet included equal amounts of trout, rabbit, beef, and chicken. While rabbits may be raised in stacked wire pens and fed alfalfa, trout require large volumes of clean, flowing, heavily aerated (not provided for in the space farm design), refrigerated water, and are carnivorous by nature. They might pass on the luxury market. Economical cattle raising depends on vast tracts of land good for little else, a condition unlikely to exist in space for some time. Chickens require virtually the same diet as humans, hence are difficult to justify as a major part of the food chain. The diets proposed for ruminants (soybeans?) take little advantage of these animals' ability to convert agricultural wastes into high-protein food.

A major goal of the 1975 summer study was to provide participants with an educational experience. While I cannot speak for others, it provided such an experience for me.

A POINT TO REMEMBER: L-5

SPACE INDUSTRIALIZATION CONTRACTS AWARDED BY NASA

Ann Elizabeth Robinson

Rockwell International Corporation, of Downey, California, and Science Applications, Inc., of Los Angeles, have won the negotiation rights for the NASA-sponsored study on space industrialization. For all practical purposes, the two companies have won the contracts; the right to negotiate means that the details of the contract have to be finalized by both the company concerned and NASA.

Twelve organizations submitted proposals to NASA by the June 29, 1976, deadline: Rockwell International: Science Applications, Inc.; Arthur D. Little; Battelle Columbus Labs; Econ, Inc.; Hudson Institute; Northrop Services, Inc.; the Polytechnic Institute of New York; Space Colonization, Inc.; Stanford Research Institute; University of Arizona; and Boeing Aerospace.

The NASA statement of work for the project was publically announced on May 28 by the Marshall Space Flight Center (MSFC), Huntsville, Alabama. MSFC is the NASA center in charge of administering the space industrialization study contracts.

Mr. Claude Priest, the Contracting Officer's Representative for the program, commented on the major objective of the study: "The main objective of this planning study program is to develop an evolutionary space industrialization program which could lead from the shuttle, space lab, and early space station experiments to the permanent practical, commercial use of space."

In a press release issued on Sept. 1, 1976, MSFC stated that outstanding consultants from throughout the country will assist Rockwell International and Science Applications, Inc., in "evaluating and prioritizing the needs, opportunities, and methods for industrializing space."

NASA defines "space industrialization" as "space activities which are undertaken primarily for the production of goods and services which are of major economic benefit to the U.S. and the world. This means utilizing the environment and vantage point of space in a productive and cost-effective way. This envisioned next phase of the space program is in contrast to most space work undertaken to this time, which was primarily for scientific or other exploratory purposes."

The September 1 press release elaborated: "Space authorities are convinced that the state of technology permits and world needs demand that space industrialization accomplishments achieved to date be expanded now into a number of disciplines beyond communications and metereology, in which they have already proven to be highly profitable and beneficial to people"

When asked about MSFC's interest in space colonization, Priest said the interest is very long term-beyond the scope of the space industrialization study now underway. The present study is limited to about a thirty year time period, ending around 2000 A.D.

Priest continued: "What we will seek is a reasonable balance between the bold opportunities of the future, such as satellite power systems and the desire for relatively immediate widespread payoffs of space utilization, such as space processing. Prospective activities include the manufacturing of materials, chemicals, and medicines; the development of new materials and processes; new communications industry; weather services; new earth resources development-ultimately, the movement of people to space for tourism or medical purposes, and the eventual industrialization of the moon."

The space industrialization study is a sixteen-month effort funded by the Office of Space Flight; the total contract value is approximately $400,000, equally divided between two consecutive eight-month, $200,000 segments. Part I of the study will concentrate on "Why Space Industrialization?"; Part II, on "How Space Industrialization?"

Part I of the space industrialization study is being contracted to two different companies at a value of $100,000 each for the eight-month segment. Mr. Priest of MSFC explained: "What we were seeking was two kinds of viewpoints-one from a predominantly systems/hardware-oriented aerospace company, who would bring a hardware development perspective to the study. We were looking for another type of contractor who would be a predominantly research-oriented company, who would bring a non-aerospace/hardware industrial and planning perspective to the study. They would both be working at the same study scope, but would be bringing two different perspectives to the study-the difference being that one company's perspective would be what comes downstream in terms of hardware. . . the other would strictly be research . . . think-tank."

According to Mr. Priest, NASA will only commit to Part I of each contract. Part I I is an option to be exercised prior to the end of Part I of the study. Around January 1, 1977, NASA would look at the results obtained to date; at that time, it would decide whether or not to renew the contracts granted for Part I.

In a recent interview, Jesco Von Puttkammer, Aerospace Scientist and Staff Specialist in the Advanced Program Office of the Office of Space Flight, said NASA has a "pretty good idea of some long range goals-space colonies, people living and doing useful work in space, products, energy." He stated that such goals demand a long range program -- about 25 years and between 150 and 200 billion dollars, which is approximately ten times the cost of the Apollo program. Von Puttkammer commented: "Knowing this, and that the public will not commit to a 25-year program, we have to decide what kind of steps we have to take to reach our goals. Space industrialization is the most efficient way of establishing these capabilities... by making each step in space pay its own way, so the public does not have to pay."

Captain Freitag, Deputy Administrator, Advanced Space Programs, when asked about NASA's 1978 budget proposal for space industrialization and colonization, explained that the details of the 1978 budget are not releasable until after the President submits his budget to Congress. He said, "If it's Ford, that means January; if it's Carter, it may take until April. It usually takes about 90 days for a new President to review the recommendations made by the previous administration."

SKLAREW TO HEAD SAI TEAM

Carolyn Henson

Science Applications, Inc. (SAI) is one of two companies receiving research contracts for NASA's space industrialization program. Ralph Sklarew, a participant in the 1975 NASA Summer Study on Space Colonization, will head the SAI study team, which includes Gerald Driggers from Southern Research Institute and consultants Robert Salkeld, Paul Siegler, G. Harry Stine, and J. Peter Vajk. Driggers, who was a speaker at the 1975 Space Manufacturing Facilities Conference at Princeton, is an expert on propulsion and construction of space facilities. Robert Salkeld, one of the top experts in the field of single stage to orbit and mixed mode propulsion vehicles, is also an expert in operations research and holds a degree in economics from Harvard. Paul Siegler, who edits the *Earth/Space News,* also holds a degree in economics from Harvard. G. Harry Stine, author of *The Third Industrial Revolution,* combines practical experience both in business and many phases of space engineering. Physicist J. Peter Vajk has developed a Forrester-style world dynamics model incorporating space colonization; he is currently writing a book on space colonization for Stackpole.

Sklarew plans to study space technologies which can provide an economic return within the 1980-2010 time frame. "We will try to be objective about the potentials," he said in a recent interview. "We may even conclude that there is nothing beyond weather satellites and communications that's worth doing."

Sklarew's team plans to consider a broad range of space projects in its search for economically viable products for space industry. "We want to find things in addition to solar power," Sklarew commented, adding that he felt excessive concentration on power satellites was a major weakness of the L-5 concept.

The team's contract runs 8 months. During that period Sklarew says they will "Look at what can be done in space, constrained only by engineering limitations. Then we will consider what is the need for these products and services on Earth. We will then develop a rationale of what could make an economic impact in the 1980-2010 time frame.

"We will place each of these possibilities into evolutionary programs that make sense. There will be a synergy effect-things will be needed in common to reach these individual goals. When we get to the stage where we have defined several possible programs, each with many goals, we will analyze each program for technical requirements and economic viability."

While this is a pretty big goal for a $100,000, eight month study, Ralph Sklarew is confident the SAI team can handle the job: "The biggest problem of the study will not be getting people to do their share, but to get them to stop working long enough to write down their results!"

O'NEILL TO TEACH AT MIT

Princeton Physics professor Gerard O'Neill, on sabbatical this year, has accepted the Jerome Clarke Hunsaker Visiting Professorship in the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology.

Eric Drexler, one of the student participants in the NASA/AMES 1976 study on space colonization, will be a research assistant to Prof. O'Neill. Virginia Reynolds, O'Neill's Princeton research assistant, will also spend the academic year at MIT. Dr. Brian O'Leary, another space habitat researcher, will remain at Princeton.

Boston area members who wish more information on MIT space colonization activities should contact the MIT Space Habitat Study Group through Beverly Hazelton, Department of Political Science, MIT.

SINGLE-STAGE-TO-ORBIT STUDY

Seattle, Washington-The Boeing Aerospace Company is conducting preliminary studies aimed toward the development of a shuttle-type spacecraft which would take off and land much the way an airplane does.

This Earth-orbit transporter-known as a Single Stage To Orbit (SSTO) system-would be designed for use in the 1990s. following a successful NASA Space Shuttle program. It will be designed to offer clear and significant cost/performance advantages over current systems.

The $213,802 contract, awarded by NASA's Langley Research Center, Virginia, calls for the identification of technologies necessary for the development of this advanced space transportation system.

The transporter, as defined by NASA, would use advanced hydrogen-fueled rocket engines for its main propulsion system. It would take off horizontally with the assistance of a sled, fly into orbit, then land horizontally on a runway.

The Boeing Aerospace Company has been studying the single-stage-to-orbit concept for two-and-a-half years. Andrew K. Hepler, the firm's manager for advanced high speed transportation systems, pointed out that a single-stage spacecraft would not need to jettison any part of its launch equipment or boosters, thus allowing reuse of all its parts.

Boeing, he said, will propose the use of a unique advanced structural concept which will allow spacecraft reentry into Earth's atmosphere without the need of ablative material.

The firm visualizes a family of these futuristic land-to-space craft which would be designed for carrying payloads as small as 3,000 pounds (1,361 kg) to payloads as large as the 60,000 pounds (27,216 kg) planned for the Space Shuttle. Fully fueled, a SST0 craft capable of carrying 60,000 pounds would weigh about 2.2 million pounds (997,920 kg).

1,000 WOMEN APPLY FOR ASTRONAUT STATUS

HOUSTON (UPI) -- A thousand women have told the National Aeronautics and Space Administration they would like to become astronauts for the nation's space shuttle.

Officials are accepting it in stride. "I've been pleased with the number of responses and with the quality of people, including women, who've responded," said Duane Ross at the Johnson Space Center's astronaut recruiting office.

"We've mailed out about 4,000 responses to inquiries. I would guess that probably 25 percent of those inquiries have been from the female population.

"They (women) seem to be very pleased that there's an opportunity for them to enter the space program."

Ross said his staff had made no tabulation of requests for information since the February announcement that 30 new astronauts including some women would be chosen by July 1978.

The aim is to have them on board for two years of training prior to the next full-scale manned mission, the orbital shuttle tentatively planned for 1980.

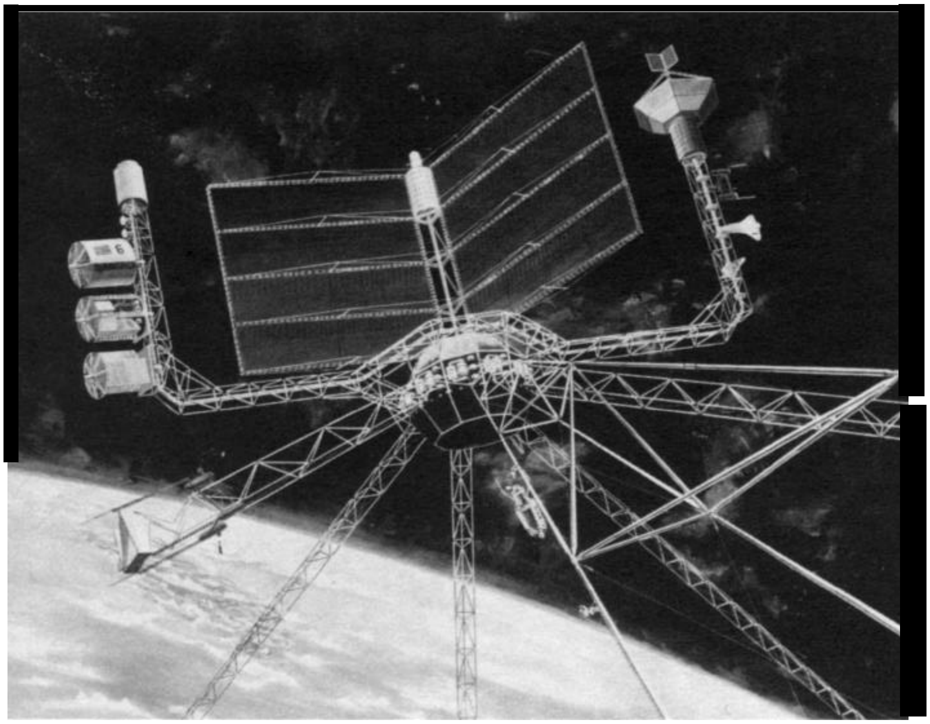
Ross said 30 (15 in an "astronaut-pilot" category and 15 in a "mission-specialist" group) is a minimum number and that more might be selected.

He said many more men and women likely would apply before the June 30, 1977 deadline.

"Most of these people are going to wait until late to apply because it gives you more time to build up your credentials, your academic background, flying time."

Aside from the selection of women, Ross said, the first astronaut recruitment program since 1967 is similar to six earlier selections that chose 76 trainees, all men.

"I think the approach we're taking is just about the same. But the requirements are quite a bit less stringent than they have been in the past."



SATELLITE SOLAR POWER SYSTEMS, ERDA, AND SPACE COLONIZATION:
An interview with Dr. H. Richard Blieden, Assistant Director, Solar Energy Applications (ERDA)

Ann Elizabeth Robinson

In an interview conducted August 31, 1976, Dr. Richard Blieden, Assistant Director for Solar Energy Applications at the Energy Research and Development Administration (ERDA), discussed ERDA's plans for funding solar power satellite (SPS) production and ERDA response to the space colonization approach. He began with a history of ERDA's involvement with the SPS program.

History

"Late last year (1975). the President asked ERDA to look at SPS and place it within the priority of the ERDA programs. Work had been underway within NASA, so, as a first step, a task force was set up within ERDA to review the ongoing SPS work that NASA had done and to make a recommendation to the President and to Congress.

"In the course of this review, there was an opportunity to hear from Dr. Gerard K. O'Neill of Princeton on his concept of space colonization as it applies to the production of power for industrial use." *(Note: On January 19, 1976, Dr. Gerard K. O'Neill of Princeton University, testified before the Subcommittee on Aerospace Technology and National Needs in the hearings on "Solar Power from Satellites." This subcommittee was formed in July, 1975, by the Senate Aeronautical and Space Sciences Committee.)*

The Change of Responsibility for SPS from NASA to ERDA

"The main rationale for SPS is the production of energy for terrestrial use, and, as such, it would be an ERDA decision to proceed with such a project. However, it is important that NASA be involved, because NASA has the expertise for the development and deployment of space power systems. . . . It is a cooperative effort, but ultimately the decision lies with ERDA, based on the energy needs of the nation."

Dr. Blieden commented on the reaction to O'Neill's presentation to Congress. It was ". . . one of considerable interest and something that needs to be looked at carefully. The whole area of SPS is one which needs considerable study and analysis before one can move into a project-oriented phase."

Blieden said that entering the project-oriented phase depends upon trade-offs with other problems ERDA is seeking to address and the resources available -- monetary, people, competition for other major energy projects by ERDA. For example, he said, ". . . if we were to proceed with terrestrial power systems, then resources may not be available for the SPS. . . . I'm saving this is not necessarily the case, but is a possibility. We will be comparing across the board fossil, nuclear, solar, geothermal, ocean thermal systems, and wind systems.

"The ERDA SPS Task Force has made some recommendations which should lead to action on the part of ERDA and NASA. This would primarily consist of the further support and conduct of studies of the SPS concept. Over the next year, ERDA will look at the various energy concepts and determine major problems and potential advantages. We have to answer a number of questions before moving into a project-oriented phase."

Blieden stated that, according to various studies by NASA and independent researchers, power from SPS will be available no sooner than the year 2000.

"A number of technologies under study have a lower front-end cost, but they may lack the advantages of SPS. ERDA needs to answer some fundamental questions about SPS -- such as, where does the orbiting system application fit into the energy system of the country?"

Blieden said the results of the next year's study could range from continuing or stopping the study effort immediately, proceeding at the level of further studies, or proceeding with a specific project and time scale. He offered no speculation as to which is the most probable direction, as he has not yet seen the results of the SPS Task Force. Dr. Blieden, however, did say that some of the results of the Task Force are now available.

Dr. Blieden made a closing comment on space colonization: "It's certainly an interesting concept. At the current time, the support for the O'Neill approach is under NASA's guidance in the Advanced Programs area of the Office of Space Flight. In view of the mandate of that program (i.e., Advanced Programs) that would appear to be the proper place for the O'Neill concept to be supported."

THE INTERNATIONAL SPACE HALL OF FAME

On October 5, 1976, in the presence of notables, scientists, and people from all over the world, the doors of the International Space Hall of Fame will be opened with an impressive ceremony that is not only part of the program of the International Academy of Astronautics where more than 450 international space scientists will discuss the past, present, and future in space. . . it is also the official Bicentennial Event for the City of Alamogordo, New Mexico.

Outside the building in the clear, dry New Mexico desert air is a growing display of historic space launch vehicles and spacecraft. . . some of them the last of their kind. Future plans call for display of launch vehicles from all world nations who have operated them.

Inside the International Space Hall of Fame building, space pioneers of many nations will be honored at the opening. It is planned to add additional individuals each year. The individuals honored have been and will be chosen with the assistance of the International Academy of Astronautics. The identities of the first space pioneers will not be revealed until the opening ceremonies.

For additional information contact the Alamogordo Chamber of Commerce, P.O. Box 518, Alamogordo, New Mexico 88310 U.S.A.

SPACE FARMING: *THE DEBATE GOES ON...*

SOIL CULTURE vs. HYDROPONICS

Dr. Ian Richards

James Kempf (July *L-5 News)* advances the case for hydroponics for colony food production, stressing advantages of yield and convenience over soil culture. He gives yields of eight crops compared under soil conditions and hydroponics. While I have little direct experience of all these crops, the yield given for potatoes grown in soil (3 tons per acre) is quite unrealistically low.

The usual seeding rate for potatoes is around 1 ton per acre so this yield is equivalent to three small tubers per plant! In the UK, average yields are about 15 tons per acre. It is quite easy, by irrigation and pest control, to achieve 40 tons per acre or more, and optimization of fertiliser rates would probably increase yields further.

In the experimental program of the Company for which I work, we regularly achieve a state in the field for many crops where the yield-limiting factor is input of radiant energy, rather than anything to do with the soil or nutrient supply. Under these conditions a change to hydroponics would be unlikely to increase yield.

The point is that for full growth, plants require certain amounts of nutrient elements-provided these are supplied, it matters little how. Yield advantages of hydroponics over field culture are more likely to be due to exclusion of pathogens and to closer environmental control in the hydroponics system. On a colony, the same care could be applied to soil culture.

However, the apparent conflict between soil culture and hydroponics may not really exist. As Kempf states, hydroponics is essential if materials must be transported from Earth as during the initial phase of colonization. At the stage of a fully-fledged colony of 10,000 people, there will be extensive use of lunar material and soil culture becomes more attractive.

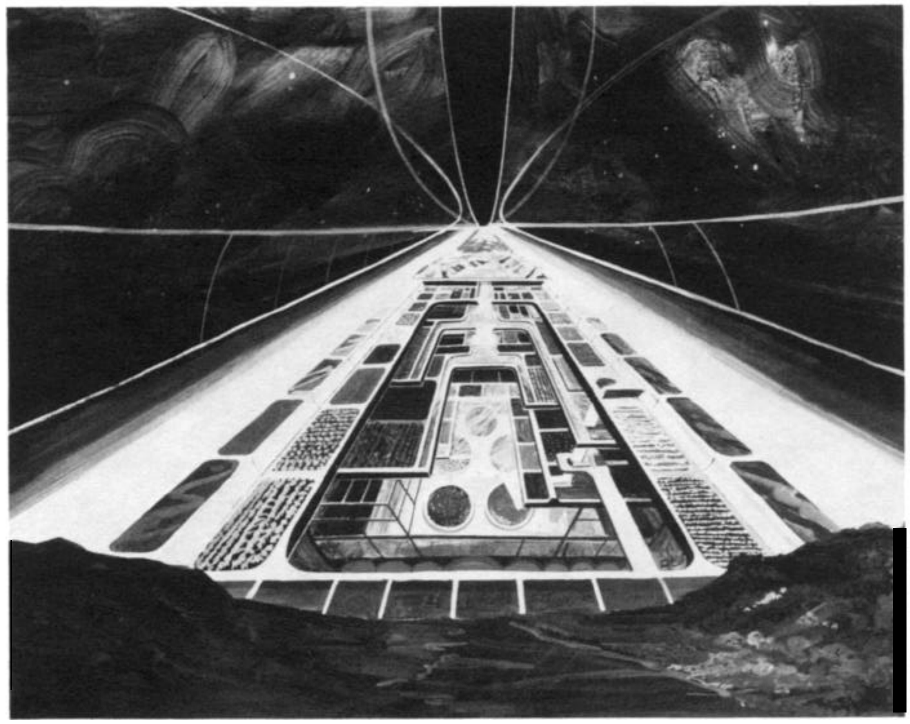
James Kempf also mentioned accumulation of organic matter in cultivated regolith and this may be roughly quantified. The rate of accumulation of an element i in the organic form (Oi) is given by:

$$\frac{dOi}{dt} = RI - RD$$

where RI is rate of addition of Oi, and RD is rate of mineralization of Oi.

RD is likely to be related to Oi by a function of the form:

$$RD = aOi^b \qquad (1)$$



An artist's conception of the agricultural area of a space colony, designed by the NASA-Ames/Stanford 1975 summer study. The area is shown situated between two parks on the top four levels of the farm, soybeans, wheat, sorghum and some other crops would be grown. The bottom level is a drying facility. Water would be supplied directly from the river and indirectly through the fish tanks that line the sides

a and b are constants and b is likely to be greater than 1.0. Thus:

$$\frac{dOi}{dt} = RI - aOi^b$$

If RI remains constant, Oi reaches equilibrium when:

$$aOi^b = RI$$

and the equilibrium level of Oi is:

$$(RI/a)^{1/b}$$

Nitrogen is one of the most important constituents of soil organic matter. Equation 2 derives from a small amount of data collected at North Wyke and Rothamsted Experimental Stations (both UK). The amounts of organic nitrogen in soils were measured and the quantities of nitrogen mineralized were estimated from crop nitrogen uptake and leaching losses.

$$\log_e RD = 1.963\log_e Oi - 9.923 \qquad (2)$$

$r = 0.931$ residual $SD = 0.349$ P 0.001

RD and Oi were on a g/m^2/year basis

Equation (2) may be expressed:

$$RD = 0.000049\ Oi^{1.963}$$

If we assume RI = 20 g/m^2 year, then at equilibrium, Oi = 722 g/m^2. The rate of attainment of this level can be estimated. In year t, the level of Oi is:

$$Oi_t = Oi_o + RI - aOi^{b/(t-1)} \qquad (3)$$

where Oi_o is the level of organic nitrogen in year zero (itself zero for lunar regolith). Combining equations (1) and (3) provides a crude dynamic model of organic nitrogen accumulation. For a constant value of RI = 20 g/m^2/year, the rates of change of Oi and RD are shown in Fig. 1. The process of accumulation of organic nitrogen is clearly long-term, and soil in the colony might be expected to evolve over many decades. However, values of a and b in equation (2) derive from a limited amount of terrestrial data; their values would be affected by the lack of winter seasons on a colony and by the species of micro-organisms chosen for inoculating the soil. The value of RI also affects the rate of attainment of equilibrium.

The accumulation of organic matter would not increase substantially the amount of soil per unit area. Soil organic matter typically contains around 5% nitrogen and, in the example above, the final level of organic matter would be only around 14kg/m^2.

REPLY TO DR. RICHARDS

James Kempf

The conflict between hydroponics and soil cultivation is actually more apparent than real, as Dr. Richards has pointed out. For the immediate future, the cost of lifting biomass from the Earth with projected lift systems will probably limit agriculture to a system with a low requirement for biomass and a short recycling time, namely hydroponics. Once the lunar mass driver and lunar mining facilities have been constructed and construction of large scale habitats at L-5 is underway, soil farming becomes a possibility. The time scales for the implimentation of the two systems are thus of different orders.

According to Dr. Richards' calculations, the time which would be required to build up organic nitrogen in lunar soil is upwards of 20 years and would involve a final level of soil organic matter (after about 100 years of soil evolution) to about 14 kg/m^2 of agricultural area. If one figures on 250 m^2 which Dr. Richards has cited as necessary to feed a single person, a final level of organic matter of some 3500 kg/person would be required (vs. about 200 kg/person for a hydroponic system), plus whatever amount is stored as food, unrecycled biomass, carbon dioxide in the atmosphere, etc.

At shuttle lift costs ($180 per kilo), lifting enough organic matter to supply a soil farm would cost over eighteen times as much as for a hydroponic system. Since carbon, hydrogen, and nitrogen are rare on the moon, most organic matter for initial habitats must be lifted from Earth, until exploitation of carbonaceous chondrites in the asteroid belt can be arranged. Hydroponics becomes more cost effective than soil farming, but considerations of soil farming are not premature, since extensive landscaping of the habitats, if it is deemed desirable, will involve just such calculations as Dr. Richards has presented.

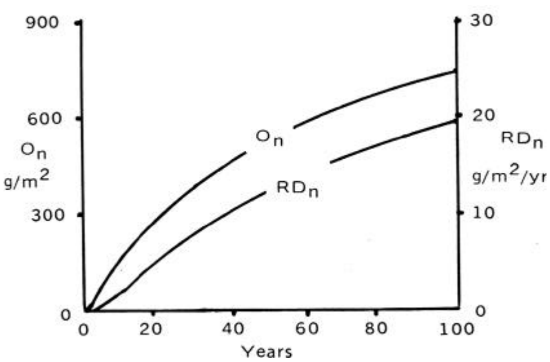


Fig. 1 Changes in O_n and RD_n with time

conferences

THIRD PRINCETON / AIAA CONFERENCE ON SPACE MANUFACTURING FACILITIES

May 10-13, 1977
Princeton University
Princeton, New Jersey

Abstract Deadline:
December 1, 1976

The Third Princeton/AIAA Conference on Space Manufacturing Facilities (including space colonization) will be cosponsored by the Princeton University Conference and the AIAA. Its purpose is to provide a forum for papers of substantive content, in both technical and relevant nontechnical areas, to consolidate in a single meeting and in a single publication the many and often disparate studies and research efforts which have been undertaken in this rapidly growing field since the previous Conference was held in May 1975. It is expected that the Proceedings of the Third Conference will provide the definitive technical and non-technical basis for accelerating the evaluation of large manufacturing facilities located in space. Papers are solicited in the specific areas of "Space Manufacturing Facility (SMF)", "Assembly and Maneuvering of Large Structures in Space," "Propulsion and Transport," "Mining and Materials Processing, " "Applications for Large Space-based Facilities," "Economics (Including Applications)," "Life Support," "International, Political, and Legal Considerations," "Anthropological, Sociological, and Esthetic Implications"; however, relevant papers of high quality which do not fit within these specific topical areas will be considered for acceptance by the Program Committee.

Prospective authors are invited to submit abstracts of 500-1.000 words or preliminary drafts of final papers for acceptance review. These abstracts should be prepared in accordance with the "Instructions for Preparation of Meeting Abstracts" appearing in the *AIAA Bulletin,* September, 1976, and three copies must be submitted by December 1, 1976 to the Program Committee Chairman: Dr. Gerard K. O'Neill, Department of Physics, Jadwin Hall, Room 302, Princeton University, Princeton, New Jersey 08540.

Authors will be notified as to acceptance of their papers about January, 1977. Authors of accepted papers will be expected to submit photoready manuscripts no later than March 18, 1977.

7th INTERSOCIETY CONFERENCE ON ENVIRONMENTAL SYSTEMS

July 11-14, 1977
San Francisco, California

Abstract Deadline:
December 1, 1976

This conference is sponsored jointly by the Society of Automotive Engineers (SAE), the host Society, the American Institute of Aeronautics and Astronautics (AIAA), the American Society of Mechanical Engineers (ASME), the American Institute of Chemical Engineers (AIChE), and the Aerospace Medical Association (ASMA). The General Conference Chairman is Dr. J.M. Spurlock, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, GA 30332.

The Conference is open to participants from any nation. Individuals who wish to present a paper need not be affiliated with any of the sponsoring societies. Proposed papers will be evaluated solely on the basis of their suitability for inclusion in the program.

There will be four days of technical presentations, with at least one morning and one afternoon session every day. Each session generally will be limited to six papers. Contributed papers are solicited for all sessions listed below. Authors who wish to contribute a paper must submit for evaluation a summary of approximately 200 words (or a full-length manuscript), in accordance with the abstract preparation instructions of any of the sponsoring societies. Three copies of these summary abstracts are to be submitted to the responsible program chairman. Each abstract should include a list of names, affiliations and mailing addresses of all authors.

Section topics and responsible program chairmen are:

Topic Area I: Marine Technology and Applications for Effluent Control, Environmental Control and Waste Management
Session Organizer
Mr. Paul Schatzberg
Naval Ship R&D Center
Code 286
Annapolis, MD 21402

Topic Area II: Advanced Technology for Spacecraft EC/LSS; Personal Protective Systems; and Waste Water Reclamation
AIAA Program Chairman
Dr. Stacy Hunt, Jr.
General Electric Co.
P.O. Box 8555
Philadelphia, PA 19101

Topic Area III: Space Shuttle and Regenerable Shuttle Environmental Control Systems and Regenerable Life Support System Evaluation
ASME Program Chairman
Mr. Franz Schubert
Life Systems Incorporated
24755 Highpoint Road
Cleveland, OH 44122

Topic Area IV: Spacecraft/Missile Thermal Control, Environmental Control and Thermal Protection Systems (papers can involve ground or space applications for missiles or spacecraft; or thermal control aspects of terrestrial energy systems, their management and conservation. Papers can cover results of analyses and/or tests in support of research, design development, and production or implementation); and Aircraft Environmental and Thermal Control Systems
SAE Program Chairman
Mr. P.B. Cline
General Electric Co.
3198 Chestnut Street
Room 3700 D
Philadelphia, PA 19101
Session Co-organizers
Mr. J.I. Gonzalez
Martin Marietta Aerospace
P.O. Box 5837
Mail Point 129
Orlando, FL 32805
and
Mr. John G. Roukis
Grumman Aerospace Corporation
Dept. 410; Plt 35
Bethpage, NY 11714

Topic Area V: Chemical Engineering Applications in Life Support Systems
AIChE Program Chairman
Dr. Robert C. Reid
Dept. of Chemical Engineering
Massachusetts Institute of Technology
Cambridge, Mass. 02139

Abstracts for papers which fall outside the above session topics will be considered if of sufficient merit and should be submitted directly to the General Conference Chairman.

Offers of papers must reach the listed Program Chairman no later than December 1, 1976. Authors will be notified of papers or abstract acceptance by January 23, 1977. Authors of accepted papers then must submit three copies of manuscripts to organizers for review by February 16, 1977. Final, approved manuscripts are due by April 1, 1977 and will be published by the ASME. Late papers will be rejected by the ASME. An author whose paper has not been published will not be permitted to present his paper at the conference.

INSTITUTE ON MAN AND SCIENCE CONFERENCE REPORT

Jon Coopersmith

I was in Rensselaerville, New York, to attend a program of the Institute on Man and Science on space colonies. It was very exciting as we (eighty odd in all) explored some of the human aspects of space colonies for five days.

Before I proceed, I should explain what the IMS is. A non-profit educational center, it explores social problems and possibilities where science and technology are major factors. The institute uses many different methods in attempting this, but always puts people before science. Our conference was an annual event and the actual title was "A Week with Isaac Asimov" which indeed it was.

The format was elegant in its simplicity. We were divided into five groups, each chaired by a volunteer and assigned a resource person. Each group discussed a topic, then presented its findings before a meeting of the whole body. Several of the presentations were quite impressive, being full stage productions.

In his opening, Harold Williams, the Institute president, emphasised that we were here to deal with people-not technical problems. With one significant exception, we did that.

Our group's first task was to determine the degree to which the first colony should represent a cross-section of the American people. We discussed several aspects of this problem, finally deciding that there should be no skewing of ethnic, racial or sexual factors, but that there should be a skewing of age, physical and mental characteristics, as well as a person's educational background.

We also brought forth a few things that seemed, on hindsight, obvious, but had not been mentioned although they were important factors. For instance, the first colonists will probably go through some common training, possibly for a few years. Aside from ensuring that needed skills will be provided, this will also wash out those who are not sufficiently motivated. And when the colonists actually inhabit L-5, they will not all go at once, but will go up in stages. These are small things, but indicative of what we were trying to do.

Another group in the first session dealt with death. This provoked the most intense emotional discussion of the conference. What do you do with the body? Is it just matter or something more? Graveyards are unthinkable, but what about cremation? Or putting the corpse in orbit around L-5? Possibly shooting the body into the sun or out of the solar system (what would happen if an ET found the bodies and became addicted to these frozen dinners?)? Or should we simply recycle the body right away for the greater good instead of waiting a few billion years? I see no "right" answers, but I have a few ideas.

After a delicious dinner (the food was superb) we had a series of speeches. Paul Siegler, the head of EARTH/SPACE Inc., spoke on economic and technocratic perspectives of L-5. He expressed the need to have a diversified rather than a single base to allow for failure, experimentation and better response to needs instead of catering to a rigid plan.

A sociology professor, Paul Meadows of SUNY, speaking about utopian communities, summed up four criteria for long-term success:

1. a sense of mission;
2. an acceptance of the meaningfulness of work (variability of jobs helps);
3. a communalized power structure with control of property, finance and authority;
4. a need for committment mechanisms to (a) instill sacrifice and reinvestment; (b) develop feelings of solidarity; (c) formulate beliefs and principles to unify the colony and explain its justification and meaningfulness

The University of Florida's Bert Swanson posed several questions of a political nature, ranging from Earth L-5 links to the functions and form of the L-5 government. He also solidified our thinking on two important concepts, random selection and random rules of governance. The former is basically an admission that we do not know the answer as to who is the best qualified, though we may know many who are well qualified. In addition, the gene pool is strengthened through diversity, a matter of no small import.

In the latter, interchangeable responsibility is built by having everyone handle a variety of tasks and functions. This is most egalitarian in nature and is a feature of a new society that I feel we should try. A higher redundancy factor is achieved also.

To be honest, I do not recall what our

The CoEvolution Quarterly

Asimov: "Expert on almost everything."

second task was exactly. I know we produced a wonderfully enjoyable skit and rewrote the question, but I forget what we dealt with exactly. I think that those long social hours which usually extended until four in the morning may have had something to do with this. Basically, we tried to express what we thought would be good characteristics for colonists to have. I won't bore you with our conclusions; suffice it to say that Plato would have been proud.

Another group worked on possible names and, after considering some seven score, selected Chrysalis.

Yet another group, studying design options, developed a novel colony concept. Instead of a cylinder or torus, it is essentially a giant corkscrew, capable of unlimited growth and opening wine bottles several kilometers in length. Most impressive.

Our third assignment after rearranging task groups was to discuss how the educational system should/would socialize the colonists. The main result of this was a demonstration of the power of the group. Over lunch the leader of the government group confided to three of us that her group was proceeding along rather limited lines and not considering several concepts of government that we happened to like. We generously offered to stage a coup d'etat to present these viewpoints, but made the mistake of mentioning this to the rest of our group. We were, to put it mildly, put down in our places.

Our fourth question dealt with the population mix of L-5. Will it be mostly permanent or transient in nature? Is L-5 a stepping stone, an observatory or a colony first? What proportion of transients should there be?

Other groups dealt with property rights (should there be any?), the rights of children, childrearing possibilities -- well, you have the general idea. We explored-not too deeply, but we did explore-some of the less thought out aspects of an L-5 habitat.

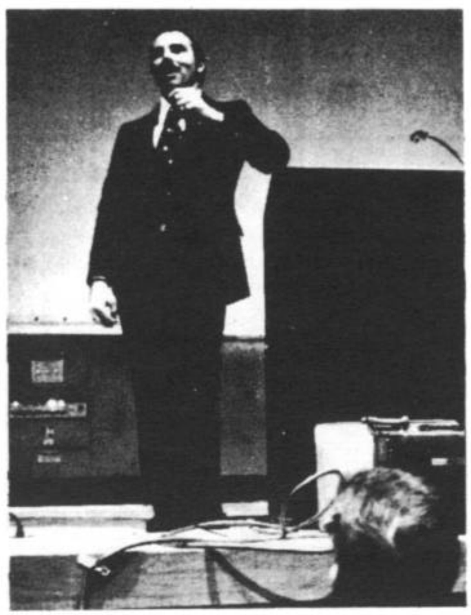
Several things are clear from the conference. A lot more thinking is going to have to be done over a very wide range of subjects. Designing a new world-a viable new world-is more complicated than it seems. For example, human rights as we perceive them in our society may have to undergo change. There may be a lessening of the sanctity of the individual.

The form of government remains a volatile question. My thinking is that a dual government will emerge-a technical semi-authoritarian part to ensure the continuance of life support systems and a semi-libertarian part to handle everything else.

Our group experience was excellent -- for five days we worked, ate, joked and lived together in a very congenial atmosphere. We had Isaac Asimov, accurately billed as an "expert on almost everything," and Ben Bova as resource personnel to comment on our proposals and to launch us forth onto other ideas (Isaac, by the way, proposed that a space laboratory be set up to undertake DNA mutation experiments so they would not endanger the earth if contamination procedures failed). We had NASA's Isidore Adler to help us also. People-and the ability to interact-were the heart of this conference. Terri Rapoport coordinated everything very well.

See you either on Chrysalis or at the Institute conference next year!

Lecture Tour



World Con -- Ready to Go

About half of the members of a general audience who have heard a lecture on Space Colonies will raise their hands in response to the question "would you like to go?" Not science fiction fans, though-they respond at about the 99% level.

L-5 Director Keith Henson queried 1500 science fiction fans when he spoke on the Life in Space panel at MidAmeriCon, the 34th World Science Fiction Convention, held over the Labor Day weekend in Kansas City. Henson spoke on the L-5 concept, '76 Summer Study results, the political and popular support for the program, and the activities of the L-5 Society.

Moderator of the panel was L-5 member Jerry Pournelle; other panel members were Joe Green of NASA, who talked about the lack of public support for space programs, especially Mars missions; Larry Niven, who spoke on possible futures on and off planets, and Marion Zimmer Bradley, who spoke on the need to carefully consider the social side effects of space colonies.

Poul Anderson responded to the panel speakers and there was a lively question and answer period, mostly on space colonies.

Austin, too

Thanks to the dedicated efforts of L-5 members Gayle Watson and Harlan Smith (and Dr. Smith's excellent staff), Austin turned out a crowd of about 500 to hear a lecture (by Henson) on space colonies.

Lunar Science Institute

"You mean we could have *tons* of moon rock?"

A hastily called meeting organized by L-5 members Larry Friesan and Jim Oberg at LSI brought out 50 people from Johnson Space Flight Center and LSI. Though initially skeptical, the discussions which followed convinced most of the audience that this is a serious proposal with a lot of technical merit and the stirrings of large scale political support.

The rate at which new members are joining seems to have increased as a result of these lectures.

The Society has several experienced lecturers in various parts of the country. Some travel for business reasons and are available at low cost to the Society. Considerable advance work is required to make these events effective: publicity, scheduling, slide projectors and the arranging of newspaper, TV and radio coverage. This kind of activity is a prime reason for the Society's existence. It also gives a local organization a large step up by bringing together people with interest in L-5 from the community. Write the Lecture Coordinator at Society Headquarters if you are interested.

BIBLIOGRAPHY NEWS

A copy of the complete L-5 bibliography is available from the Society for $1.00. It will also be sent free to anyone who orders publications from the Society.

The society is in the process of gathering permissions to reproduce copies of as many items as possible from the bibliography list. We hope to become a national (and international) clearinghouse for information on space industrialization, satellite solar power, and the permanent habitation of space.

Part 2

HOME, HOME ON LAGRANGE

The first installment of Heppenheimer's story (see August issue) told of the selection of colonists and training procedures at Houston.

In the on-the-job training, some tasks were quite familiar. The manufacture of wire, needed in huge quantities for strengthening pressure chambers, was nearly the same as on Earth. Similarly, there were few changes in the rolling of steel and aluminum plates or beams. One novel process, however, required a good deal of care: vacuum-vapor deposition.

In this process, aluminum structures are built up by being literally sprayed on. The aluminum is vaporized in a furnace, and in vacuum the vapor is made to escape through a small hole. The resulting spray then is directed at a form which rotates past, as if it were paint from an aerosol can. Over time, the form builds up a thick coat of aluminum, which can then be further strengthened with wire.

We had to contend with the problem of weightlessness, because so much of our work was to be in zero-g, yet our training was in Houston at normal gravity. Thus, we spent a fair amount of our time in simulators. These had TV screens and joysticks to be moved by hand, all hooked up to a computer. A trainee would be shown computer-generated scenes typical of actual industrial activities to be encountered in space; he then had to move the joysticks so as to respond appropriately. The joysticks had mechanisms attached to give a proper feel to the motions, as would indeed be experienced in space. The computer-would allow the test to proceed if the trainee was doing things right, but if he goofed, it would inform him of the consequences: YOU ARE TUMBLING ASS OVER ELBOW AT 13.5 RPM or YOU HAVE JUST CRASHED INTO THE WIRE-DRAWING MACHINE AT 20.3 MILES PER HOUR.

Also, some of the colonists were to be engaged in agriculture. In space, they would have sunlight round the clock, available whenever the plants needed it for optimum growth. In Houston, there was artificial lighting to serve that purpose; but apart from that, the setup was very much as it would be in space. The agriculture is very intensive up here; it's the equivalent of a 100-acre farm providing food for 10,000 people. Though this yield is much higher than you get on a farm in Illinois or Indiana, it is only twice the yield of the best greenhouses, in deserts like Abu Dhabi.

The trick is to adjust the growing conditions to what the crops like best. This means adjusting the lighting, temperature, humidity, as well as treating the crops with just the right mixture of chemicals. A lot of the work in Houston was of the nature of experimental agriculture, determining optimum conditions and things like that. One important task was to develop farmers' judgment as to how individual crops were doing. This required practice; a stand of wheat or alfalfa, which in Iowa might win a 4-H prize, by the standards of the colony might be positively sickly.

There was quite a lot of humbug about space agriculture, in those days. Some people pointed out, quite correctly, that on Earth crops are grown within a complex ecology, or web of life. They then stated, quite incorrectly, that crops could not be grown apart from this web. If you take that kind of argument at all far, you find yourself arguing that we can't grow crops without the mealy-bug and the locust and boll weevil. Actually, the scientific basis of agriculture goes back to the German chemist, Justus Liebig, in 1840. He showed that it was a matter of adding the proper chemicals to the soil, and plants would grow. That's all; it's very simple. Actually, though, we have always raised our colony's plants as part of a web of life. The plants grow, and we eat them-there's your web.

I'm getting a bit ahead of the story now, but I can't help bragging about our crop scientists and the wonderful things they've done. Like dosing the crops with ghiberellic acid, for super-fast growth. Or introducing new varieties bred for emphasis on growing fruit, not stems or leaves. We get oranges as big as cantaloupes, and watermelons you wouldn't believe.

Well, about a year after we all got to Houston, it was announced that the flights to the colony were about to begin. We were grouped in batches of 200, and every couple of weeks one of these batches would leave our center in Houston, to go to Cape Canaveral for the launch. For most of us, it was the first chance in a year to see the world outside our earthbound space colony-and, we knew, the last such chance, quite likely for many years to come.

We all had seen space launches, both on TV and as part of our training, but that wasn't quite the same as seeing our rocket up close and actually flying in it. The thing was really impressive. The first stage was as big as a Boeing 747, standing on its tail, and a good deal fatter. The main stage was mounted upon its belly, and looked nearly as large as the Washington Monument, though at 300 feet tall it was, of course, a lot shorter. The top 100-odd feet of it was fitted out as a wide-body spaceliner. There were two decks, each with a hundred couches. We also had partitions which we could draw around the couches, for privacy, somewhat like in the old Pullman cars. There were portholes, and a large viewing area at the nose.

Since we would initially be living in the construction shack, we could not take along all our household furnishings; there simply wouldn't be room in the little cubicles where we'd be living. Each of us was allowed to take 500 pounds, which at least was enough for things like clothing, books, stereo, and tapes or records. The Government announced that it would store the rest of our stuff until the colony was completed and we were ready to move in. At least they had the decency not to charge us for this storage.

The flights out were rather uneventful. There was the flight to orbit, with everyone lying on his couch. After the end of thrusting, the passenger section would separate from its second-stage booster, with a loud bang which used to startle some people. Then a rather strange-looking collection of tanks with a single rocket engine in the middle would approach. This was the space-based rocket, to take us to the colony. The trip took five days.

It was, for most of us, our first experience with weightlessness. There

was always a doctor or two on board, to help some of us adjust; you'd see people running round the aft bulkhead, to get acclimatized. The food was okay, and they served steak a couple times-just to let us know what we'd be missing, once we got to the construction shack..

That shack had initially been built in low Earth orbit, and carefully checked out there. It wasn't quite what you'd call a pleasure dome, but it had all the facilities we'd need to build the colony and the powersats. There were large solar-energy systems for power, and an extensive ore-processing plant which would turn out a couple hundred tons of aluminum per day, I believe. There was a construction sphere, a hundred meters in diameter-a closed sphere in which assembly of major components could take place. And there was a cluster of thirty-foot-diameter modules for people to live in. After it was assembled, a bunch of astronauts and other senior types went on board to live, in order to see that it was fit for human beings, and to check out the equipment. These same people were there when we arrived, to make sure we'd quickly be able to get working in it.

Before we could start building a colony, there was a little matter of some housekeeping around the construction shack. We had to strengthen the construction sphere with wire, spun from steel and titanium smelted in the ore-processing plant. This was so the sphere could be pressurized. The project management very thoughtfully had arranged that most of our work would be without space suits, in chambers pressurized with oxygen. We had been introduced to space suits during our Houston training, and they were a hell of a thing to wear. They were described to us as "constant-volume" suits, which supposedly should flex and bend easily, but the only thing that was constant was the volume of our complaints as to how difficult it was to work in them. Anyway, the arrangement was that we would assemble major structural sections in the construction sphere, then move them out into space for final assembly. That way, only for final assembly need anyone work in a space suit.

As I say, we had to strengthen the sphere with wire. We also had to build a thick shell of lunar soil over major parts of the shack, for protection against radiation. This shell also served for storage of lunar materials, since from time to time we would take some of it and feed it to the ore-processing.

Our lunar material did not come to us directly from the Moon, but came in a bit of a roundabout way. In the Oceanus Procellarum there was the lunar base, with its mass-driver. That was, and is, an electromagnetic catapult-I don't really understand the principles involved. It launched chunks of lunar material with very high accuracy, to a point behind the Moon where they could be caught. The catching was done by catcher vehicles, huge, cone-shaped affairs somewhat resembling a sawed-off dirigible both in size and shape. There were two of them, and some fan of the New York Yankees had named them the *Yogi Berra* and the *Elston Howard.* Every couple of months one of them would hove into view-they were self-propelled-and deliver to us about half a million tons of lunar material.

It didn't take long to settle down into a routine. We built the power satellites because that was our job, but we built the colony because it was our future home. There was a master schedule ticking down the days till the colony would be complete and we could move in, and of course everyone knew from day to day just how construction was progressing. It was one of the things that kept our spirits up. We certainly needed all of that we could get, because life in that construction shack really could be quite unpleasant.

It just was too cramped for any real comfort. It made some of us think of sea duty in aircraft carriers, while others were reminded of freshman days at college, squeezing four into a two-man room. We had these little cubicles, each for two people. Since we were big boys and girls, we could choose our roommates, so from that standpoint at least it was okay. The lucky ones had rooms with a porthole. We had these zero-g showers, and zero-g toilets, in which currents of air served in place of gravity. Also, there was zero-g eating.

We got our food at various stores in the shack. Most of it was grown in the shack, after a while. The variety wasn't all the greatest, but it certainly wasn't the freeze-dried crap which they still were serving in the Spacelab missions. And it was a far cry from that marvelous diet, of distilled urine and toasted Chlorella algae, which had been proposed back in the early days of astronautics. In addition to fruits and wheat, we grew lots of soybeans. Some of our chemists rigged equipment to turn soybeans into TVP -- textured vegetable protein -- and they tried to make artificial steaks and things from the TVP, using artificial flavors. I think most of us appreciated their effort, if not their product.

We got real meat from rabbits. We grew alfalfa for their feed, and the fact that rabbits multiply like, well, rabbits, meant that they were another very productive crop. Rabbit meat tastes and handles like chicken, and we found lots of ways to prepare it. Some enterprising guys even opened a fast-food stand, "McPeter's", which served quarter-pound rabbit burgers with cheese.

We also raised chickens, which gave us eggs. And we kept a herd of dairy goats, fed with the leaves and stems of the plants. These goats were chosen because they were very good at producing milk. We got enough milk to have plenty of butter and cheese, not to mention ice cream. It got so we were eating ice cream two or three times a day, and those chemists I mentioned kept whipping up new flavors for us. I guess it was to help boost our morale. But what really boosted it was when some of us learned to run the milk through a still.

Our recreational activities mainly centered around various types of media. We had excellent radio facilities for communication with Earth, of course, so it was easy to make phone calls to our former homes. This has remained true ever since, that there is the policy of making it easy to make phone calls to Earth. Certainly, in those days it was easy enough to get to feeling isolated on an outpost, and a long phone chat then could be much better than a letter from home. The public has always been quite aware of what we were doing and how important it was, and our friends and relations back on Earth were usually very proud of us. After the first colony was finished, quite a few of them were intrigued by our stories of life in space, and came up to join us.

We had a film library of about five thousand movies, on videotape, dating back to the 1930's. We had a library of records and tapes numbering in the tens of thousands. Also, there was a TV and radio station, retransmitting programs sent from Earth. Mostly the TV showed baseball or pro football from the preceding week; it also ran two or three soap operas. Not exactly the Public Television Network, but it suited our tastes. Also, there was a big library of books and magazines on microfiche, with portable plug-in readers that were actually convenient for reading in bed. We used to get new tapes or microfiches along with our mail, on the regular flights up from Earth.

We got our paychecks every week, with Social Security and income tax deducted, of course. The colony administrators had gone to some effort to ensure that the internal economy would not be too different from what we were accustomed to. There was a system of subsidies for the cost of space transport, so that a tube of toothpaste, imported from Earth, cost 79 cents instead of the thirty-odd dollars it would have cost if we had had to pay the actual freight charge. Our food costs were also adjusted so that we paid pretty much what was reasonable. We paid rent of $300 a month for those little cubicles, $400 if it had a porthole-and for what we were getting, that sure was a lousy deal, even though it included the cost of utilities. Our finances didn't really involve paying cash or check; we would have needed too many people minding cash registers. Instead, we used credit cards coded with electronic data, to charge our purchases and expenses with the aid of a computer. Similarly, our paychecks really were notices of the earnings and deductions credited to our accounts. All our banking was by computer, and if we wanted to put money into a bank, that too was handled via communications with Earth. You could go for months without seeing a dollar bill. But the system was enough like the checks and credit cards we all were accustomed to, that it worked okay.

Except for having to live in those cramped cubicles, those years in the construction shack weren't bad. We had plenty of work, and the pay was good. Most of us were regularly salting something away, and the microfiche *Wall Street Journal* was heavily read. Of course, we could communicate with our banks by phone or letter (the spacemail rates also were subsidized), to arrange for investment.

After the first few weeks in the shack, we were ready to go ahead with round-the-clock construction. The first powersat took a Year to build; the ones after that went more quickly. The first one, when it was finished, was sent off towards the Moon. That was to provide a great deal of additional power for the lunar base. This, in turn, meant that in due time they would be able to greatly increase the rate of shipping material out to us. The second powersat, and all the ones after, went down to synchronous orbit around the Earth. When the first of these was turned on and began sending down its power, we all stopped work to watch on TV. There was a ceremony with the President, and he was making some sort of speech about a "new inexhaustible source of power". Really, the TV cameras should have been on us and not him, since we were the ones doing the work; but that's the way it is.

Those powersats really are beautiful things. If you think of the old clipper ships, you may recall their tiny hulls and tall masts, spreading such huge expanses of sail. That's what a powersat is like. There are the generator plants, with radiator panels attached, which are a thousand feet across. There also are support structures, which are barely visible at a distance. But largest of all are those huge solar mirrors. The mirror surfaces are nearly two miles across, and each powersat has four or five of them. It's not the size, though, that makes the powersats impressive. In space there is little perception of distance, and a ten-mile-wide powersat a hundred miles away looks much the same as would a much smaller one, closer in. But those huge expanses of mirror surface, shimmering in the light, with barely visible ripples running slowly across them-those are what sticks in my mind.

We began building the actual colony about the same time as the first powersat. There had been rumors that the program would be changed on us and that we would wind up building powersats only; I think there'd have been a mutiny if that had happened. The main part of the colony was in the shape of a huge bicycle tire, a mile and a half wide, with the rim being four hundred feet wide. To start the construction, we were sent from Earth an actual inflatable plastic form, in the proper size and shape. Certainly it was the largest inner tube ever built.

We inflated it just enough so it would hold its form, in the vacuum, then wrapped it with miles and miles of wire and cable. That was to strengthen it, so we could inflate it some more. Then our vacuum-vapordeposition people went to work. Over a period of about a year, they built up a thick layer of aluminum over the form. Also, our glass workers fitted thick panes into the inner rim. This was so that by placing mirrors in the center of the colony, at the axis of that bicycle tire, it would be possible to reflect sunlight into it. Once that outer shell was complete, of aluminum and glass, we strengthened it with another wrapping of cable and pressurized it up to a normal atmosphere. This meant that when working on the inside, we would be breathing real air again. Also, we removed the plastic form from the inside, to be used in time for building the next colony. Then that shell was slowly spun up to one rpm, to give normal gravity.

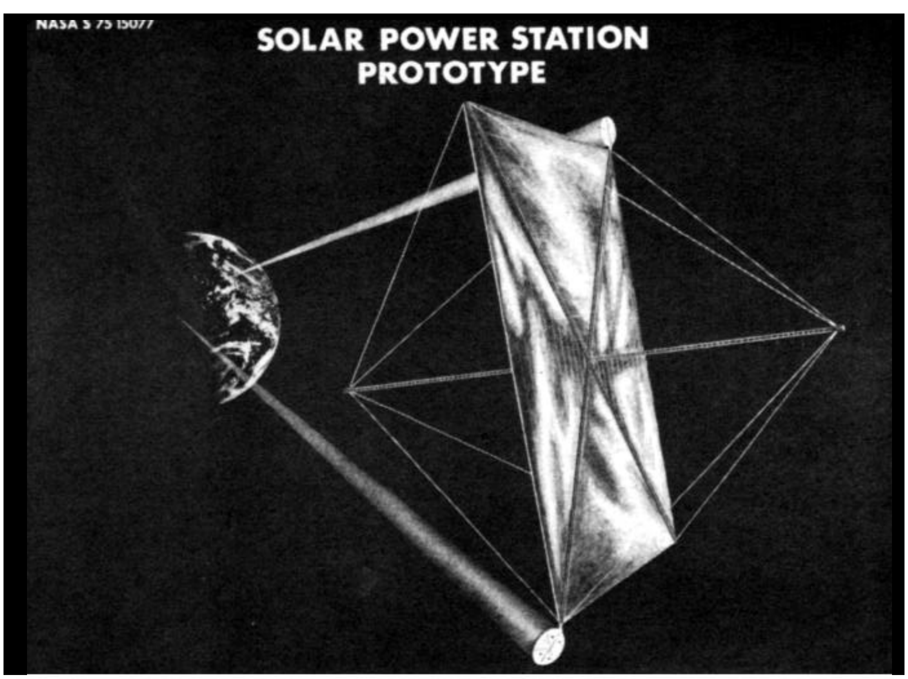
The part that took the longest to build was the radiation shield. If you think of the colony as resembling a bicycle wheel, the shield was the tire over that wheel. It was of ordinary rock and soil covering the whole colony, and six feet thick. There were angled sections with mirror surfaces, over the windowed areas, to let the sunshine through. This shield weighed ten million tons, so it took several years to build. It kept down the level of radiation inside, from solar flares, cosmic rays and whatnot, to about the level of Denver, Colorado. This meant that those of us who wanted to could go ahead and have kids.

We had all along had a few kids in the construction shack. Some were old enough to learn the exercise routines everyone did, to stay healthy in weightlessness. Those who weren't, were continually fussed over by doctors, and given frequent rides with their mothers on centrifuges so they could see what gravity is like. I think the young babies really were better off for living so much in zero-g. It was somewhat like what they had known in the womb.

Once the main, bicycle-tire portions were completed, the rest went very fast. The agricultural areas, the apartment complexes, the shops and parks, and the central hub with its big spokes to the rim-those all were completed while the radiation shield was being filled. Then some of the main industrial areas of the construction shack were detached and hooked up to the central hub. We built a big radiator, for temperature control, and installed the necessary systems to make the colony run. Then everyone had to wait impatiently until the President could arrange to come up and formally dedicate the colony, before we could move in.

He came up along with a bunch of Cabinet members and Congressional leaders. He shook as many colonists' hands as he could, grinning all the while for the cameras, and then he made his big speech. He quoted from John Kennedy, and talked about humanity's never-ending future on the High Frontier. Maybe I'm a bit cynical about politicians, but it really was a fine speech. He said a lot of what we'd been thinking all along. And, of course, it's nice to see the President supporting so strongly what we had been doing.

Then he unveiled a plaque which stated that our colony was the Morris K.



Udall Center for Space Industrialization. Mo Udall was a Senate leader, who for many years had supported and advocated the colonization of space, working on its behalf even while he was still a member of the House of Representatives. Of course, the real founder of the whole thing was Gerard O'Neill of Princeton University. Starting in the early 1970's he and his associates had developed the major ideas, and in time won enough support in Washington to put it over. Still, O'Neill never was a member of Congress, which is why the colony didn't get named for him.

There was one O'Neill idea which goes back to the earliest studies of colonization, which we all very much appreciated. This was that there should be a lot of effort and attention paid to making the colonies pleasant places to live. From the first, O'Neill had talked in terms of garden apartments, of trees and grass and flowing streams, and of similar pleasing prospects. Unfortunately, he hadn't reckoned with the fact that the architects and designers would be working working for that vast and unimaginative bureaucracy, the Space Industrialization Administration. Still, if we aren't living amid the scenic beauties of O'Neill's early descriptions, what we have is at least as good as anything most of us have ever had on the Earth. And it's a far cry from the construction shack cubicles.

We have terraced garden apartments, with nice rooms, furnished with the stuff we had initially brought to Houston and then left in storage. The bedrooms and family rooms are quite attractive. Most apartments have patios facing out over the colony interior. They were built in a sort of a cluster style, resting on top of each other, but arranged in such a way as to leave room for the patios and for our little lawns. The floors and ceilings are well soundproofed.

We were able to buy small electric carts, similar to golf carts, with which to get around. This meant that even though the colony was as crowded as a major city, it was quiet and free of auto fumes. Also, quite a lot of us have bought bicycles.

It didn't take long before the population began to grow. We set up new day-care centers and began to set up schools, too. The teaching is by TV and radio link to the Earth. The teachers there work with the children a quarter-million miles away, but we try to have real, human teachers to drop in on the children as often as they can.

The space colony really seems to be a good place for children to grow up. There are not a great many kids here, so they're valued and wanted more, quite likely, than if they lived on the Earth. On Earth, children and teenagers often have trouble finding appropriate roles, in societies that don't really need them. But we need ours, to help our society grow, and they know it. From early in their lives they learn what it means to be space colonists, and we see it reflected in their play and in their games, as well as in the way they talk.

So that pretty well brings us up to where we are today. Since those early days in the last century, we've built hundreds of powersats, and half-a-dozen or so new colonies. We've built a settled type of life here. Most of us expect to stay here quite happily, except for occasional vacations back at Earth.

We can take such vacations now, now that there is the new Super-Shuttle. It carries as much payload as the old Heavy-Lift Launcher, but it's completely reusable. So now it's no sweat getting from here down to Earth; and next week, that's exactly what my wife and I will be doing.

Our daughter is already down there, at the University of Michigan. One of these days we're probably going to get a good university up here, but meanwhile we send our bright young people down to the Earth. We'll be visiting her, certainly, but we'll be doing much more.

We've been round the world hundreds of times, but always at high altitude. Now we'll be going around it once more, but this time at ground level. My wife has always been fascinated with Hong Kong. As for me, I'm intrigued with visiting the castles in the northeast of England. So on the next Earthbound flight, we'll be aboard.

SPEND A DAY ON MARS

As the answers to questions hundreds of years old crackle across space to the planet Earth from the Viking spacecraft on Mars, new questions are being raised. Theories concerning the basic ingredients of life are being challenged, changed, and fortified by the Viking Mars missions. The ramifications of the search have broad scientific implications, as well as the philosophical and sociological questions of "Who are we?" "How did we get here?" "Are we alone in the Universe?"

FASST and the American Institute of Aeronautics and Astronautics (AIAA) invite you to take part in a student symposium, "The Search for Life in Our Solar System." The conference is to be held at the Jet Propulsion Laboratory in Pasadena, California, October 8, 1976.

Involved in the program will be:

Ray Bradbury, Noted Science/Fiction Writer: "Evolution of Our Cosmic Perspective"

James Martin and Dr. Gerald Soffen, Viking Project Team: "The Viking Project and First Results"

Jesse Moore, J.P.L. Flight Projects Planning Office: "The Future of Unmanned Probes"

Scientist/Astronaut Dr. Karl Henize, Johnson Space Center: "Manned Exploration of the Planet Mars"

Dr. John Billingham (Special Dinner Presentation) Ames Research Center: "The Search for Extraterrestrial Intelligence."

Participation is directed, but not

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

NL609

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

NAME: ____________________

COMPLETE ADDRESS: ____________________

AFFILIATION (OPTIONAL): ____________________

TITLE OR POSITION (OPTIONAL): ____________________

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

__ Back issues of *L-5 News* available, $1.OO each.

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

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

limited, to college students and faculty. The registration fee is $9.00 which includes a tour, materials and dinner.

For those wishing to participate, send your registration fee with the following information to FASST, 1785 Massachusetts Avenue, N.W., Washington, *D.C. 20036: Name, mailing address, college represented, major field of study, phone number.* Registration deadline -- October 1st.

Inside L-5

The L-5 staff this month included New Yorker Bill O'Boyle; Jim Parker of Covina, California; Eric Drexler of Cambridge, Massachusetts; and Tucsonans Fred Michael, Dennis Riggin, Jim Kempf, Keith and Carolyn Henson, Daniel Lomax, and Jonathon Nix.

Those who wish to come to Tucson to work on the L-5 staff are offered free room and board with the Hensons. The Tucson staff enjoys the stimulation and fresh perspectives of the visiting staff. Visitors enjoy encountering the quaint customs of the Southwest and often comment on the stimulating nature of the contents of the Society's files. The file labeled "Vituperation" is one of the more popular. For an exciting vacation in the balmy winter resort of Tucson, make your reservations now!

CHANGE OF POLICY

L-5 library subscriptions are being reduced to $20 per year. Newsletters are normally priced very high to libraries-if they are available at all-as a library subscription displaces many regular subscriptions. (People just copy them.) But the *L-5 News* has now grown so big it costs more to copy it than to subscribe, so library subscriptions are now to our advantage. We would appreciate it if L-5 members would ask their local libraries to subscribe.

HAPPY BIRTHDAY, L-5 NEWS

This month the *L-5 News* is one year old. That first issue was only 4 pages long. It carried articles on Gerard O'Neill's testimony before the House Committee on Science and Technology; the preliminary report of the 1975 NASA Summer Study on Space Colonization; a quote from Peter Glaser, father of the solar power satellite concept, and an extensive bibliography.

One year later the *L-5 News* is up to the status of a regular magazine and new members are coming in at a record rate. The L-5 staff would like to thank those of you who forked over $20 for membership in the Society back when we were first starting; without you we would have never gotten off the ground. With the continued support of our members, in our second year we can further raise our standards.

Special thanks goes to the many researchers in the field. The Society wouldn't have had much use for members and donations if research on space habitats and industries had failed to show promise.

We also really appreciate the cooperation of NASA in providing the *L-5 News* with artwork, and all our members who have contributed articles and letters.

Writing Letters to the Editor

"What do I have to do to get my letter printed," some members have asked. (1) Stick to one subject. Letters which ramble from one topic to another are hard to read and understand. (2) Be brief. In general, an opinion stated in 500 words is a great deal more interesting than the same opinion elaborated on for 2000 words. (3) Don't call people names. We have a file labeled "Vituperation" for those letters. (4) Get a friend to read a draft of your letter. What appears crystal clear to you may look like mud to a friend. Rewrite until your letter is easy to understand.

ADMINISTRATOR'S DESK

Some of you will be receiving notices that your membership in the Society has expired (or will be expiring). If this notice does not match your expectations as to membership expiration, let us know. Some of the volunteers who made entries into subscription files did not record the effective date of the subscription.

For the same reason, some of you may not receive a notice who should be getting one. If this is the case, please send in your membership renewal, and tell us with what issue of the *L-5 News* your membership began.

The financial base of the Society is memberships. The more members we have, the better service we can provide each member. You may notice that we now have a larger newsletter and are beginning to expand our membership services. This is because of the generosity of a private donor, who has provided additional funding for the Society for a limited period of time. If each current member would find us one new member, we would be able to continue to operate on this level with no additional miracles.

L-5 SOCIETY, LOS ANGELES CHAPTER

Walter and Dorothy Travis will be having a combination swim party, pot luck, L-5 meeting and star party at 6 pm, October 16, at 1000 Wardman Dr., Brea, CA. RSVP: 714-529-5437.

AVAILABLE FROM L-5 SOCIETY

Nontechnical Presentation Slide Set: 16 slides, $6.00

Technical Slide Supplement: 16 slides, $6.00

Slide information for Nontechnical Set: $4.00 (includes lecture material)

Supplemental Slide Set: 8 slides, $4.00

Back Issues of L-5 News: Numbers 1-13, $1.00 each.

CoEvolution Quarterly: Fall, 1975, and Summer, 1976 issues largely devoted to this fascinating subject: space colonization. $2.50 each.

LETTERS

I *would like to suggest* that the L-5 Society consider changing its name to the "Space Colonization Society" for the simple reason of more rapid identification from the general public with the goals and purposes of the Society. I would like to suggest that a vote be put before the Board of Directors regarding their desire to continue the use of the name L-5 Society or, change to the name Space Colonization Society. In addition, an item in the newsletter regarding the proposed change might also be appropriate.

Although I am personally quite familiar with the problems of changing names, I believe that the logo of the organization can be maintained. I fear for the day when another group of individuals forms a separate society utilizing the name "Space Colonization Society" which would then, unavoidably, leave those of us in L-5 far behind as far as membership is concerned.

Sincerely,
David M. Fradin
Executive Vice President
Environmental Balance
Association of Minnesota

How do you feel about changing the organization name from L-5 to Universe Society? Some people get the impression the only place we can build is at L-5. Would appreciate your comments.

Bill Agosto

As a fellow active member of the L-5 Society, I read with interest about our $25 reward "for an interview with either of the candidates for President on the L-5 project." I quote again the same issue of the L-5 News: "'But what does he think the ideal society would look like?' Brand (tolerantly): 'He'd say that's the wrong question, because the answering of it prevents the realization of it. As soon as you've got a plan of what everyone wants to do, there's no way it's going to happen.'"

Realizing the overwhelming influence our $25 reward will have on the course of the American Presidential election, I mention the possibility this year of a third major Presidential candidate.

I agree with independent Presidential candidate Eugene J. McCarthy that cuts should be made in military spending (where the money is); I disagree with him about cutting space spending (where the money is not). (Indeed, I support Dr. O'Neill's space colonization program.) Two close friends of Gene, Governor Jerry Brown and economist John Kenneth Galbraith, apparently also disagree with the Presidential candidate here, while agreeing about cutting military spending. (Whether Rep. Mo Udall would play a role in a McCarthy administration I cannot say at this time.)

Gene has expressed his desire that more decisions be made by Congress or the Cabinet rather than by a single person (no matter how benign) who in America is called President rather than King or Dictator.

Gene is, I feel, the most honest and the most intelligent of the Presidential candidates. When one tries to think in net effects, however, it is difficult. Thomas Jefferson, also honest and intelligent, had always claimed the federal government possessed no right to increase the national domain by treaty. Yet as President he bought via treaty "a scrap of paper" also known as the Louisiana Purchase.

With McCarthy, a compassionate economist and a person of duty and common sense, the American economy and spirit might radically improve. The American spirit and economy may be of major importance re space spending and the L-5 project.

Working for the ideal society and voting for the best candidate sound easy. It is easy to fool ourselves. The proper roles of reason and intuition remain a mystery. Good Working and Good Voting!

Charles E. Tandy

In regards to Dr. Leary's article in the August '76 *L-5 News,* I would just like to say, "He's right you know."

Donald C. Flint
member L-5 Society

I was watching Dr. Timothy Leary on the Tom Snyder program a few weeks ago and immediately wondered if he has the support of the L-5 Society. I wonder if having Tim Leary as a vocal ally of the space migration theme will help or hurt the cause. Dr. Leary is not exactly Washington's favorite armchair philosopher. In fact it seemed to me that if you replaced the words "space migration" in his recent article in the *L-5 News* with "psychedelic experience" you'd be reading an article he might have written in 1968. It's not that I don't like Tim Leary, because in '68 I was a big fan of his. It's just that I don't see him being of any real help to the project when what the project seems to need is friends in Washington. I'm afraid too many people will begin to equate the L-5 project with Timothy Leary and all the negative things he may represent in their minds such as the single most responsible person for the undermining of the nation's youth in respect to the drug revolution. The L-5 project must not appear in the least as a new way for Tim Leary to Turn on and Drop out. I cannot support Dr. Leary in his new quest for a far out cause that he can be spokesman for.

I'd very much like to know the L-5 Society's position on Dr. Leary. If you don't support him I believe it should be so stated in the next issue of the *L-5 News.*

Sincerely,
Jim Ryan
Indianapolis, IN

Dr. Timothy Leary is not a member of or representative of the L-5 Society. However, he has been in communication with Society headquarters (see his article in the August, 1976, L-5 *News), and we have "'supported" him to the extent of providing him with information on space colonization and materials promoting the L-5 Society, in the same manner as we would act in support of any member of the public who needed assistance in spreading information about the subjects.*

To repeat, however, he does not officially or unofficially represent the Society, and we can take no responsibility for his actions. We printed his article because we felt it would be of interest to our readers; the opinions were his own and not necessarily those of the L-5 Society or staff.

On the other hand, we feel the L-5 project is big enough to accommodate the support of all kinds of people, orthodox and unorthodox.

BOOSTERS OF BIG BOOSTERS, TAKE NOTE!

Keith Henson

A worrysome note to some NASA people has been the tendency of those in the Space Colonization/Space Industrialization (SC/SI) camp to hold forth that the very large boosters (1/2 million pound up) will not be required. They argue that Solar Power Satellites can be built from Lunar materials without without them. This may, or may not be true, but if the big boosters come first, SC/SI will look much better economically because of the reduced front-end transportation cost. Alternately, if SC/SI can be made to pay at all with Shuttle and Shuttle-derived vehicles, then it's clearly worth while to build the big ones to take over the freight load as soon as possible. SC/SI as we see it now has to take a radical step to lunar resources to make sense, but if it does, the transportation system can evolve just as aircraft have evolved from DC-3s to 747s. A very interesting concept to consider is building the Heavy Lift Lunar Vehicles in space by vapor deposition (the metallurgy is well understood). Absolutely seamless tanks and shapes can be deposited on inflated forms at low fabrication cost, and foamed metal is a distinct possibility. Best of all, a lot of you would have to be on hand, and I haven't met a rocket engineer who wouldn't jump at the chance to go.

(See illustration on back cover.)


5