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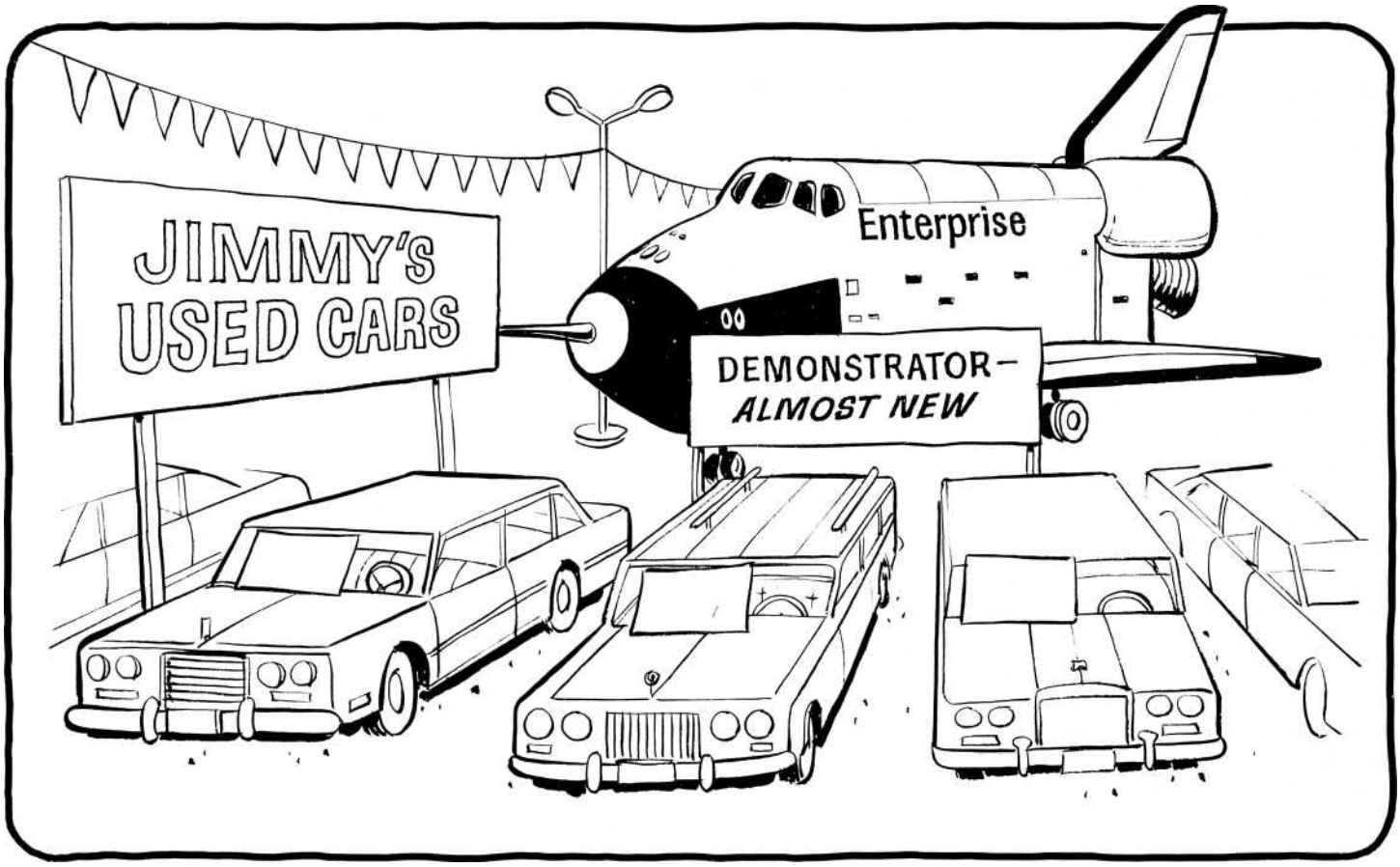
Cover: Lower left, a mass driver reaction engine is propelling an asteroid into Earth orbit. Lower right, a mining and processing operation has been set in operation on a second asteroid. Upper left, a solar power satellite is under construction, utilizing resources from the nearby asteroid. Upper right, a Bernal sphere space colony houses 10,000 people, many of whom are working as asteroid miners and SPS construction workers. *(Artwork courtesy Johnson Space Center.)*



Boland's Committee Cuts NASA Appropriation

by Carolyn Henson

The NASA FY '79 Appropriations Bill suffered several cuts before being passed by the House Appropriations Subcommittee on HUD-Independent Agencies (chaired by Rep. Howard Boland (D-MA)).

Perhaps the most serious cut was the deletion of funds for the Teleoperator Retrieval System (TRS), which must be funded *this year* in order to prevent Skylab from plunging to Earth. Besides the loss of a possibly still usable space station, Skylab could cause damage or injury when it crash-lands. The TRS will be available for other space projects after the re-boost of Skylab.

The Solar-Polar Mission was also cut. It would give us our first view of the polar regions of the Sun. It was planned as a joint US/German mission. If we drop our share of the project, the Germans may be unwilling to continue alone. A short delay in the funding could result in a long delay in the mission, because launch windows only occur at widely separated intervals.

Funds for the search for extraterrestrial intelligence (which, despite the interest aroused by "Close Encounters", received Proxmire's Golden Fleece award) were also deleted. Finding another civilization could have quite an impact on our society, perhaps comparable to the Copernican

The funds, reinstated by the House Science and Technology Committee and Senate Commerce Committee, to outfit the Enterprise for space (which would raise the shuttle fleet to five) were cut to $4 million—barely enough to keep the Enterprise from being cannibalized for parts in 1980 (as OMB has planned).

The $3 million reinstated for microwave testing and large space structures was also deleted. However, the $3 million for SPS research and the $7 million added to the Advanced Programs' $5 million allowed by OMB were left in the budget.

The NASA Appropriation next goes to the Senate Subcommittee on HUD-Independent Agencies. We are told that they will not vote on the NASA bill until sometime in June. If the Senate appropriation differs from the House appropriation, the conflicts will probably be ironed out in a House/Senate Conference Committee next July or August. It should be noted that, due to the Conference Committee process, that Boland's NASA cuts are by no means final. If Proxmire's Appropriations Subcommittee chooses to reinstate funds, the Conference Committee can work out a compromise between the House and Senate versions.

L-5's Legislative Information Service members are reminded of the surprise House floor vote called by Boland last summer when he was unable to get the Conference Committee to accept his demands to delete JOP. NASA Appropriations could be at least as exciting an issue this year. We'll keep you informed.

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Secret White House Studies Completed

by Carolyn Henson

Two secret White House studies were given to Carter in mid-May. The national security-oriented one, PRM23, has been signed by Carter and is now policy. Because it is totally classified, we must rely on "leaks" for knowledge of its content. The basic problem with PRM23 is that **it provides no goals** and only gives a superficial view of civilian space options. Some insiders view it as a blatant attempt by Defense Secretary Harold Brown, who headed the study, to take over NASA.

The civilian-oriented study is reported to be little better. While the solar power satellite option has been included (our sources say Frank Press was responsible for this), White House sources say that SPS doesn't fit within the NASA budget constraints proposed by the study. This study is also classified, so we must rely on rumor for details.

However, on the principle that "if you can't say something good about NASA, it's better to say nothing at all", White House advisors have urged Carter to avoid making a public statement on NASA. If he keeps quiet on the topic for now, he will later be able to change his NASA policy without loss of face.

The full impact of Carter's adoption of the PRM23 policy will not be felt until OMB releases the NASA FY '80 budget allowance next January. We hear it may call for the closing of Marshall Space Center and the disbanding of Advanced Programs. But a great deal could happen in the next eight months.

In the meantime, would it be possible to persuade Carter to reveal the contents of his NASA policy? He ran for office on an "open government" platform; perhaps it's not too late for him to return to his publicly stated ideals.

DOE, NASA'S Plans for SPS

by Carolyn Henson

DOE and NASA are opposing the $25 million Solar Power Satellite Research, Development and Demonstration Act (now numbered HR12505). Their line is that their "SPS Concept Development and Evaluation Plan" is adequate for SPS work.

What is the "Plan" and how does it differ from HR12505? The most immediately obvious difference is in funding. While HR12505 would kick off FY '79 with $25 million, the NASA/DOE plan has been running according to the table below:

However, the most serious differences between the "Plan" and HR12505 are in what the money will be used for. The "Plan" calls for definition of a final solar power satellite system this October. (DOE evaluators have already rejected several SPS design approaches, including O'Neill's "High Frontier" concept.) Then a comparison of SPS with terrestrial energy alternatives will begin in February 1979. A final decision to either reject or go ahead with an SPS construction program will be made in Nov. 1979. (i.e., early in FY '80).

TOTAL FUNDING IN THOUSANDS OF DOLLARS

	Fiscal Year				
	1977	1978	1979	1980	TOTAL
Systems Definition	1,800	1,700	1,300	800	5,600
Space Related Technology	700				700
Environmental Factors	220	1,940	2,050	1,740	5,950
Socioeconomic Issues	164	537	537	322	1,560
Comparative Assessment	95	376	754	565	1,790
TOTAL	2,979	4,553	4,641	3,427	15,600

RESOURCES

The following table gives a brief summary of the resources allocated to NASA managed studies by the "plan".

	1977	1978	1979	1980	TOTAL
Systems Definition					
JSC	900	850	650	400	2,800
MSFC	900	850	650	400	2,800
Space Related Technology	700				700
TOTAL	2,500	1,700	1,300	800	6,300

As the NASA/DOE budget for SPS shows, space related technology research was terminated last year. Since then, the thrust of the NASA/DOE plan has been *evaluation* of what research has already been done.

Under the proposed Solar Power Satellite Research, Development and Demonstration Act, the heads of NASA and DOE would be directed to reinstate space related technology work and reopen consideration of SPS concepts to include photovoltaic, solar thermal and even orbiting nuclear power plant concepts.

SPS researchers assert that the DOE/NASA "plan" is a thinly disguised program to kill the SPS concept. They say they need time and money in order to have a fair chance to prove or disprove the viability of SPS. The NASA/DOE "Plan" tells them they've already had their chance—now it's time to evaluate. HR12505 will put the R&D show back on the road, leading—if no "show stoppers" are found—to a demonstration SPS in the mid-eighties which should finally prove or disprove the environmental and economic viability of SPS.

Will the show get back on the road? Watch Congress this summer for exciting developments.

SPACE INDUSTRIALIZATION STUDY INDICATES SPACE INVESTMENTS YIELD HIGH RETURNS

100,000 New Jobs by 1985?

A study just completed for NASA indicates that a world of pocket telephones and solar-powered homes and factories may only be a few years in the future. It also concluded that while sales of services originating from space are already producing world-wide gross revenues of more than $1 billion a year, by the year 2000 the figure will have grown to $10 or $20 billion with only minor advances in present technology.

These facts were reported in the summary of a space industrialization study recently completed for NASA's Marshall Space Flight Center in Huntsville, Ala., by two companies, Rockwell International and Science Applications, Inc.

The report stated that, with technological advancements in power production, structures, transportation and materials processing, earnings from space could well reach the $40 billion a year mark or beyond.

Space industrialization is already an international and multinational endeavor, with approximately 111 nations actively participating. At least five nations are now sponsoring materials space processing research with at least three organizations or nations actively conducting launches.

Of the four general categories of space industrialization, it is Information Services that is nearest to maturity. Commercially owned satellites that provide communications and information on earth resources and weather are already producing revenues. The remaining categories—products, energy and people in space—will require new technologies before markets can be opened up.

The Science Applications study predicted that, by 1985, 100,000 new jobs could be created in the United States alone as a direct result of a space industrialization program that includes development of technology for a satellite power system. Such a program would generate $800 million in tax revenues, but the total impact to the nation's economy would be much greater because of the many indirect jobs and services that would be made possible by these space industries.

By the year 2010, according to the study, new space industrialization jobs would increase to 1,900,000 and tax revenues to $20 billion. The contribution of the program to the gross national product (in 1976 dollars) would be from 200 to 800 billion dollars and the balance of trade impact could be as much as $50 billion.

One of the more interesting services that could be provided from space is the wireless pocket telephone, operating via satellite and offering almost instant communications with any part of the world. For instance, a paramedic in a remote African village would be able to get the best possible emergency medical advice by calling a medical specialist in New York, London or any other city of the world. A businessperson would have instant contact with associates and access to job and marketing information on a world-wide basis.

In the United States, satellite-linked portable telephones could be used by police, paramedics and other professional or semi-professionals, as well as the general public. The study predicted a long distance toll rate of about 20 cents.

The same space platform that provides telephone service may also provide direct broadcast educational television to homes, with five channels broadcasting programs 24 hours a day. A home adaptor for these broadcasts would cost less than $150, according to the report.

In addition to vastly improved communications, space industrialization can provide energy and products. A satellite power system could produce energy from sunlight that would provide power for processing materials and operating systems in space, or as an alternative to coal and gas on Earth. Properly commercialized and managed, this power source could also be exported to other countries.

Energy availability appears to be the key to space industrialization and the report recommends that its growth be divided into three 10-year intervals.

The space shuttle would be used to its fullest extent in the interval of the 1980s. The center of activities during this time would be in low Earth orbit with power provided by an orbiting power module like the 25kw power module now being considered by NASA for early development.

Activities during this interval would include establishing a geosynchronous (stationary) platform and a global weather and resources base to provide world-wide benefits. Later, a construction base, a space factory and a space operations center could be established as one facility in low Earth orbit. Here, the capability to construct large space structures would be perfected as a step toward construction of the satellite power system.

In the second 10-year interval (1990s) the capabilities of the space factory, the geosynchronous platform and the global weather and resource base could be in use and initial operation of a satellite power system could begin. Beyond the year 2000, oxygen and materials for massive energy-related projects at geosynchronous orbit would he obtained from the Moon.

Benefits in education, health and conservation of resources and productivity could be available to the entire world from information and observation services in the 1980s. The energy scarcity problem could be dealt with in the 1990s and, by the turn of the century, energy from space installations could become a worldwide energy source.

What will space industrialization cost in terms of taxpayer dollars? The Rockwell report states that the government cost of providing the opportunity to use the pocket telephone is about 33 cents per person per year. Annual per capita costs for other services the space industrialization program could make available include: direct broadcast education (five channels), 33 cents; world medical advice center, 20 cents; national information service (Library of Congress), 39 cents. None of the costs cited include user charges.

Throughout the entire program, services would continue to be expanded, new products would appear, and research would move toward full understanding, prediction and localized control of Earth's weather and climate.

The study predicts that in the future the public will become increasingly involved with space, first by directly receiving immediate and tangible benefits and later by directly participating in the space activity itself—even in space travel.

Shuttle Pollution

A shuttle propellant system could be developed which would yield only non-polluting water and carbon dioxide and cut the cost per launch by $1 million. The "miracle" booster? It's a liquid oxygen/kerosene burning engine similar to the Saturn 5 first stage.

However, several years ago Congressional budget cutters nixed the system, citing its $1.5 billion development cost. They settled on the cheaper to develop (but more expensive per launch) solid rocket boosters (SRB's) currently under development. The SRB's supplement the thrust of the three Orbiter engines, which emit water and hydrogen. The SRB's burn an ammonium perchlorate-based propellant which emits chlorine compounds in the ozone layer.

NASA's environmental impact statement calculates that 60 shuttle flights per year, using the SRB's, will decrease the atmospheric ozone concentration by 0.2%, which would correspond to a 0.4% increase in ultraviolet light reaching Earth's surface. The environmental impact statement indicates consequences to agriculture, ecology and the climate "are considered insignificant", and that there is "no conclusive evidence" that it would cause a detectable change in the rate of melanoma skin cancer.

In the lower atmosphere, while pollution is not expected to "exceed the allowable limits for human beings, wildlife or plants," the SRBs' exhaust will create hydrogen chloride, which can combine with rain to form dilute hydrochloric acid. This could temporarily damage vegetation.

However, the environmental impact statement pointed out that the shuttle will produce less pollution than the expendable launch vehicles currently in use: Scout, Delta and Titan III boosters. And if environmentalists complain loudly enough, the alternate non-polluting shuttle boosters may get funded yet.

Battelle Microwave Study

Long term biological effects of microwave exposure that may be associated with solar power satellite energy transmission are being studied by Dr. Richard Phillips, a research physiologist at Battelle's Pacific Northwest Laboratories. He is also considering electromagnetic and radio interference effects.

"The electromagnetic interference and biohazard studies will begin with surveys of known microwave effects," explains Phillips. "Battelle researchers will then identify unknowns or uncertainties in current knowledge and propose specific studies to fill in that knowledge." Battelle expects to complete the investigation by September, 1978.

In addition, the lab will sponsor a symposium on biological effects of extremely low-frequency electromagnetic fields in October, 1978. The symposium will concentrate on bioeffects associated with electrical power production and transmission.

Rockwell Receives Solar Cell Contract

DOE has awarded a one-year contract for $999,870 to Rockwell International, Thousand Oaks, California, to direct a program aimed at developing new techniques of growing gallium-arsenide thin films and using the films to make photovoltaic solar cells.

The overall goal of the program, which will be carried out by Rockwell's Science Center and four university subcontractors, will be to develop thin film solar cells that have a conversion efficiency greater than 10% and that can be produced at a cost of $100-$300 per peak kilowatt. Current laboratory thin film gallium arsenide cells have a conversion efficiency of approximately 6%.

The four schools and Rockwell will develop new crystal growth techniques, perform materials research, and develop processing techniques. The universities are: Brown University, Cornell University, Howard University, and North Carolina A&T State.

This project permits significant involvement of minority universities in DOE's photovoltaic research program. Besides directing the laboratory work at Howard and North Carolina A&T, Rockwell personnel, with the aid of faculty from Cornell and Brown, will also provide lectures and specialized instruction in solar cell technology at both schools. The program is expected to stimulate expanded photovoltaics research capabilities at the two universities and will help faculty and students gain additional expertise in photovoltaic technology.

The project is funded through DOE's Solar Technology program.

Skylab Update

If NASA decides to reboost the orbiting Skylab space station to a higher altitude—a possibility on the basis of recent findings by NASA crews who were able to recharge Skylab batteries and receive data from its computers—the move could provide an opportunity to reactivate and use the on-board systems and instruments in a variety of useful projects.

The large living quarters and crew accommodations aboard Skylab would be a welcome addition to Space Shuttle and Spacelab missions involving extensive mission equipment and long mission durations. In addition, useful experiments might be conducted with Skylab instruments, some of them in conjunction with complementary instruments planned for flight aboard Spacelab.

Another possibility concerns new experiments, missions and demonstrations made possible with the orbiter that might be feasible if Spacelab were docked with Skylab. Assembly and support of large space structures for communications, solar energy or other public service operations might be accomplished by this means, for instance.

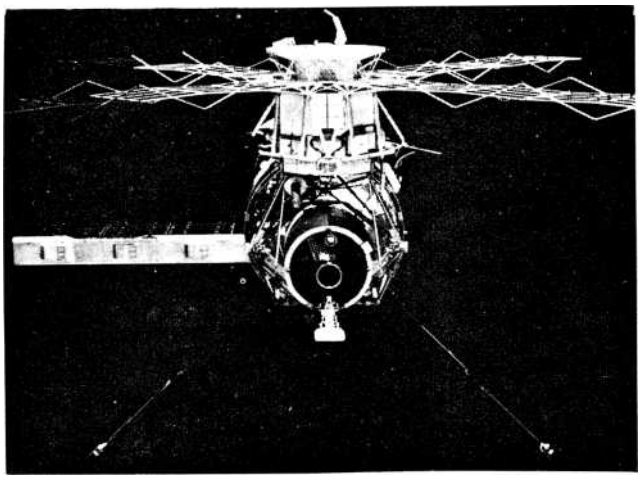
NASA's Marshall Space Flight Center has awarded parallel study contracts, each in the amount of $125,000, to Martin Marietta Corp, at Denver, Colo., and McDonnell Douglas Astronautics Co. at Huntington Beach, Calif. The two firms will conduct simultaneous but independent studies of the possibilities and benefits to be realized from reuse of Skylab.

The spacecraft is the largest payload in Earth orbit. It weighs 86 metric tons and is about 29 meters long. The main portion is cylindrical, 9 m in diameter. In orbit, Skylab is passing above the areas of Earth between 50 degrees north and 50 degrees south latitude.

Skylab was launched in May 1973 and manned during three missions by three different astronaut crews. The last crew left Skylab Feb. 8, 1974 at an altitude of 440 km. Skylab now is 408 km above Earth.

At the time the final crew departed, NASA estimated that the orbiting workshop would remain in space until 1983. Since then, the orbit has decreased and NASA has been adjusting its predictions. Contributing to the more rapid rate-of-descent is an increase in atmospheric drag which in turn is caused by sunspot activity.

When it became evident, last February, that Skylab could begin reentry into the Earth's atmosphere as early as late summer of 1979 and as late as the second quarter of 1980, NASA project managers began attempts to reactivate the spacecraft. Engineers from the Marshall center, controllers from the Johnson center and tracking crews from the Goddard center spent a week at a ground station in Bermuda, checking out systems that have been dormant aboard the spacecraft for the past four years. The purpose of their activities was to check out the capability of Skylab to respond to commands as a prelude to activating the thruster attitude control system. The results were most encouraging, and plans are presently underway to reactivate Skylab once again this month when the system may be used to reduce atmospheric drag and prolong the Skylab's orbital lifetime, perhaps for several months.



Skylab looked like this four years ago in its final fly-around, made by astronauts Jerry Carr, Ed Gibson and Bill Pogue just before they returned home. At the time (February 1974) Skylab's orbital lifetime was calculated at 10 years. Atmospheric drag caused orbital decay from its original 237 nautical miles down to 220 in 1978. Photo was taken from the Skylab-4 command and service modules.

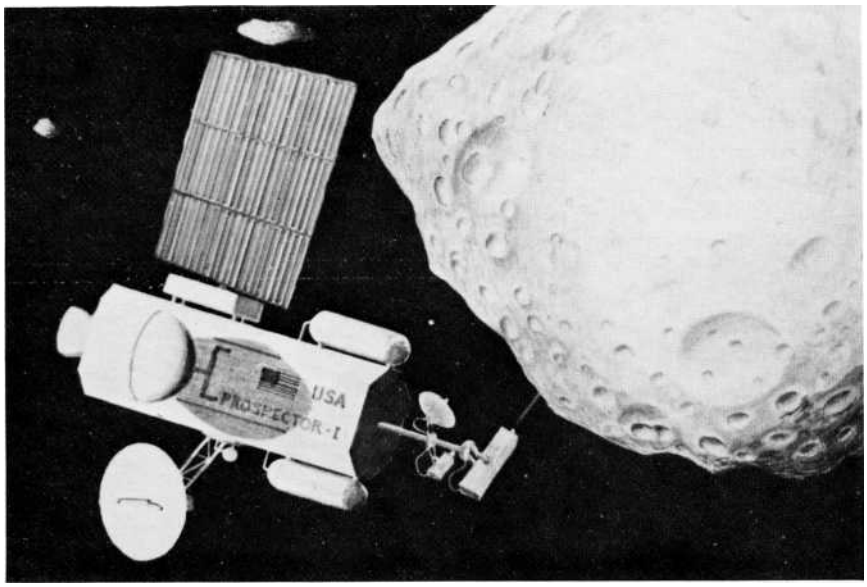
Intrinsically Valuable Materials in Space

by Stewart Nozette

At present, cost seems to be the overriding factor in any plan to expand our space program. Does an expanded space program mean that only money will be spent, and that there will be no substantial economic payoff? Supporters of space industrialization and space colonization have argued that there can be substantial economic payback from these types of ventures.

Satellite solar power stations have been suggested as one way to derive economic payback from space industrialization. In this article I will explore the possibility of other faster methods to pay back the initial investment required to set up space manufacturing facilities. Supporters of such large scale- projects would see their efforts gain large amounts of support if, within a few years of initiation, a large quantity of intrinsically valuable substances could be delivered from space factories. Space utilization could proceed in steps with each step providing the economic return to pay for itself. Energy is one attractive justification, but power satellites would require a large initial investment before full payback could be realized. During that time new energy technology developed for terrestrial use could reduce the payback from space systems, and make their expense difficult to justify. Examples might be fusion technology or a practical method of harnessing tidal and thermal ocean effects.

This is not to say that satellite solar power stations could not be an important source of energy in the future. However, we must seek other methods of economic payback so as not to suffer from unforeseen developments in one specific area. There are subsidiary space manufacturing and processing schemes that could support the cost of these activities. Specifically what are prospects for finding intrinsically valuable materials in space?



A prospecting probe approaching an asteroid. (Artwork courtesy Robert Lovell.)

The oil embargo of 1973 dramatically showed our country's dependence on imported oil for energy. Yet oil is not the only thing that we must import to maintain our highly industrialized society. Many of our key minerals also must be imported from other countries. The energy crisis has dramatically illustrated the fragile relationship between resources and the industrial society they helped create. Materials such as helium, chromium, platinum, nickel, cobalt, copper and petroleum are discovered, turned into resources, used in many productive ways, become indispensable, and then become scarce. Even at present use rates known reserves of several important minerals will be exhausted in 200 years.' Such estimates are difficult to make due to the change in

supply and demand. The point is that we will run out of these things sooner or later.

Also, some parts of Earth are relatively high in mineral reserves, and other parts low. North America, for example, is rich in molybdenum, poor in manganese, tin and chromium. Asia is poor in molybdenum, but rich in manganese, tin, and tungsten. Most of the world's chromium comes from South Africa and Rhodesia. Cuba and new Caledonia supply about half the world's nickel.

How long a reserve of a mineral lasts depends not only on its supply but how fast it is used, and this rate of consumption is increasing. The metal consumed world-wide since the start of World War II exceeds the total metal production of all previous years. The United States has long been the largest consumer. It now imports most of its aluminum ore, chromium, manganese, nickel, and platinum.' Except for bulk non-metallic materials such as gravel and cement, the U.S. is self-sufficient in only iron, magnesium, molybdenum and a few minor metals. This puts our country in a fragile position. Our wealth is primarily derived from ready access to materials and mineral resources. What would happen if instead of an oil embargo, we faced a nickel/chromium embargo? The results could be disastrous.

Can we look to space to help gain independence from foreign mineral sources? In considering likely places for mineral deposits, both major and minor planets may be considered. Major planets are gravitationally disadvantaged and too far away. The moon is lacking in many of the minerals with high intrinsic value. Most reduced metal found in lunar soil is probably derived from meteorites impacting the surface. The moon lacks many of the processes that concentrate ores on Earth such as hydrothermal solutions and active tectonic processes.

To be a likely candidate the source in question must be close in terms of the velocity interval required to reach it. It must be high in intrinsically valuable metals which can be obtained with a minimum of processing. The earth crossing asteroids may provide this source.

The basic reflective spectra of an asteroid can give us some idea of its surface composition. We can compare the spectrum obtained from an asteroid with the spectra of meteorite samples we have here on Earth. In this way a basic idea of asteroidal composition may be obtained. Other workers[3] have obtained these types of data from several earth crossing asteroids. One likely candidate is 433 Eros. It has a spectrum in reflected light resembling a group of meteorites known as H group chondrites. A typical whole-rock analysis is shown below

Compound	Wt. %
Iron—Fe Metal	16.30
Iron FeO	10.24
Nickel—Ni	1.74
Silicon—SiO2	36.74
Magnesium—MgO	23.44
Calcium—CaO	1.60
Aluminum—Al2O3	2.04
Platinum—Pt5-9x10(6)	gm/gm metal
Sulphur + Iron	5.48
Chromium—Cr203	.55

In meteorites, iron, nickel and trace metals tend to occur together in metallic inclusions similar to the one shown here. The oxides occur in the silicate minerals, and sulphur occurs with iron. Thus the important metals are already reduced and can be extracted, possibly by a magnetic method.

What would 433 Eros be worth on today's market? We can assume that to get the body back to near-Earth space, the silicate portion may be used as reaction mass for a solar powered mass driver. Eros is a good target because the velocity interval for return of its material is on the order of 9-13 km/sec.

A rough back of the envelope sort of calculation is adequate for this level. Observations of Eros indicate a size of about 35x26x7 km. This is a bit too large for exploitation, but it serves as a good example, because its reflective spectra and orbit are well known. Using this size we get a volume of about 3.92x10(18)cc. Approximate whole rock densities for H-group chondrites are about 3.8 grams/cc. So a total mass would be on the order of 1.5x10(16)kg. Assuming a whole rock analysis similar to the one given previously, Eros would contain about 2.6x10(14)kg of nickel and 2.43x10(15)kg of iron. These elements would he in metallic form. Concentrated in these metallic phases would be about 2x10(10)kg of platinum. Dispersed through the entire body would be about 5.6x10(13)kg of chromium in the form of Cr203. We can see that a direct value calculation would have little meaning, because at present prices for some of these materials the value would exceed the gross national product of the United States.

In conclusion, asteroid utilization appears to hold a promise of payback on the same scale as satellite solar power. A typical near-Earth asteroid might contain large amounts of vital metals now imported from other countries. The materials gained could supply a large program of space industrialization. Some of the more precious metals could be exported for profit. The cost of such an asteroid mining scheme is not well known at present. But the potential gains surely warrant some funding for closer investigation. We are running out of time. This situation grows more critical as time goes on. By the end of the century we will look with great interest at the vast wealth present above the atmosphere.

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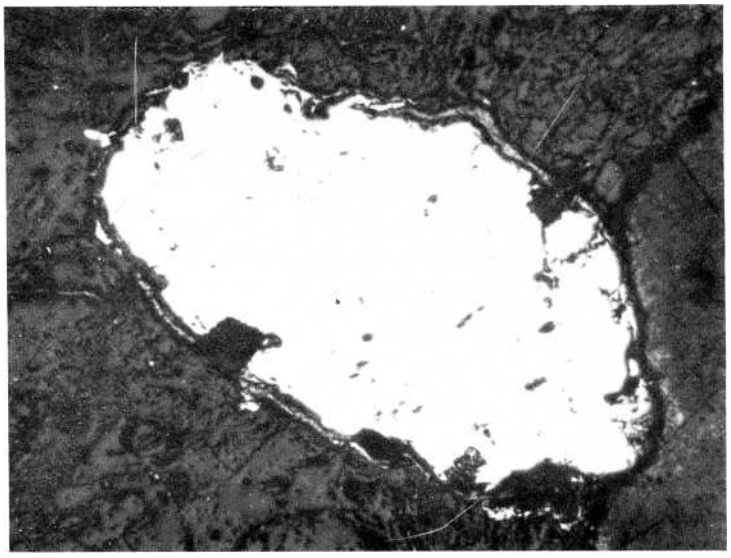


Iron/nickel, iron sulphide in a H4 chondrite. (Photo courtesy Lunar and Planetary Laboratory, University of Arizona.) Scale: 1.25 inches = 0.5 mm.

Some Rudiments of Economics for Non-Economists

by Gordon Woodcock

Historical background

Questions about energy supplies and use have their roots in economics issues. The history of the industrial revolution provides a background to the relationships between economics and energy. Until quite recently in human history, of course, energy was not an important problem. Early and historical people needed little of it and what little they needed was supplied by muscle power and firewood. The early developed civilizations such as the Greeks and Romans did not perceive a need for anything like industrialization because their economic system was built on the widespread use of slavery. The scientific principles involved in building machines to do work were known to the Greeks. Their ideas regarding proper occupations for educated men, however, discouraged the idea of putting scientific knowledge to "base" (i.e. practical) use.

The first energy crisis actually occurred before the industrial revolution. In England in the 16th century, demands for wood included heating, building of shelters, and shipbuilding. Wood was actually imported from the continent and the colonies, and a price inflation much like the current one in oil occurred. The result was a turn to coal for heating and ironworking. (See the March 1977 **L-5 News** for a more complete discussion by Romualdas Sviedrys.)

Also in England, but later, in the 18th century, initial steps toward industrialization were taken. At the beginning of that century, primitive steam engines were developed. These machines were originally used to pump water out of coal mines. By the middle 1700's, sources of capital were becoming available from trading the raw materials and products of the English colonies. Machines had been invented that vastly improved the productivity of manual work in spinning and weaving. The Enclosure Acts had displaced many poor farmers and rural dwellers to the cities where they sought employment.

Industrialization was inevitable! The earliest factories were built even before the advent of mechanical power. Its use began with water power, but with the invention of the improved steam engine, steam began to see widespread use.

Thus began a process that still continues. It has profoundly changed the predominant economics of the world. The pre-industrial situation was one of scarcity in which nearly everyone eked out a bare subsistence; a life that has been described aptly as "solitary, poor, nasty, brutish, and short." Only a few were powerful and therefore rich, and their pleasant existence was at the expense of the poor. Now, in the industrialized countries, most of the population enjoys a material existence that would have been the envy of the rich a few centuries ago. One often reads of philosophical views to the effect that the high material standard of living of industrial societies has somehow "degraded" us. It is my view that those who express such opinions have not tried the primitive way of life they espouse, and have little appreciation for the hardships of life as experienced by the average citizen of, say, the middle ages. The contemporary view of "roughing it" - - mine, at least - - is a few days spent camping in the wilderness with elegant high-technology equipment made of aluminum, stainless steel, and various synthetics!

Today our primary source of energy is oil, but the reason for oil's displacement of coal was primarily economic rather than due to a shortage. Oil is cheaper to get out of the ground and more convenient and cleaner to use. Oil, however, is becoming a critical resource and some changes must occur. The industrialized societies have prospered and grown at the expense of profligate consumption of resources: Even at today's use rates, however, the availability of most resources is not critical if one is willing to think of using lower-grade sources, such as production of aluminum from clays rather than bauxite. As raw materials become more precious, recycling becomes economically more attractive.

One resource that cannot be recycled and is not so plentiful is the set of hydrocarbons that we call fossil fuels. It will be necessary in the next few decades to find some alternative to our present dependence of this set of resources. This necessity for alternatives is our "energy crisis". To evaluate the potential alternatives we must take an excursion into the mysterious realm of economics. It is made the more mysterious by frequent discussions of such esoteric matters as monetary theory and the like. To understand something about energy needs, however, only the rudiments of economics are necessary. And one might even argue that these rudiments are based on common sense.

Basic concepts of economics

Economics is the science of wealth. Lest we turn someone off with the use of that word, we do not use it in the sense of riches, but rather in the generic sense of the goods, services, and knowledge produced by human societies. We do not mean money. Let us consider for a moment what money is. It is often called a medium of exchange. Although historically moneys have often had intrinsic value as exemplified by gold, modern moneys have little actual value except as societies agree on the universal exchangeability of money for things of real value. This is becoming increasingly true as our monetary systems evolve in abstraction from coinage to paper bits of data. Money is essential to the functioning of a complex and diverse economic system. Without it, we would be reduced to barter.

Now that we have discussed money briefly, let us see if we can structure a concept of economics without discussing money further. To begin with, how is wealth created? Clearly, by the products of effort. And how is it destroyed? By the ravages of time, the "corruption of moth and rust," by consumption as in the case of food, or by becoming irrelevent as in the case of superseded knowledge. One could think of a "half-life" for wealth — if now more were created, how long would it be before half of what we had was gone? Some human creations last a long time, as the great cathedrals and castles of Europe, not to mention the pyramids (are the pyramids irrelevant?). But most are gone quickly. Perhaps the half-life would be ten years, perhaps fifty. But our total wealth is clearly a balance of creative and destructive forces.

The ability to create wealth is productivity. As productivity is increased, the balance of creative and destructive forces shifts in the direction of the creative effort in human work, most commonly measured in manhours. The amount of wealth produced by a manhour is determined by productivity. A person aided by a machine can ordinarily produce more than an unaided person. This is the advantage of industrialization. (As has often been observed, however, the machine operator

may receive less job satisfaction.)

The increased productivity of industrialization is not all pure gain. In the case of an artisan or laborer working with simple tools, the total effort involved to produce a personhour of production labor is only slightly more than one personhour: some labor is invested in the tools and some goes to supplying raw materials and perhaps to packaging and marketing the product. Several personhours, however, are generally required to effect a personhour of production labor in a large machine-equipped factory. Much labor is invested in the factory and tools and equipment. Support labor includes factory and equipment maintenance, raw and in-process materials logistics, production planning, and so forth. There probably is, as argued by [I], an optimal level of capitalization (investment in industrial production) for any product or process. The optimal level will change as the availability and costs of technology and labor change, but it is not valid to think that more capitalization is necessarily better. (Schumacher seems to believe that productivity in the highly industrialized economies could be increased by reducing the present levels of technology and capitalization. I do not agree, and suspect that this view may have been ideologically motivated. I will discuss my reasons in the next article.)

Several basic economic concepts are pertinent to energy issues and to the possibility of large-scale human settlements in space.

The market is the economic construct for the exchange of goods and services among individuals and organizations. A great deal of economic theory is based on the idea of the free market. In an idealized free market, sellers offer goods and services in open price and quality competition and buyers have complete freedom to buy from the seller of their choice. The antithesis of the free market is the totally planned economy: no competition, no choices. The virtues of the free market are demonstrated self-regulating characteristics and in the improvements in products, services, and prices that occur through competition. Self-regulation here refers to the adaption of types and quantities of goods and services to buyer wants. An electronic analogy for the free market is distributed processing with negative feedback; the planned economy is like centralized processing with far less feedback. The idealized free market also affords great opportunity for mischief and in some situations is not workable; practical economies have varying degrees of legal regulation, planning and control.

The *law of supply and demand* simply states that in a free market the prevailing price for a given item will vary until the supply equals the demand. A rising price tends to increase supply — more producers and sellers trying to get in on a good thing — and tends to shrink demand — fewer buyers willing to pay the higher price. Even in a partially controlled market, this law may function. During the oil embargo of 1973-74, the dollar price of gasoline was regulated. But the manhours (real) price escalated dramatically when one included the hours spent waiting in lines at service stations.

The change of demand with price is sometimes quantified. The *elasticity* of demand measures how much the demand changes for a given change in price.

The *division of labor is* the economist's name for the idea of specialization. A worker who only lays bricks is likely to be a more efficient bricklayer than one who also does plumbing, TV repair, carpentry, computer programming, and any other odd job that comes along. (As do-it-yourselfer I ignore this premise in my personal life.) Many skills in a technological society are so highly sophisticated that one simply must specialize and devote most of one's working time to the specialty in order to be proficient. Our economy requires many hundreds, if not thousands, of specialty skills. The division of labor has a hearing on the establishment of self-sufficient settlements in space since they will require some number of technological as well as other skills. The population must be large enough to encompass all the required skills. I don't know how large this is and have never seen a report of an analysis of minimum population size for a space settlement performed with division of labor in mind. Such an analysis might, among other things, help to dispel the notion that space residents will all be astronauts and computer scientists.

In order to have a highly industrialized economy, one must pay for the construction of factories and equipment. This is the problem of *capital formation:* where does all this wealth come from? It must, of course, come from the products of human labor. It is wealth diverted from immediate consumption. Think of it this way: if you had $5000, you could buy a new car (consumption) or purchase some capital stock in a corporation (capital formation). Those who invest some of the fruits of their labors expect a return, that is, they expect some reward for having chose investment rather than consumption. This may take the form of an increase in the value of their investment, e.g. in the price of the stock, or in the form of periodic payments, e.g. dividends, or both. I have seen capital gains and dividends called "unearned income" by ultra-liberals. This seems to be a case of ideology displacing common sense. One who elects to invest rather than consume deserves a fair return.

There are, of course, other means to capital formation. In the early clays of industrialization, the workers were grossly underpaid: their wages were small compared to the actual wealth they produced. Some factories made what today would be called "obscene profits." Ploughed back into the business, these profits represented intense capital formation and produced rapid growth. (This early exploitation of workers led to the philosophies of "public" rather than private ownership of the means of production. When put into practice, these philosophies have resulted in ownership of the means of production by the government.) Regardless of ownership, capital formation is absolutely necessary to an industrialized economy. If the means of production are government-owned, "investment" tends to be compulsory rather than voluntary; pay scales are set such that capital formation comes directly or indirectly from operating profits. (Never mind what they may be called, they are **profits.)**

I am spending quite a few words on investment because it is important to our subject in two ways: first in evaluating growth versus no-growth policies, and second, in the questions of economic feasibility of solar power satellites and of space settlements.

An economic unit, be it a corporation, a family, or a government, may also acquire wealth by *borrowing.* Borrowing is the act of acquiring real wealth now in return for a promise to repay with a greater quantity of wealth later. And where does the real wealth now come from? From the same place that capital formation comes from: investment. And what are these sources of investment? Some comes directly from individuals, but most comes from institutions: banks, savings and loan associations, insurance companies, retirement funds, investment institutions (e.g. mutual funds) and the like. All these sources have something in common: they are investing *your money:* your savings, your insurance premiums, your retirement fund, your mutual fund shares. The future income you are counting on from these kinds of sources is undoubtedly substantially tied up in someone's *promise to pay.* (The rest is probably tied up in the continued economic success of some group of institutions and companies.) Remember, all real wealth comes from the working population, not from a printing press. The ability of these institutions to make good on your investments is predicated on financial factors that assume continued economic growth.

The issue of economic growth versus limits-to-growth or no-growth thus has profound implications for everyone's future, both economic and political. Can you imagine voluntary investment in a no-growth or permanently declining economy, wherein the investor could count on his investment declining in real value? Or a lender voluntarily lending at negative interest rates? Yet the economic functions of investment and lending would still be required, although perhaps to a lesser degree. If not voluntary, then what? The answer is obvious.

Economic growth could be defined as an increase in aggregate perceived wealth. I have used the term **perceived** wealth to avoid the erroneous implication that economic growth equates to ever more profligate consumption of dwindling resources. Is endless economic growth possible on a finite planet? I don't know. I am not convinced the answer is negative, but I suspect the question is at any rate irrelevant.

One additional factor is extremely important to increasing productivity and to economic growth. This is the accumulation of knowledge and its associated technology. It is easy to understand that improvement of productivity depends in some way on development of knowledge and technology, i.e. better machines lead to greater productivity. It is extremely difficult to quantify this in any way. Improvements in productivity come from capital formation, from technology, and perhaps from other sources. The effects of the sources cannot be separated to allow measurement of each. I have seen some learned judgements that allocate productivity increases roughly equally between capitalization and technology. But no one knows if this is right. A common problem in analytical economics and the construction of economics models is that one cannot separate variables and effects and measure them in the laboratory. This is especially true of dynamics models (see below). It is as if we were trying to understand atomic and nuclear physics solely from observation of stars and other cosmic phenomena. It is not surprising that various economic models differ in their predictions.

Some simple examples of economic modeling

Two techniques are of particular interest to this subject - one because it has application in the analysis of space settlements and the second because it serves to illuminate some of the doomsday predictions of the World Dynamics studies.

The first example is input-output modeling. Input-output models are schemes for modeling the interrelationships in a complex economy. They amount to linear systems of equations. Let's use a simple example for a hypothetical space settlement. The actual values used in this example are assumptional, not supported by an analysis, and therefore no conclusions should be drawn from the results.

In a space settlement, suppose that:

Seventy-two working hours are available per person-week, not counting purely personal time.

Four hours per person-week are lost due to illness and other lost time factors.

Five hours per person-week are required for habitat maintenance.

Ten hours per person-week are required for agriculture.

Twenty hours per person-week are requited for domestics, trade, and so forth.

Settlement administration requires two hours per person-week plus 1/2 hour of export labor and 1/2 hour per hour of logistics operations labor.

Raw material throughput is 0.01 tons per manhour of export labor.

Finished product is 0.25 tons per ton of raw material.

Logistics operations require five hours of labor per ton of raw material

The problem is to determine the productivity of the settlement. The above assumptions can be arranged into a set of equations represented by the following matrix:

lost time	maintenanc	domestics, e	agriculture	administration	logistics	export labor	raw materials	finished product	
1	0	0	0	0	0	0	0	0	4
0	1	0	0	0	0	0	0	0	5
0	0	1	0	0	0	0	0	0	20
0	0	0	1	0	0	0	0	0	10
0	0	0	0	1	-.5	-.5	0	0	2
0	0	0	0	0	1	0	-5	0	0
1	1	1	1	1	1	1	0	0	72
0	0	0	0	0	0	1	-100	0	0
0	0	0	0	0	0	0	-4	1	0

This matrix can readily be solved with the following results:

.049225 tons of finished product are produced per person-week

. 1969 tons of raw material are processed per person-week

19.68 hours of export labor are available per person-week

.9845 hours of logistics labor are required per person-week

12.33 hours per person-week are required for administration.

To construct one 100,000 ton SPS per year, a settlement size of 39,000 people is calculated. The result is sensitive to productivity assumptions. If the productivity is increased by a factor of tell, i.e. to 0.1 tons of raw material per hour of export labor, the settlement size is reduced to about 5600 people. This example input-output model illustrates a type of analysis badly needed in the continuing study of space settlements. The studies of which I am aware have used the frivolous assumption that all (or at least most) of the settlement people are available for export labor. And no careful estimates of productivity have been made, to my knowledge. In fairness to the studies I am referring to, they simply did not have the time or resources to get into these matters. I think they should, however, be given high priority for future work.

The World Dynamics models developed by Meadows and others are a form of dynamic economics models. Whether these models are more than illustrative of a potential problem is debatable. They predict the collapse of civilization in the not so distant future due to exhaustion of resources, or massive pollution, or failure of food production, et cetera. The models are aggregates of differential equations numerically integrated by a computer. As discussed above regarding the problems of economic modeling, the key question is whether the equations have any relationship to the real world.

One can construct a very simple dynamics model that illustrates the crisis behavior exhibited by the World Dynamics models. One needs only to simulate exponential growth and a finiteness limiter to growth. Take the case of finite energy resources: Assume that (I) the pricing of the finite resource is inversely proportional to the amount remaining raised to some exponent,

$$\text{Price} = \text{Initial Price} \left(\frac{Q}{q} \right)^a$$

Assume that the law of supply and demand operates so that the amount consumed is depressed by a factor inversely proportional to the price raised to some exponent:

$$\dot{q} = (\dot{q} \text{ at Initial Price}) \left(\frac{\text{Initial Price}}{\text{Price}} \right)^b$$

Assume that the initial consumption is one percent of the quantity remaining, and that without the price depression of consumption, the consumption would grow exponentially;

$$\dot{q} = .01Q\, e^{ct}$$

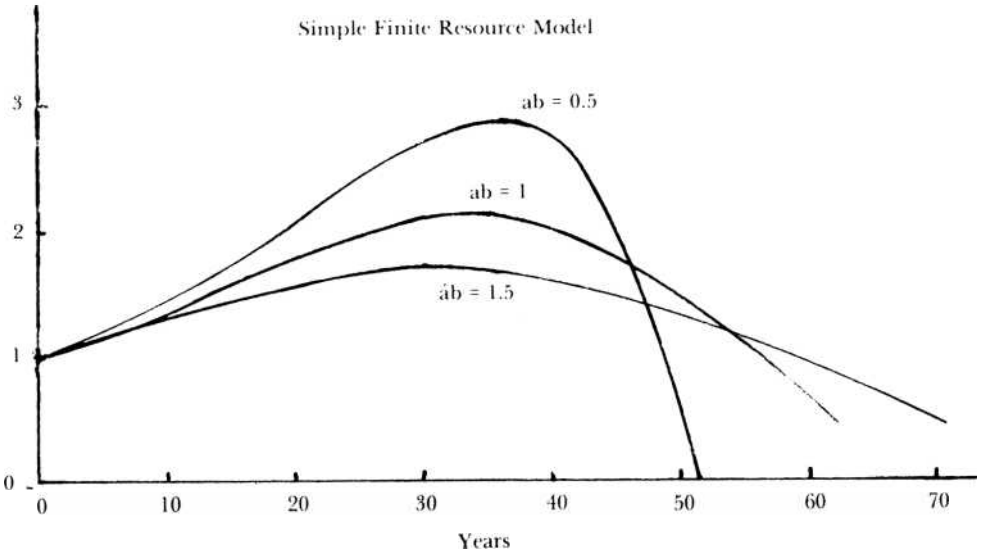
These can be combined into a differential equation;

$$\dot{q} = .01Q^{(1-ab)}\, q^{ab} e^{ct}$$

The equation has an exact solution:

$$q = Q\left\{ 1 + \frac{.01}{c}(1\text{-}ab)(1\text{-}e^{ct}) \right\}^{\frac{1}{1\text{-}ab}}$$

This model is so simple that you don't even need a computer! The rate of consumption is plotted for three values of the exponent ab below.



It is interesting to note that the consumption closely follows an exponential behavior until relatively close to the end. Real changes in price tend to be irregular and to take place in jumps. This kind of model would predict that in between price jumps, the consumption would tend to follow exponential behavior, but on a new (and lower) curve after each price jump . Interestingly, that seems to be what Is happening in this country with energy consumption.

In the next article we will take alternative views of energy supplies and futures.

1. Schumacher, E.F., **Small is Beautiful** , Harper & Row, 1973

2. If the rate of inflation is greater over the term of a loan than the rate of interest established for the loan, the borrower is in the fortunate position of being required to repay less real wealth than that which he or she acquired through the loan.

Responses to "Space Mines"

Eric Drexler's article on the legal status of space mining was interesting, but perhaps a little too optimistic. While one might interpret the Outer Space Treaty as flexibly as he suggests, that may not be the only treaty that will affect the mining of extraterrestrial resources. There is now before the U.N. Outer Space Committee a complete draft of an "Agreement Governing the Activities of States on the Moon and Other Celestial Bodies." This draft was put together by the Austrian Delegation, and has the tentative agreement of the other delegations to the Outer Space Committee.

This agreement draws heavily on the. language of the Outer Space Treaty, including clauses referred to by Mr. Drexler. But it appears to go farther in some respects, and it has articles which bear directly on the utilization of lunar and asteroidal resources.

The treaty's preamble notes the (unstated) benefits which may be derived from the exploitation of the natural resources of the Moon. Article I states that references to the Moon in the treaty include orbits around or other trajectories to or around it, and that the provisions of the treaty will also apply to all other celestial bodies within the solar system, other than the Earth, until such time as specific legal norms may enter into force with respect to those bodies.

Article IV provides that the exploration and use of the Moon will be the province of all mankind and will be for the benefit of all countries, irrespective of their degree of economic or scientific development. States are to inform the U.N. and the public of their activities concerning the exploration and use of the Moon, and the results of their missions.

Article VI requires states to take measures to prevent the disruption of the lunar environment or the contamination of it, and to inform the U.N. in advance of radioactive materials placed on the Moon. This article also provides for the creation of protected international scientific preserves of the Moon.

Article VII allows states to engage in the exploration and use of the Moon anywhere on or below its surface, as long as they do not interfere with the activities of other states. Article VIII allows states to establish manned and unmanned stations on the Moon, provided that they use only the area required for the needs of the station.

The most important part of the treaty for prospective moon-miners is Article X, under which the Moon and its natural resources would be considered the common heritage of mankind. The Moon would not be subject to national appropriation by any claim of sovereignty, or by use or occupation. Neither the surface nor subsurface of the Moon, nor any part thereof or natural resources in place, could become the property of any state, international organization, national organization, non-governmental entity, or any natural person. States signing the treaty would undertake to establish an international regime to govern the exploitation of the natural resources of the Moon as such exploitation becomes feasible. The main purposes of this regime would include (1) the orderly and safe development of the Moon's natural resources; (2) the rational management of these resources; (3) the expansion of opportunities in the use of these resources: (4) an equitable sharing by all states in the benefits derived from these resources, whereby the interests and needs of the developing countries would be given special consideration.

Under Article XIII, states will bear international responsibility for national activities on the Moon, whether such activities are carried on by governmental agencies or by non-governmental entities, and are to ensure that non-governmental entities under their jurisdiction engage in activities on the Moon only under the authority and continuing supervision of the appropriate state. Article XIV makes most of the articles of the treaty apply to any international inter-governmental organization which conducts space activities (e.g. the European Space Agency).

Article XV provides that all space vehicles, equipment, facilities, stations, and installations on the Moon will be open to other states.

The draft treaty contains a number of other provisions concerning the banning of nuclear weapons and other weapons of mass destruction from the Moon or orbits

and trajectories to or around it; the banning of military bases, military maneuvers, and the testing of weapons; the prohibition of the threat or use of force on the Moon or from the Moon; scientific cooperation, and shelter for personnel in danger; consultations and disputes; and other matters.

The key to Moon mining will be the international regime mentioned in Article X. But even the present draft treaty implies that private enterprise will not have free run of the Moon—or the asteroids. The draft treaty, and the yet-to-be-agreed international regime, also would apply to asteroids. It would appear that, in addition to mining, planetary terraforming might be restricted.

The full Outer Space Committee will meet in New York June 26 through July 7. Well before that time, the U.S. Government will have to take a position on the draft treaty.

Michael A.G. Michaud
Bethesda, MD

Eric Drexler's article on "Space Mines, Space Law and the Third World" makes some good points about the need to expand the world's understanding of the potential of space, but I think there are some basic problems with his image of what international law is and how it works.

Its very important to remember that international law is not like the domestic law of the US or any other country. In the US a sovereign—i.e., legally supreme—power makes laws which are binding upon itself and its citizens, and which it has the right and authority to enforce with its police and courts. But there is no one sovereign power in international law. International law is made by the mutual agreement of a number of sovereigns, each of whom is bound only to the extent that it feels and acts bound. There is no central court system with the right and the power to settle issues of law whether the parties concerned like it or not. Nations take international law fairly seriously for a lot of reasons, including the important one that is usually easier and cheaper to act legally than illegally. It saves an awful lot of hassle with everybody, including one's own citizens and officials, if a law exists on the matter at hand. Of course there are disagreements between sovereign nations on just what the law means, and other sovereigns are at liberty to try to enforce their particular view by means of diplomatic nasty notes, economic pressures, even war if it's important enough. But this means that international law is a sub-division of international politics, not a replacement for it: what laws are established, who they bind, and whether a nation stays bound even when doing so will cost it becomes a matter of the politics of law rather than of the wording.

From this perspective, Drexler's points are mostly either trivial or solid gold, depending less on the wording of the treaties than on political goals. Does one want to push a treaty phrase flat against the last possible wall, or are we interested in working within what is virtually certain to be seen by other nations as the "spirit" of the law?

For example, contrary to Drexler, the fact that astronauts bring back a few kilos of moon rocks for scientific study does **not** create a precedent which requires all nations to cheerfully accept establishment of a moon-mining facility using millions of kilos for industrial purposes. There is much more involved here than a mere matter of scale, as Drexler suggests. The 1967 Outer Space Treaty clearly encourages scientific exploration in space. It also clearly, explicitly and repeatedly forbids "national appropriation" of space resources and insists upon use of space resources in ways which do not discriminate, so that all nations may benefit "irrespective of their degree of economic or scientific development." Nor is it likely that one could get other nations to accept the argument that a US (Govt. or private, or joint) strip mine on the moon to provide materials for a U S space industry does not constitute "national appropriation." One need not plant flags and file claims to "appropriate" a resource. Consider: if you were an official or citizen of a rival or even doubtful nation, would you be willing to buy an argument like that? Since other nations are both judge and jury in deciding whether they'll accept some other nation's legal interpretation, I'm doubtful that well will many cases with such self-serving

Developing nations claim that as fellow human beings on our mother planet, they have a right to share in the benefits flowing from exploitation of a common property—the seabed or space. Drexler urges us to show that space exploitation actually increases access to resources and will be of great value for all nations. This is an excellent point, but the developing nations want a share of the benefits—be they resources, energy, or hard cash profits—and they want them guaranteed up front. Who can blame them? Many developing nations see exploitation of the seabed space as a dandy way for the rich to get relatively richer and the poor to stay poor. While Americans may not for a minute believe that the US is an imperialist colonialist exploiter, in many countries that merely proves that naive, self-serving, egotistical nature of the

The point then is that the US interpretation of international law is not and cannot be the only one, nor can it be enforced on other nations. We cannot avoid challenges if we act in ways which invite them, and it is reasonable to think that well get further and faster if we can mobilize a cooperative effort rather than trying to go it alone. For instance, Drexler makes an excellent political point when he proposes that the US accept some self-limiting resolution: a guarantee not to "appropriate" more than some very limited share of the resources of space for our exclusive use. If the potential of space is as large as we think, such self-limitation is relatively costless in any practical sense, immensely useful in a symbolic sense. That's the kind of appreciation of the political realities of international law which will help; an attempt to insist upon a rather transparently self-serving reading of the law will hurt. There's a "second law" in politics too: if we want something, we'll have to pay for it one way or another.

Jack Salmon
Williamsburg, VA

Eric Drexler's article in the April issue is an interesting interpretation of international law, but he fails to recognize the need for security of investment. Before a company invests in commercial exploitation of the moon, it must be assured that the developing countries will not invoke the principles expressed in the 1967 Space Treaty in an attempt to share in profits or even take over the facilities. Though no precedent exists for

U.S. Delegation to the Outer Space Committee

Who will represent the United States at the Outer Space Committee June 26-July 7 where the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies" will be negotiated?

The tentative list (as of May 15) shows Gerald B. HeIman, Deputy Assistant Secretary of State for International Organizational Affairs as delegation head; the first alternate will be Neil Hosenbal, general counsel for NASA; second alternate, Steven Bond of the Stale Department: senior advisor, Herbert Reis, head of the U.S. mission to the United Nations; advisory board members Irwin M. Pikus (State Dept.), Kalman Scheafer (Federal Communications Commission), Commander Edward Melanson (Dept. of Defense), Helen Cupperman (NASA) and Edward Iift (NASA).

interpretations of the treaty which would require international agreements, only such agreements will assure the security of investments (short of war).

International conflict will undoubtedly arise if a US company begins mining the Moon. Perhaps this was an influential factor in NASA's decision to exclude the lunar resource idea. The fact that US and USSR missions returned lunar samples cannot justify unilateral exploitation of the Moon to the exclusion of developing nations in the face of such agreements as Articles I and II of the treaty. And withdrawal from the treaty is certainly no answer, for we then would be unable to demand compliance with other articles such as IV, which prohibits placement of weapons of mass destruction into space.

The developing nations are not asking us to save some for them, but they want to participate. If we agree that they have good reason to favor exploitation of space, why challenge them by doing it unilaterally? We should set up a private transnational corporation, or maybe a public multi-national company, to begin space industrialization. Because this venture is in the interest of all countries, I believe international cooperation will be forthcoming—unlike the law of the sea convention. In fact, the establishment of a legal regime in outer space may set a precedent to finally settle the seabed conflict.

The proponents of a national approach appear to favor creating international conflict, in derogation of international principles and our own national policies, rather than cooperation.

Brian Maxwell
Tempe, AZ

Response to Responses to 'Space Mines'

by K. Eric Drexler

I share Jack Salmon's perceptions on the nature of international law (hence my statement that "... more than just signed treaties affects international relations," and my subsequent discussion of third world interests and positions), and thank him for his clear discussion of the basic concepts. As he points out, the issue is international politics, which flows from precedent, treaty, power, and perceived interests. Our greatest leverage at present is on the latter—which just happens to motivate the whole show. My point in discussing the 1967 Outer Space Treaty was not to show that it (or anything else!) can "require all nations to cheerfully accept establishment of a moon-mining facility", but to show that, contrary to the impression many have gained from past discussions of space law, the U.S. has not yet signed away its right of access to a share of space resources. Salmon seems to agree that the treaty has many possible interpretations (I will refrain from a second round of nit-picking on possible meanings of "national appropriation"), and that nations will follow their interests. We must recognize, however, that other nations do not yet *understand* their true interest in space, any more than does our own. This was the thrust of the latter part of my article, with which Salmon appears to agree.

Brian Maxwell fails to recognize that I recognize the need for security of investment. Again, the topic is vast, and my article was short. Multi-national corporations may well represent a viable approach, and should receive further attention.

Michael Michaud discusses a draft agreement deserving great attention from those interested in our future in space. It is explicit where the 1967 treaty is not. By denying property rights in extra-terrestrial materials, this agreement would discourage space colonization. Further, it would apply the undefined concept "common heritage of mankind" to space resources in the very midst of a battle over the same concept as applied to the seabed—and, as I have argued, the seabed makes a very poor analogy to space.

An agreement intended to divide supposedly scarce resources among the nations of Earth will be bad law if the real problem is speedy exploitation of unlimited resources and eventual division of the solar system among the people of space. An agreement made today would necessarily be the work of blind people; an agreement made in the future could be a working constitution for humanity in space. Those interested in a decent future in space should work to delay sweeping agreements of this sort until such time as the world better understands the significance—for everyone's sake.

Precis of the Article in 17 Col. J. Transnational Law 67 (1978) on

"DOMICILE AND INDUSTRY IN OUTER SPACE"

by J. Henry Glazer

The flight of the space shuttle constitutes the first step for introducing in space a far-flung, yet totally interdependent, "system of artifacts" leading ultimately to space industrialization and human settlement. To achieve these ends people will be obliged to use space as a permanent place of abode (domicile) and not merely as a medium for transient voyages.

The article explores whether the existing state-centric system of international law is flexible enough to accommodate people as domiciliaries in outer space or whether drastic departure from the present system—such as "World Government" as suggested in an early study by NASA's Marshall Space Flight Center—would be a necessary concomitant. The research points out that the four existing Space Treaties are not geared to the regulation of interdependent "systems of artifacts" in space. Nonetheless, the paper suggests that the present state-centric orientation of international law is not only flexible enough to accommodate people as space domiciliaries but also furnishes an optimum format for space settlement.

These near-term legal events must be addressed immediately by the proponents of space settlement, or contemporary treaty-making could hobble, if not pre-empt, the future of space settlement itself.

As supported by precedents in international law and by the other sources which have been cited in the footnote material, the following conclusions have emerged from this study. All are of novel impression in the research literature.

1. World Government is not the *sine qua non* of space settlement. In fact, the opposite is true. The present state-centric system of international law, if it endures for the next hundred years, should ensure that a

healthy variety of entities, both public and private including profit-making, will have a hand in the venture. Their involvement portends that political power during early or beginning states of space settlement will not be monolithically centralized.

2. The imminent negotiation of a Moon Treaty, and increasing international regulation of the geostationary orbit, are near-term legal events which will affect substantially the future of space settlement. However, international conferences and draft treaty texts concerning the Moon and the geostationary orbit are oriented to resource allocation for States on Earth, and do not take into account in any degree space settlement and the future priority needs of space settlers for such natural resources. These near-term legal events must be addressed immediately by the proponents of space settlement, or contemporary treaty-making could hobble, if not pre-empt, the future of space settlement itself. One approach might be for private proponents to seek collectively so-called "Non-governmental Organization" status under the United Nations Charter, in order to ensure that a proper flow of expert information takes place on international as well as domestic levels.

3. Space law in its present posture deals with "space objects" and lunar-emplaced facilities in an isolated or limited context. It is not responsive in identifying a usable legal regime applicable to a far-flung, yet totally interdependent, "system of artifacts" essential for space settlement—ranging from habitats at the Lagrangian points, to a Moon-based mass driver, to PowerSats in geostationary or bit, and to the various spacecraft derived from shuttle geometries which are to service all these. Future space treaties which elaborate the status of objects in space and permanent facilities constructed on celestial bodies, should be oriented toward a "systems approach" in the regulation of all such artifacts, and not deal with each category in an isolated context.

4. Both the technical and legal regimes of re-usable Earth-to-Space Transport systems (the Shuttle) are moored, and will remain moored, to aeronautical experience. In marked contrast, the technical and legal regimes of intraspace transport (carriage of goods and persons in space alone) will tend to follow maritime experience. With respect to intraspace transport, this study has furnished to the research community the legal concept of "Space Cabotage" (a concept derived from Maritime Law) which is defined as follows:

> **Space Cabotage:** "Means navigation between points in space including those on or above celestial bodies other than Earth by spacecraft neither designed nor intended for flight or passage in or through terrestrial airspace."

Of all of the legal and technical regimes in space the future one of "Space Cabotage" is most susceptible to exploitation by private enterprise with minimal public regulation or interference.

5. The study is one of only a few in the legal literature dealing with the question of human rights and fundamental freedoms in the context of space settlement. Treaty-criteria for emigrant selection are also proposed as well as it common working language for space. Adverting to legal precedents in treaty law and in the law of diplomatic relations the paper proposes that French be adopted for this purpose.

6. On the matter of space settlement, presentations to the Congress of the United States and to others have tended to focus upon engineering and "hard sciences" aspects, together with the enormous costs involved. It might be wise, however, to investigate in greater depth and to furnish the Congress and others with reports focusing upon the inexpensive "soft science" problems bound up in space settlement research such as those concerned with the rational extension into outer space of human rights and fundamental freedoms; operational roles for private enterprise in the system of artifacts essential for future space settlement; juridical modeling for solar power delivery; the tree City approach to space settlement in lieu of sovereign entities: the dangers of negotiating a Moon treaty, at this time, without taking into account the priority needs of space settlement and Spacekind. The "Million Dollar Research Grant" is clearly not essential to explore, and to resolve, these important questions, all of which are as central to space settlement as the engineering and "hard sciences" necessary to bring it about.

Epilogue to "Domicile and Industry in Outer Space":

SOME REFLECTIONS BEYOND THE CITY IN SPACE

by J. Henry Glazer

For some, the *sine qua non* of space settlement is world government, an ideal which ignores completely the pluralistic quality of the international community with its almost universal consensus against any drift toward a monolithic planetary Earth State. For others, neither the existing nor future political alignment of the planet will be of any importance when tested against the scientific postulate that space settlement must inevitably produce a sense of cosmic "apartheid" so total in separating humankind and the space descendants they will spawn that each will be obliged to treat the other as an alien life form.

The purpose of this investigation was not to assail these positions. The results, however, tend to support the conclusion that the impact of such positions upon space treaty-making at the key international conferences remaining in the Twentieth Century *is destined to be imperceptible.* Thus, it will continue to fall to the orthodox space jurists with their positivist doctrine to shoulder the essential burden of formulating defensible models for space settlement.

The narrow object of this investigation focused initially on whether a person as a domiciliary, and not just a transient voyager, could be accommodated in space without frontal assault on the state-centric system of international law. In concluding that this was possible, a funny thing happened, however, on the way through the Free City of Danzig' to the Free City of Lagrangia, precipitated by one of the strangest paradoxes of the Twentieth' Century. The paradox is that good can come out of evil and evil out of good, and that:

"The 'goodness' in 20th-century

thought was the burgeoning idea of unity of peoples as exemplified first in the League of Nations and then in the United Nations. The 'badness' was seen in the residual 'tribalism' of people that separated one group from another out of pride, or fear, or envy, or contempt. In the modern world such tribalism takes national form. "[2]

By some strange dint of irony it seems to have been the backward-looking person with his primitive sense of homeland rather than the forward-looking cosmopolite with loyalty to none who has managed to impede and even check the march of murderous despots from Austerlitz to Auschwitz—thereby proving anew, and for all the wrong reasons, that in history "goodness" and badness are inextricably intertwined.

In the milieu of space settlement, "goodness" for space jurist and Star-Trek aficionado alike seems to be institutionalized in the personage of the future space inhabitant as agent and cosmic envoy for a collective humankind while "badness" remains lodged in the virulent tribalism which remains rife and abroad on the planet. To a limited extent, and doubtless unwittingly, the scientific literature on space settlement contributes to this fund of "goodness" by sheltering humankind's envoys in a "space *colony", a* term which, for the juridical purist at least, conjures up the image in space of a dependent political community tied to some future single Earth-State, yet to be established, whose benevolent (or oppressive) writ extends to every area of our planet and to all people both on and off of it. The "bad" derived from all of this "good" is that such a colony would not merely become a clone-colony of the Earth-State, but perhaps a clod-colony reflecting in its peoples all of the leveling of national diversity and elimination of differences digested in the giant maw of some cylindrical or Torus-like Orwellian nightmare.

For the Western-style democracy in retreat before contingents of gun-toting rulers, dictators, and presidents for life, each with the latest U.N. anti-Zionist resolution in hand, a certain allure must persist for the preservation of the state-centric system of international law and the *rational* perpetuation in outer space of the wide diversity which it is bound to engender. In the paradox of "goodness" and "badness," however, the counter argument seems irresistible that it is precisely this diversity, precisely this "tribalism", which has caused for millenia all the war and misery afflicting planet Earth and human condition. The potency of that counter argument cannot be met save by hopeful speculation which focuses upon the conceptual differences between sets of treaty obligations in space as opposed to those on Earth.

Of the four conventions which exist for space, one is dedicated in its entirety to the rescue and return of persons and space objects. On Earth, SALT talks continue to generate proposed texts for terrestrial disarmament treaties, but in space the *prevention of armament treaty* has managed to make its debut and with it another chance for all of us. [3]

If these distinctions are lost upon statespeople, they may still be of some currency to the writer of science fiction weaving a plot around a powerful cultural taboo in space against force of arms—its primeval source, in Twentieth Century treaty-making, lost forever in aeons of time which in their passage witnessed the settlement of the entire solar system by a kind and congenitally nostalgic Homo alterios.[4]

So it was that in a demonstration of Spain's imperial power to the innocent natives of the New World, the cannon from NINA, with PINTA standing by, poured roundshot into the shipwrecked SANTA MARIA the day after New Year's 1493,[5] while separated from that event, through a millenium of time and space, not one among the sixteen-thousand member expeditionary force of officers and crew sent in the star ships ATHENS, DANZIG, and LAGRANGIA to terraform the lifeless planets of Barnard's Star had ever fired, had ever seen, or had ever known of, a military weapon.

References

1. The Free City of Danzig, unique in the annals of international law, was established after World War I under the provisions of the Treaty of Versailles as a less-than-fully sovereign community. Human rights and fundamental freedoms were secured to the Free City's inhabitants by an unusual melding of treaty law and local municipal law with disputes resolved from time to time through the advisory opinion process of the Permanent Court of International Justice at The Hague. The author concludes that the treaty model for the Free City of Danzig can serve as a precedent for the establishment by treaty of Free Cities in Space.
2. "The Intertwining of Good and Bad", Chicago Daily News, October 29, 1976. Reprinted by permission of Sydney J. Harris and Field Newspaper Syndicate.
3. Significantly the Antarctic Treaty, the Seabed Demilitarization Treaty, and the Space Treaties contain the common theme of "prevention of armament" in those places.
4. In his book **Living in Outer Space,** the commentator, Robinson, suggests that the physical and psychological characteristics of space settlement are bound to produce in future generations a being in space, "Homo alterios", whose value-forming processes differ in kind, rather than degree, from those of his Earthbound ancestor, Homo sapiens.
5. This description of Columbus' departure from the New World homeward bound for Spain is reported in Morison, **The European Discovery of America,** 81 (Oxford Univ. Press 1974).

Space Habitat Class Offered

It is interesting to note island societies are considered as peaceful and contained, while frontier societies are considered lawless and aggressive. Will space settlements be the frontier? Will they be islands? How might they perceive the Earth, and each other?

These and other questions will be taken up in a new University of Massachusetts/ Amherst course titled "Environmental Concerns, Earth Habitat/Space Settlement," to be offered this fall at the Orchard Hill Residential College.

The course, listed as Orchard Hill 290E, examines the concepts of space settlements, addresses the issues implicit in the design and building of systems which support large numbers of humans, and then looks at the actions we may take in managing or mismanaging our earthly habitats.

Based upon two books; **Colonies in Space** by T.A. Heppenheimer, and **Earth Habitat/Space Settlement**, by J. W. Stryker, the course is taught at two levels; a popular or overview suitable for freshmen and sophomores in any discipline, and at a rigorous level suitable for juniors and seniors in environmental science, physics, engineering and the biological sciences.

Topics covered are: the mathematics and physics of space settlements and the earth habitat; energy and resource management; human factors and human values; pollution and health; ecosystems, classical terrestrial and hypothetical ecosystems suitable for space settlements; and applications of high technology to solve environmental problems.

Thoreau said 125 years ago, "What use is a house if you haven't got a tolerable planet to put it on?" This course addresses the problems of making both Earth habitats and space settlements liveable, hospitable, and humane.

For more information, contact Orchard Hill Residential College, 413/545-2882.

Inside the L-5 Society

L-5 SOCIETY, INC.

REVENUE
AND EXPENSE STATEMENT
July 1, 1977 - April 30, 1978

REVENUE	
Membership Fees & Donations	$47,318.83
Sales	18,450.96
Misc.	14.61
TOTAL REVENUE	$65,784.40
EXPENSE	
L-5 News, Mailing, & Purchases	$32,716.41
Operating Expense	29,704.71
TOTAL EXPENSE	$62,421.12
NET OPERATING SURPLUS	$ 3,363.28

Annual Elections

The annual election of the L-5 Society Board of Directors has arrived. Please detach this ballot and mail it back in the attached envelope. We request that you sign the ballot envelope.

The ballot lists all candidates for the Board which received approval from the Nominating Committee. Its members were Carol Motts, Conrad Schneiker, John W. Braue III, H. Keith Henson and Barbara Marx Hubbard.

You can vote for as many Directors as you wish, including write-in votes. Not voting for a candidate is equivalent to voting against him or her as each candidate must receive votes in excess of half the total number of ballots cast in order to be elected.

The Nominating Committee recommends that you vote for all candidates listed. They are recommended on the basis of their work towards the goal of having tens of thousands of people living and working in space by the end of this century. They have all taken an active interest in the work of the L-5 Society.

What is the job of the Directors? They are responsible for setting policy and controlling expenditures of the Society. They are the guardians of the interests of the members.

Also on the ballot are some bylaws changes. They have been drawn up in response to recommendations the US Chamber of Commerce has provided for associations.

The annual meeting will be held July 15th at 2 PM in the L-5 office at 1060 E. Elm, Tucson, Arizona. At the meeting ballots will be validated and counted. (We are waiting that long because experience tells us some of you will once again receive the **L-5 News** late. If it hasn't arrived by June 26th, please complain to your local post office and also to us and we will file another complaint.)

Bylaws Changes

I do ____ do not approve all the proposed changes.

(If you do not approve all the proposed changes, please check which of those below you approve. *Please remember, failure to vote for bylaws changes is equivalent to voting against them.)*

The L-5 Society Board of Directors has proposed the following changes and additions to the Society bylaws:

Article VII: Officers

__Section 1. Officers of the organization shall be a President, Secretary and Treasurer, and Coordinators as needed and authorized by the Board of Directors. As soon as practical after the Annual Meeting and election of the Board, The Board shall nominate and by majority secret ballot elect from the members of the Board the Officers. Each Officer's term of office shall be coterminous with and dependent upon each Officer's tenure as a member of the Board, except that a retiring Officer shall continue to serve until replaced by the new Board.

__Section 2. Officers who resign or otherwise vacate their position may be replaced by the Board, using the procedure in Article VI, Section 2 above.

Article VIII: Duties of the Officers

__Section 1. President. The President shall preside at membership meetings. The President shall have charge of the business of the organization and shall administer all affairs of the organization in accordance with the Charter and these Bylaws, and shall act as official spokesperson of the Society, but in all cases the President shall be bound by the policy established by the Annual Meetings and the Board of Directors. The President shall sign all contracts, appoint the Chair of all committees responsible to the President, and may sit as an ex officio member of all committees.

The President may, with approval of the Board of Directors, hire and appoint an Executive Director, to whom may be delegated operational responsibility for such duties as may be appropriate.

(Note: this material would replace the current Art. VIII-1, thereby deleting most references to Coordinators. Since the original assumption about the role of Coordinators has not been fulfilled, this seems appropriate. Art VIII-4 still allows appointment of Coordinators for special projects. The provision for an Executive Director is new.)

__Section 2. The Secretary shall maintain records of the proceedings of all meetings and shall discharge such other functions as the President or the Board shall direct. The Secretary shall carry out official correspondence, preserve written records (except financial records), keep the membership roll, provide notice of meetings of the Board or the Society, and shall receive, verify and record all votes of the Board or Annual meeting. The Secretary shall have charge of maintaining and supplying copies of the Charter, these Bylaws, and other official papers of the Society.

Article X

__Section 4. Voting shall be by mail or secret ballot. Each ballot shall be returned to the Secretary, who shall certify the election of each person who shall obtain a majority of votes from among those voting.

Section 5. The President shall cause to be announced in the next available issue of the Society Newsletter the names of such persons as are elected to the Board.

Article IV. Dues and Assessments.

Section 1. Delete Section I and replace with "The annual dues for each member of the L-5 Society shall be determined by the Board of Directors."

Under our present bylaws, a small group can pack the Annual or a special meeting and take action damaging to the Society. We propose renumbering Article V, Section 5 to Section 6 and inserting:

__"Section 5. The authority to approve policy positions, statements on behalf of the L-5 Society, and institution of new programs shall be reserved to the Board of Directors."

____It may be wise to require Board approval of bylaw changes, in -addition to the presently required 2/3 of members' votes. Hence, we propose that Article XI, Part A be amended to read "Approval by majority vote of a quorum of Directors at any meeting of the Board of Directors."

We propose amending Article X, Section 3 to delete "The number of Directors to be elected will be determined by majority vote of the Board of Directors." Also, we propose adding: "Section 7. A special election to elect additional members to the Board of Directors may be called at any time by majority vote of a quorum of the Board of Directors."

Article XII - Indemnification

__"The L-5 Society, by resolution of the Board of Directors, provides for indemnification by the association of any and all of its Directors or officers or former Directors or officers against expenses actually and necessarily incurred by them in connection with the defense of any action, suit, or proceeding, in which they or any of them are made parties, or a party, by reason of having been Directors or officers of the L-5 Society except in relation to matters as to which such director or officer or former director or officer shall be adjudged in such action, suit, or proceeding to be liable for negligence or misconduct in the performance of duty and to such matters as shall be settled by agreement predicated on the existence of such liability for negligence or misconduct."

If we are sincere about our goal of "to disband, in a mass meeting, at L-5" (Sept. 1975 **L-5 News**) we should include:

Article XIII—Dissolution

___The L-5 Society shall use its funds only to accomplish the objectives and purposes specified in these bylaws, and no part of said funds shall inure, or be distributed, to the members of the L-5 Society. On dissolution of the L-5 Society any funds remaining shall be distributed to one or more regularly organized and qualified charitable, educational, scientific, or philanthropic organizations to be selected by the Board of Directors."

(Please check the candidates you wish to elect to the L-5 Board of Directors.)

_____Isaac Asimov—He is a science writer whose articles on space settlements have appeared in publications ranging from **National Geographic** to the **Saturday Review** to **Fantasy & Science Fiction.**

_____Senator Barry Goldwater, Sr.—He was one of the first members of Congress to support both solar power satellites and space settlements.

_____Robert A. Heinlein—He is a science fiction writer; his books such as **The Man Who Sold the Moon** and **The Moon Is a Harsh Mistress** foresaw many of the issues which are now a matter of serious international debate.

_____Gordon R. Woodcock—He is Boeing's solar power satellite study manager.

_____Barbara Marx Hubbard—She chairs the International Committee for the Future. She was one of the earliest financial supporters of space settlements research, and was responsible for framing House Concurrent Resolution 451.

_____Hon. Edward R. Finch, Jr.—He is Chairman of the American Bar Association Aerospace Law Committee.

_____Arthur Kantrowitz—He is Director of Research at Avco-Everett Labs and one of the world's foremost experts on lasers.

_____Philip K. Chapman—A scientist/astronaut, he was responsible for crew training and coordination for the Apollo 14 mission in 1970. He is an advisor to the Earthport project and currently works for Arthur D. Little, Inc. on solar power satellites.

_____Norie Huddle—She is an environmentalist and author of **Island of Dreams,** a chronicle of the environmental crisis in Japan.

_____Harlan Smith—He is head of the Astronomy Department at the University of Texas in Austin and Director of McDonald Observatory.

_____Konrad K. Dannenberg—He is a veteran of Peenemunde, former project director of the Jupiter missile system and deputy manager of the Saturn Program.

_____J. Peter Vajk—He is a space industrialization researcher for Science Applications, Inc.

_____Jack D. Salmon—He is a professor in the Department of Political Science at Virginia Polytechnic Institute and State University.

_____H. Keith Henson—He is president of Analog Precision, Inc. and a space industrialization researcher. He was the first president of the L-5 Society.

_____Carolyn Meinel Henson—She is the editor of the **L-5 News** and current president of the L-5 Society.

_____William Weigle—He has been the treasurer of the L-5 Society since it was founded in 1975.

_____Phillip Parker—He has been the President of the West European Branch of the L-5 Society since 1975.

_____Mark Hopkins—He is a researcher with Rand Corporation.

Write-in votes:

_____

_____

_____

_____

Article I

The name of this organization shall be the L-5 Society.

Article II

The purposes for which the Corporation is formed are to operate exclusively for charitable and educational purposes, namely to promote space colonization. In furtherance of these goals the corporation may:

A.
1. Educate the public with technical and general information.
2. Conduct research.
3. Fund research by others on solar energy, space colonization and related areas.
4. Prepare models for use in space and participate in their use.
5. Carry out other activities in furtherance of these goals.

B. In order to carry out and achieve the foregoing purposes the Corporation may:
1. Receive, hold, administer, lend and expend funds and property.
2. Make contracts.
3. Solicit, collect, receive, acquire, expend, invest and lend money and property, both real and personal, received by gift, contribution, bequest or otherwise.
4. Sell and convert property, both real and personal into cash.
5. Use the funds of the Corporation for any of the purposes for which this corporation is formed.
6. Purchase or acquire, hold, use, sell, exchange, assign, convey, lease or otherwise dispose of and mortgage, or encumber real and personal property.
7. Borrow money with or without security and to incur indebtedness and secure the repayment of the same by mortgage, pledge, or deed of trust on real property or personal property of the Corporation.

C. The foregoing statement of purpose shall be construed as a statement of purposes and powers and the purposes and powers in each clause shall be regarded as independent purposes and powers.

Notwithstanding any of the above statements of purposes and powers, this Corporation shall not engage in activities which in themselves are not in furtherance of the charitable and educational purposes set forth in paragraph A of this article.

Article III

Membership

Section 1. Regular membership in the organization shall consist of all who are willing to serve, attend meetings of the membership, vote, and who have contributed dues for the current year.

Section 2. Student membership in the organization shall be limited to those who are enrolled in a recognized academic institution and shall be entitled to all the privileges and prerogatives of regular members.

Section 3. Institutional membership in this organization is open to all organizations and corporations. Institutional members shall be entitled to all of the privileges and prerogatives of regular members, except that they may not vote at elections, hold elective office in the organization or act as chairman of a standing committee.

Section 4: Non-members may attend and participate in all open meetings, social gatherings, and any regular activities of the organization, except that they shall not have a vote in any decisions, and may be required to contribute their fair share toward any expense incurred through such participation.

Section 5. The powers of the members of this organization shall be limited to those usually held by stockholders of a commercial corporation, as such powers may be further limited by the Laws of Arizona and the U.S.A. for members of a non-profit corporation.

Article IV

Dues and Assessments

Section 1. Each regular member shall pay dues of $20.00 per individual or per family per year, $10.00 per student. Institutional members shall pay dues of $100.00 per organization per year. (Minor children of all members may participate in all educational and social activities of the organization.) Dues shall be payable to the Treasurer on the first month that they begin to receive the newsletter and become delinquent on the 30th day of the month in the following year. Suspension of membership shall be automatic if dues are not paid within thirty days. A member may be re-instated upon payment of current dues.

Section 2. There shall be no general or special assessment levied against the membership, unless approved by a two-thirds (2/3) vote of all members after discussion at a duly constituted meeting. This provision, however, shall not prevent any member or group of members from making voluntary donations to the organization for the support of specific projects.

Article V

Meetings of Members

Section 1. There shall be at least one (1) regular business meeting of the membership each year, which will be the Annual Election meeting. Special meetings of the membership may be called at any time by concurrence of at least three members of the Board of Directors. The Secretary shall notify members by mail of the time and place of each meeting, at least two weeks in advance. Such meetings may be conducted by mail or by phone.

Section 2. Business of the organization may be transacted at any meeting attended by not less than three members, hereinafter called a quorum, of the Board of Directors. This meeting may be held over the telephone or by mail, with all decisions mailed to the three or more Board Members at that meeting for majority vote in order to be valid.

Section 3. A simple majority vote of a quorum shall decide all issues calling for a vote, unless a greater number shall be required by law or these by-laws. Only paid-up members shall be entitled to vote at these meetings, and each member shall have only one (1) vote on each issue. Votes for amendment of the By-laws or Annual Elections, and upon demand by any member, the vote on any other question before the meeting, shall be by written secret ballot. Members may vote by U.S. Mail and members shall not be required to be present at any meeting to vote thereon provided notice is given to each member and such notice included full particulars of the nature and extent of the issue to be voted on.

Section 4. The rules contained in Robert's Rules of Order, Revised shall govern all meetings of the organization in all cases where applicable and not inconsistent with these By-laws.

Section 5. The decisions reached by duly constituted meetings of the membership shall be binding upon the Board of Directors and shall be executed by the officers to the best of their ability. No member or group of members other than said Directors or Officers shall approach any outside organization or act as representative of the organization without the prior approval and authorization of the Board of Directors granted at a regular or special meeting of said Board.

Article VI

Board of Directors

Section 1. The Board of Directors shall consist of at least five qualified members of the organization who are duly nominated and elected to Directorship by the members at large at an annual election as hereinafter provided. The term of office shall be one (1) year, beginning with the Annual Meeting.

Section 2. Any vacancy on the Board occurring through death, resignation, disqualification, or any other cause, may be filled for the unexpired term by an affirmative vote of the majority of a quorum of the remaining directors.

Section 3. A board member may be removed for just cause by a majority of the Board.

Section 4. The Directors shall meet whenever required, at the time and place or by telephone or mail upon written or telephoned request of three or more of the elected officers. Verbal notification to all Board members may be given in any manner necessary to assemble a quorum.

Section 5. Any three (3) members of the Board of Directors shall constitute a quorum for the transaction of the business of the Board.

Section 6. The business of the Board of Directors shall be conducted in such order as the Board may from time to time determine by resolution.

Section 7. The Board of Directors shall have the management and control of the operation of the organization. The Board may exercise all of the powers of the organization, and do all such lawful acts as it deems necessary of the membership as prescribed by these By-laws and the laws of the State of Arizona and the U.S.A.

Article VII

Officers

Section 1. The Officers of the organization shall be Coordinators as needed and authorized by the, Board of Directors, Secretary, and Treasurer. At the Annual Meeting, and immediately following the election of directors, the newly elected Board of Directors shall nominate and by majority secret ballot, elect from the members of that Board the Officers. The term of office of each officer shall be coexistent with and dependent upon each officer's tenure as a member of that Board of Directors. The newly elected officers shall be installed at the end of the Annual Meeting.

Article VIII

Duties of Officers

Section 1. Coordinators. The Coordinators shall choose one of their numbers to preside at any given meeting of the membership and the Board of Directors, that person not necessarily being the same for all meetings. That person shall have general charge of the business of the organization discussed

in that meeting and shall administer all affairs of the organization in reference to business done at that meeting subject to the direction of the Board. That person shall be responsible for implementing Board action to carry out all general policies and projects established by vote of the membership at that meeting. That person shall sign all contracts duly entered into by the organization after approval by the Board of Directors at that meeting. That person shall appoint the chairpeople of standing committees related to these activities and special committees and sit as an ex-officio member of such committees when expedient. These Coordinators shall call regular and special meetings of the membership of the Board of Directors as required, and instruct the Secretary to notify members thereof. In the absence of the Secretary, the Coordinators will appoint a Secretary Protem. In this manner different Board members will be able to take responsibility for different projects or duties.

Section **2.** Secretary. The Secretary shall be present at and record the proceedings of all meetings of the organization and of the Board of Directors. That person shall be responsible under the Coordinators for all official correspondence for the organization and shall preserve all written records, except financial records, of the organization. The Secretary shall keep a roll of all members, and shall receive, verify, and record all absentee ballots or proxy votes. That person shall give reasonable written notice of all meetings to the members thereof, and prior to each meeting shall inform the Presiding Officer of any correspondence or unfinished business to be transacted, and verify that a quorum is present. The Secretary shall keep available to all members of the organization copies of the Constitution and these By-Laws, including all amendments thereto.

Section 3. Treasurer. The Treasurer shall receive, record, and safeguard all monies paid into the organization, including collection of dues. That person shall keep full and accurate books of account for all financial transactions of the organization, and shall render a financial report when called upon by the Board of Directors or the membership. That person shall open the books for inspection at any time deemed necessary or desirable by the Board of the membership. The Treasurer shall pay all bills duly approved by the Board of Directors. The Treasurer shall prepare and present to the Board of Directors an Annual Financial Report, covering all transactions for the calendar year, July 1 through June 30. The Treasurer shall inform the Secretary of all new memberships and dues paid, as needed.

Section 4. Coordinators. They shall be chosen by majority vote of the Board of Directors to head up specific projects as needed.

Section 5. All correspondence, conveyances, encumbrances, releases, discharges, contracts, or obligations of the organization, of every nature and description, shall be executed or countersigned by the President, unless the Board of Directors otherwise directs.

Section 6. Local Chapters. The Board of Directors of the L-5 Society shall recognize any local chapter that has at least one member of the L-5 Society in it and whose activities are in agreement with the Articles of Incorporation and the By-Laws of the Society. Local chapters may include members who are not members of the L-5 Society. Each local chapter shall elect a President, Secretary, and Treasurer. The Secretary of the local chapter shall be responsible for keeping the L-5 Society informed of the local chapter's activities. The Treasurer shall provide the parent organization with the financial records of the local organization when requested by the Board of Directors. Local chapters shall have the right to establish additional by-laws regarding their chapter, providing that the by-laws do not conflict with the By-Laws or Articles of Incorporation of the L-5 Society. The local chapters shall have the right to determine how locally raised money is to be used, providing that its use does not conflict with the By-Laws or Articles of Incorporation of the L-5 Society. The L-5 Society shall, upon request of any of its members, provide the names and addresses of the nearest local chapters. The tax status of the L-5 Society shall also cover the local chapters which are recognized by the Board of Directors. If the Board finds that a local chapter has engaged in activities in violation of the By-Laws or Articles of Incorporation of the L-5 Society, it shall revoke its recognition of the local chapter. Any local chapter which is not recognized by the L-5 Society shall not fall under the tax status of the Society, nor shall the Society be held responsible for its actions.

Article IX

Expenditures

Section 1. All proposed expenditures up to and including $500 may be approved by the Coordinators responsible. All proposed expenditures exceeding $500.00 shall be approved by the Board of Directors prior to actual disbursement.

Section **2.** All expenditures are subject to review by the Board of Directors at any meeting.

Section 3. The Board of Directors is responsible for maintaining appropriate records to account for all property purchases for or owned by the organization.

Article X

Annual Elections

Section 1. At least one month prior to the Annual Meeting, the Board shall appoint a nominating committee, at least three of whom are not current members of the Board of Directors.

Section 2. Not less than one week prior to the Annual Meeting, the Chairperson of the nominating committee will provide the Secretary with the names of the selected nominees, and the Secretary will notify the membership of the time and place for the meeting, and the names of all current Directors and nominees.

Section 3. At the Annual Meeting, the Chairman of the nominating committee shall place in nomination the slate of candidates selected. Thereafter, the membership at large may make additional nominations from the floor, and the Secretary shall place in nomination any names proposed by absentee ballot. All such nominees who do not personally decline shall comprise the slate of candidates for election to the Board of Directors. The number of Directors to be elected will be determined by majority vote of members.

Section 4. Voting shall be by written secret ballot. Each ballot shall be filled in with as many names of the voters' choice as desired up to the previously voted upon limit. The nominating committee shall tabulate the ballots, including absentee ballots, in the presence of the membership. All candidates receiving the **vote** of a majority of members voting in the election shall be elected Directors.

Section 5. The election results shall be confirmed and announced by the presiding officer at the Annual Meeting. That person will preside as chairperson protem while the newly elected **Board** of Directors shall immediately elect from among themselves the new officers of the organization. The new Officers shall be announced and installed before the end of the Annual Meeting, and serve from that date.

Section 6. The Annual Meeting will be held in June, or earlier if decided by a majority **vote** of the **Board.**

Article XI

Amendment of By-Laws

The By-Laws of this **organization** may **be** adopted, amended, or rescinded in whole or in part by a three-stage procedure as follows:

A. Approval by majority vote of a quorum of members at any duly constituted regular or special meeting of the membership, or by majority vote of a quorum of Directors at any meeting of the **Board of** Directors.

B. Publication by U.S. Mail to all current members, of the intention to make, amend, or rescind the By-Laws, with a brief outline of the proposed changes, and notice of time and place for a regular or special meeting of the membership **to vote** on the **proposed** changes.

C. Final approval by a two-thirds (2/3) majority vote of a quorum of members present at a duly constituted meeting of the membership, to be held not less than one month following notification as required above **or by** two-thirds (2/3) **vote** of those responding by mail if the vote is held **by** mail.