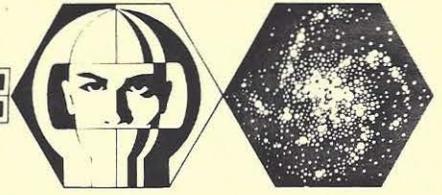


COMMERCIAL SPACE REPORT



ENERGY

Progress Towards Profit

This is the year that laser powersat potential has come to the attention of space power advocates. High powered lasers in space could potentially revolutionize both space industrialization activities as well as the energy marketplace on earth.

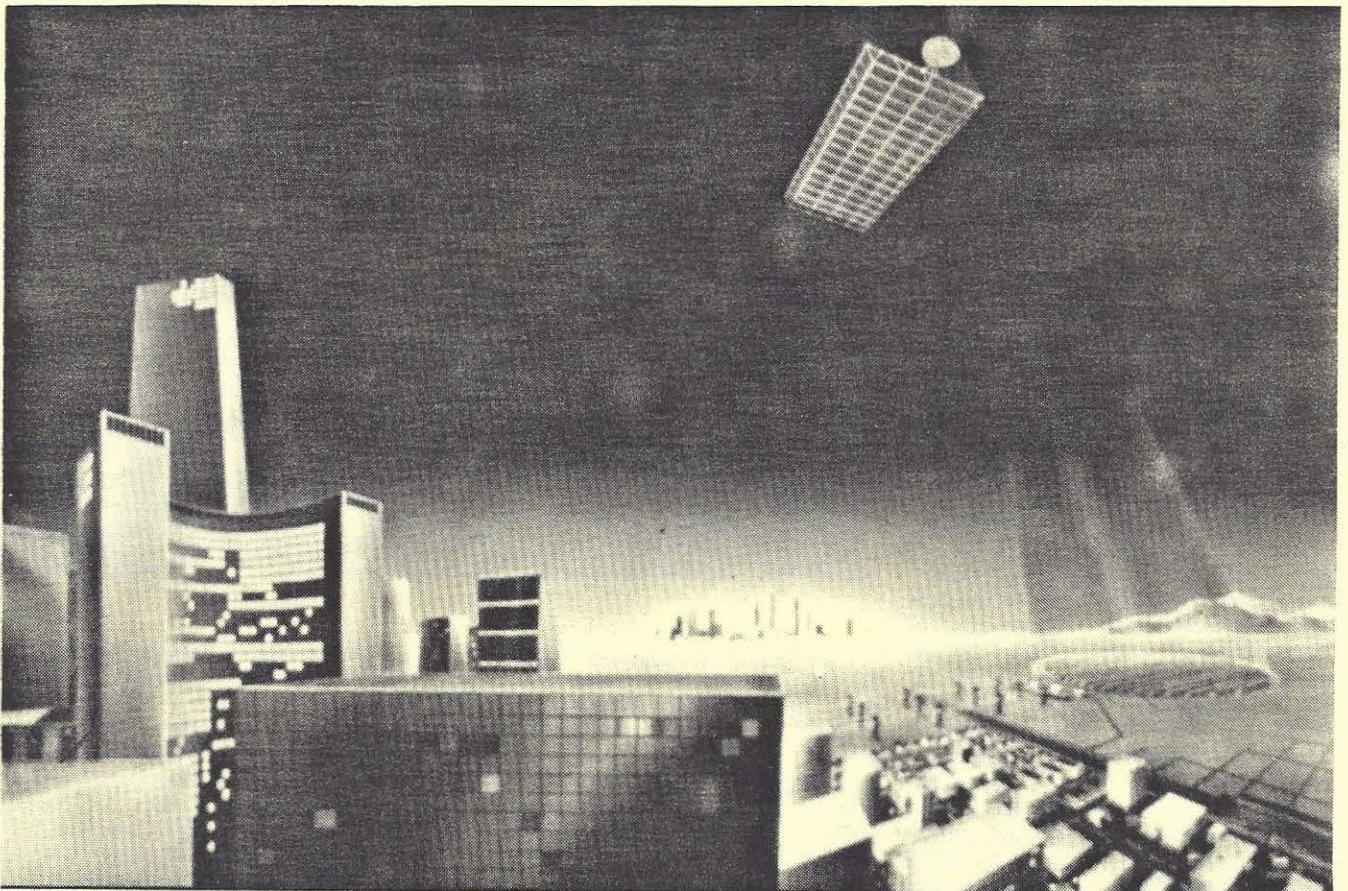
Using lasers that are directly pumped with solar energy or indirectly pumped via electricity derived from solar cells, it would be possible to design orbiting power stations which could direct focused beams of laser energy to the ground in the near future. Compared to the conventional microwave solar powersat concept, the

lasers offer several advantages. First would be a much lower capital cost to develop the system, since the lasers can be deployed at power levels of around 100 megawatts each rather than the 5000 to 10,000 megawatt figure necessary for microwave SPS. This means the project can be begun on a small scale without the massive investment necessary for the original SPS concept. Also, it appears that the laser beam offers less potential for environmental and communication system disruption than does the microwave beam planned for conventional SPS. The laser system might allow the

YEAR END SUMMARY ISSUE

At the close of the second complete year bringing you news and opinions about space industrialization and commercial space activities worldwide we once again offer a summary of interesting and important events from the past year.

1979 has been a year of both achievement and potential disaster. The disaster, of course, is the movement of the draft Moon Treaty from the UN Committee on the Peaceful Uses of Outer Space to the floor of the General Assembly for vote, with the approval of the United States. The achievements have been in many different fields. In this issue we will look at Energy, Resources and Transportation.



use of direct laser energy on the ground in process heat applications and in manufacturing.

The proponents of microwave satellite solar power systems have also had a reasonably good year. A bill before the United States House of Representatives to allocate \$25 million for research to investigate SPS has recently been approved. Passage is still necessary in the Senate, however, and this appears less likely. The SPS concept has been addressed in magazines with large circulations such as *Science*, the official journal of the American Association for the Advancement of Science. Meanwhile the concept has gained wide popularity in the aerospace and technical community. However, the first major criticism of SPS has also surfaced this year, including comments by the environmental lobby known as the "Citizens' Energy Project". In their report number 40, entitled *Solar Space Satellites*, and funded by the Department of Energy, they attack the concept. One of the chief concerns of this group is that the SPS may fall out of geosynchronous orbit, and hit the earth as Skylab fell from low earth orbit.

On a more realistic note, the ever accelerating world energy crisis is bringing more attention to the opportunity of using space solar power as a secure means of insuring energy independence for the United States in the decades to come.

RESOURCES

Space Raw Materials for Both ET and Ground Use Practical

This past year, the 4th Princeton Conference on Space Manufacturing was held in May at Princeton University, and attracted more than two hundred participants. A prime focus of the conference was extraterrestrial resources.

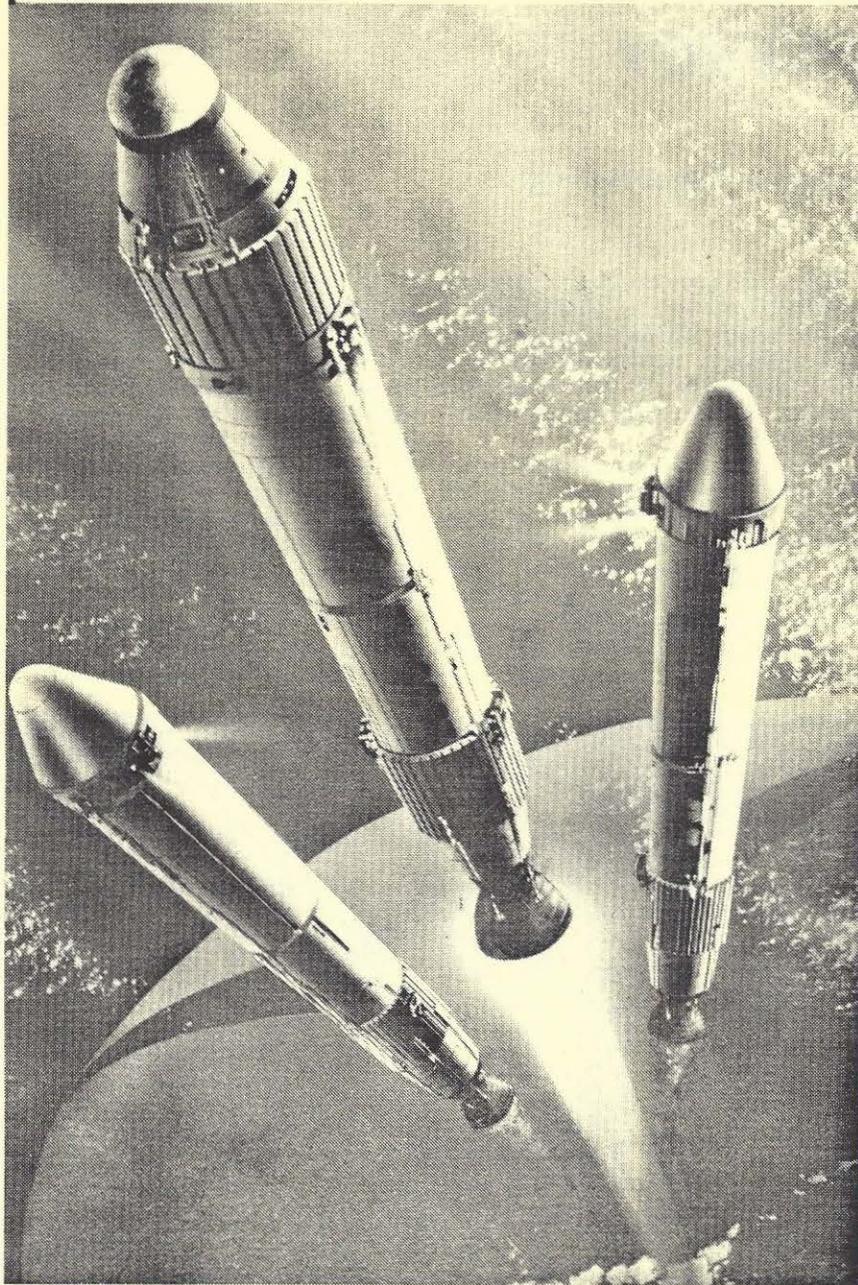
For the first time it was suggested in a scientific paper that resources of the moon and the asteroids could be used to fill market needs on earth, rather than be used in space manufacturing exclusively (though see *Report*, January, 1978). David Kuck, a geological and mining consultant in Arizona, presented the paper and suggested that a one hundred meter diameter asteroid could have a precious metal content worth 2 to 3 billion dollars. He also examined the possibility of obtaining titanium from the moon for sale on earth, which now is being seriously considered by other lunar scientists.

At the same conference, Drs. Waldron and Criswell of the Houston-based Lunar and Planetary Institute suggested novel chemical processing means to extract metals and other materials from the lunar soil. The plant that they propose should be capable of processing its own weight in products every week, and would be located in space rather than on the moon.

Staff scientists at the Jet Propulsion

Laboratory, meanwhile, are attempting to determine ways to use the cometary flyby mission (now in trouble, see *News Notes*) to investigate the resources available at a carbonaceous chondrite asteroid. There are several reasons to conduct such a mission including analyzing the asteroid to determine if it could be moved into high earth orbit for space manufacturing purposes.

Foundation, Inc. has announced completion of a two year long study of the Commercial Large Launch Vehicle (CLLV). Illustrated in the artist's conception below, the vehicle would be capable of inserting payloads into earth orbit from 10,000 to 150,000 pounds. Initial cost/pound would be about \$50, dropping to \$16 with advanced engines and large traffic volume. Development cost would be less than \$40 million. *Artwork copyright © 1979 by Ron Finger.*



Another motivation to investigate the use of asteroids came, curiously enough, from Princeton Professor Theodore Taylor (former director of the ORION project and a member of the President's Commission on Three Mile Island). He cautioned that there is a hazard of large object collisions with the earth. He suggested that because of the 100,000 to 1 odds that a major collision could occur in any year, it would be practical to spend up to 10 million dollars per year to track asteroids which might impact the earth at a future time. Besides giving us warning with sufficient time to move the objects from a collision course, it is also likely that a search could aid in the location of valuable extraterrestrial resources.

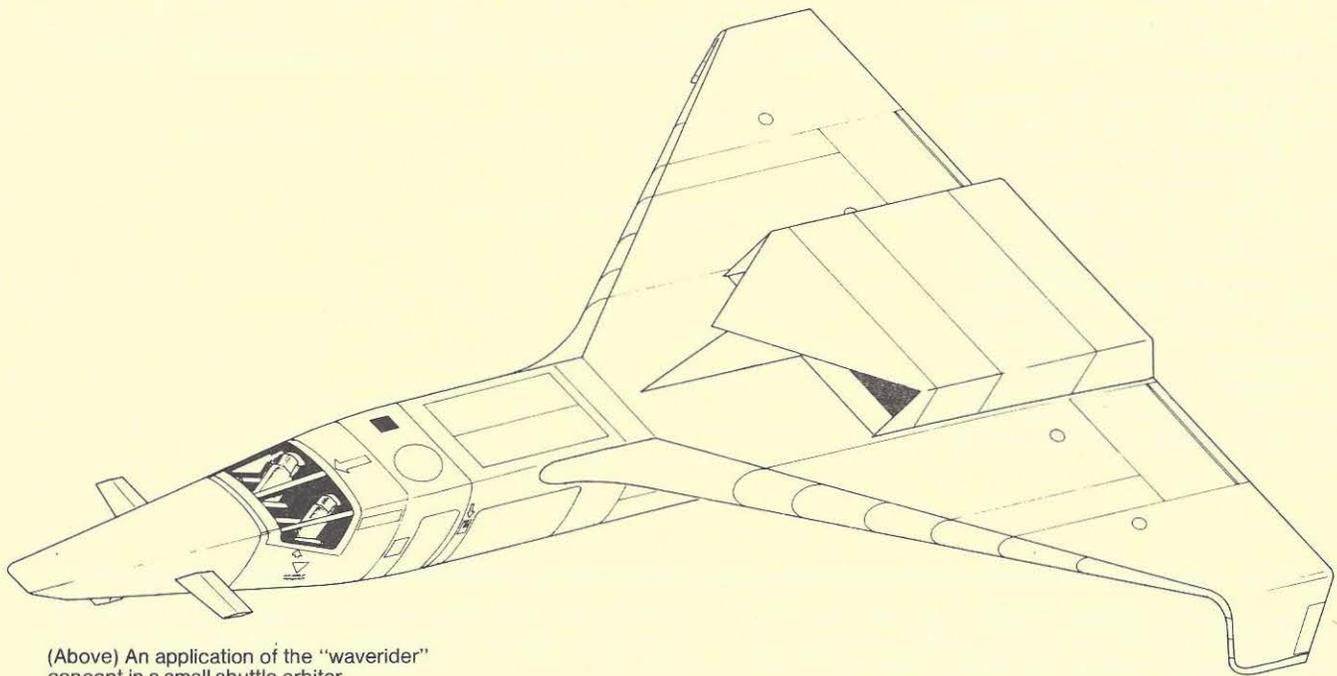
The National Academy of Science is now considering whether or not resources in space could be used for the manufacture of space solar power stations. The Academy held a meeting in Washington during the last week in November, and has apparently come to

the conclusion that space derived resources must be considered for SPS as seriously as earth-launching manufacture schemes, according to an attendee at the meetings.

The big story in ET resources this year, of course, was the untimely approval of the draft Lunar Treaty by the UN Committee on the Peaceful Uses of Outer Space on July 3rd. This agreement, which space industry observers generally agree would effectively ban the exploitation of the space frontier and space resources by private enterprise, would be a disaster to those who hope to benefit from this new high frontier. However, recent information about the attitudes of some US Senators (see *News Notes*) lead to cautious optimism about the possibility that the Senate might not give the necessary advice and consent to the treaty should the President sign it. Given the present concerns of the Carter Administration in the coming year, it is likely that no action might be taken on this agreement for the

duration of the Presidential campaign.

Besides the near term resources possibilities which have already been addressed, it is fascinating to consider the opportunities afforded us following the close look at the Jovian system obtained by the Voyager 1 and 2 spacecraft this year. All the materials for large scale space industrialization exist in the Jovian system, including hydrocarbon compounds in the atmosphere of Jupiter, and water and other raw materials on the surface of the major satellites of the giant planet. Carbonaceous chondritic materials are available in Almathea and probably in the newly discovered small satellite which is just outside the ring system. It is a source of "geo" thermal energy from subsurface heating which could be used to power industry on the other satellites via power relay by laser or microwave beams. It is now a candidate for investigation as a possible terraforming target as well, using water launched from the other satellites.



(Above) An application of the "waverider" concept in a small shuttle orbiter.

TRANSPORTATION

The Options Increase for Low Cost Travel

This is the year which saw the advent of the High Performance Solar Sail, the mass driver launcher which could operate from the surface of earth, new "waverider" aerodynamics, and the Supersonic Orbital Airship.

At the Princeton Conference earlier this year, MIT student Eric Drexler

proposed a version of the conventional solar sail which, if made in space out of very thin reflecting metal films, could far out perform any previous solar sail concept. According to Drexler, a sail several kilometers in diameter could be fabricated in less than a year with automated machinery

which would be no heavier than a few tons. This sail could reach Mars with a useful payload in about four months. Such sails would be useful for asteroid mining, and the sails might ultimately be constructed from asteroidal materials.

At the same conference, Henry Kolm of MIT also proposed a new version of an old idea. Kolm suggests it might be possible to build a version of the mass driver (which is proposed to operate only on the lunar surface or in the vacuum of space as a reaction motor) that could launch telephone pole sized slugs of nuclear waste (or other ma-

terials) off earth. The high speed that the payloads could achieve with mass driver launching would mean that the "vehicles" could reach escape velocity even if they lose a substantial portion of their velocity during their 8 second transit of the atmosphere.

Krafft Erhicke, formerly of Rockwell and now with Space Global Corp. in La Jolla, California, has suggested an equally hair-raising idea for landing payloads on the moon. He proposed in a paper at the recent International Astronautical Congress in Munich a means by which incoming rockets would use practically no fuel during landing if they used the effect of friction on the lunar surface to brake. He thinks the landers could be equipped with drag brakes and could touch down on a lunar runway much like an airplane.

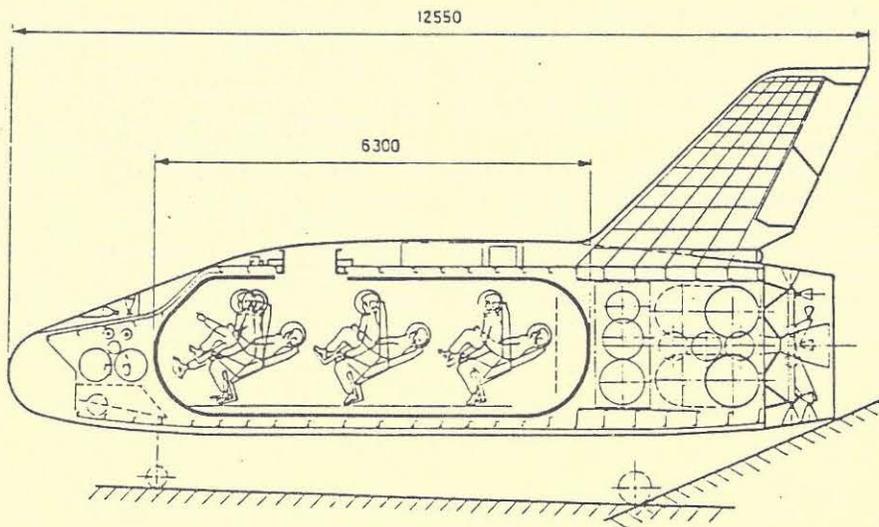
From the same conference came a paper by Arthur C. Clarke concerning orbital elevators (which is also the subject of his latest and last novel, *The Fountains of Paradise*). Clarke pointed out that while we could not build a tower to geostationary orbit at this time for earth, a lunar one might not be out of the question.

Also from Europe came two interesting developments. One is a new proposal for a manned Space Shuttle-like vehicle which could be orbited by the Franco-German Ariane booster and would carry a crew of six people into earth orbit. The other is from a British team of aerodynamics researchers who have come up with a new design for reentry vehicle. The concept, called "waverider", uses a high wing and a specially shaped body to fly more gradual reentries than the Shuttle. This would lead to lower heating

and longer crossrange for the orbiter.

Lasers are also in the news. NASA has recently performed some tests of a laser propulsion concept which has doubled the predicted performance of laser boosted vehicle. And at the Princeton Conference, researcher Liek Myrabo suggested that very large, lightweight spaceships could be built using the principles of the old airships,

coupled with MHD engines driven by orbital lasers. The advantage of his plan is that entire sections of space settlements could be lifted into orbit from earth in *one piece*, using thousands of times less laser power than any propulsion scheme proposed until now. He calls his idea the Supersonic Orbital Airship . . . and the largest of the three he proposes is *one kilometer long*.



(Above) The proposed French "Hermes" mini-shuttle.

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NEWS NOTES:

CITIZEN'S ENERGY PROJECT PANS SPS...Washington D.C...The Citizen's Energy Project, in a government-financed report, declared solar power satellites to be a "centralized, highly complex and economically as well as environmentally expensive technology." The report expresses several fears. Among these is the concern over the centralization of energy generating facilities in the hands of an amalgam of government and space-and-power industries. The use of the SPS in wartime, either as a weapon or as a hostage to the good behavior of the satellite-dependent nations was also mentioned. Environmental problems mentioned in the report hinge on "long-term" effects, with the worry expressed that even very low levels may be harmful. It was pointed out in the report that although the SPS levels of radiation are only 1/10 the official U.S. microwave limits, they are over 100 times the stricter Soviet standards. (It is assumed that the Soviets have extended a special exemption to the U.S. embassy in Moscow.)

THE VIKING FUND...Menlo Park, California...The last of the two Viking orbiters is due to run out of attitude control gas early in 1980. This eliminates the last signal relay for the two landers on the surface of Mars. However, the Viking I lander, located near the Martian equator, could still send back data direct to earth in short "bursts" until 1990. NASA is grudgingly agreeing to fund the reception and storage of this data, but money is needed for analysis and continued experiments. The San Francisco section of the American Astronautical Society is establishing the "Viking Fund" to guarantee continued operation of the Deep Space Network as well as potential follow-on activities. This is an important effort to shift funding of a financially small but scientifically important portion of the space effort to the private sector. Donations (minimum \$1.00) should be made payable to the Viking Fund, and sent to: THE VIKING FUND, P.O. BOX 7205, MENLO PARK, CA 94025. All contributions are tax-deductible. Contributors will receive acknowledgement of their gift, regular updates on the Fund and Viking, and an open invitation to the presentation of the fund to NASA in July 1980.

HOUSE AUTHORIZES INITIAL SPS SPENDING...Washington D.C...On November 16, the House of Representatives passed a bill to allow spending of \$25 million on initial R & D for Solar Power Satellites. The bill, passed by a vote of 201 to 146 faced stiffer opposition than a similar bill which passed the House by a vote of 267 to 96 last year. Prospects in the Senate appear dim.

LASER PROPULSION HEATS UP...Aviation Week and Space Technology reports NASA experiments in propulsion by heating a gas to a plasma with an external laser beam have resulted in possible performances of up to 4000 seconds specific impulse. This is over 8 times the efficiency of the best hydrogen-oxygen rocket. The concept uses a laser to sustain a hot

plasma which then is used to heat the remaining propellant.

NEW JOVIAN MOON...Pasedena, California...The NASA Jet Propulsion laboratory has reported the discovery of another moon around Jupiter. About a third the size of Almathea, the new moon lies within Almathea's orbit and barely skirts the outer edges of the Jovian ring system. The moon was discovered during analysis of a Voyager photograph of the ring system.

SPACE COVERAGE...Washington...Science, the prestigious journal of the American Association for the Advancement of Science, has in the last month devoted three articles to space-related matters, which it generally ignores. A major article on the problems of the Space Shuttle led the list in the November 23rd issue, with an article on the Moon Treaty following in that same issue. The treaty article quoted the Report in regard to to treaty, but did not mention this newsletter's name. In the November 30 issue, Science covered the recent House vote on SPS research funding, but spent much of the article emphasizing the "trillion-dollar pricetag" of a full blown SPS.

MOON TREATY STALLED?...Washington...In an encouraging development for foes of the draft agreement on the moon and other celestial bodies, the ranking majority and minority leaders of the Senate Committee on Foreign Relations have written the Secretary of State: "There are several aspects of this draft agreement which could prove damaging to our national economic and security interests, and we urge you to instruct the United States delegation to the 34th UNGA (United Nations General Assembly) not to support the opening of this treaty for signature as presently drafted". The three page letter, dated 30 October, is a welcome step forward in getting a renegotiated agreement. It is unlikely that the State Department and the Administration, whose hands are already full with other matters, will find it useful to flout the expressed wishes of the head of the committee, Sen. Frank Church or the minority leader, Sen. Jacob Javits. The Carter administration needs their support on the upcoming SALT II vote. The letter closes: "...we urge that the United States delegation take no action during this General Assembly to further commit the United States to the draft moon agreement. Indeed, we hope that the treaty will be returned to the Committee on the Peaceful Uses of Outer Space and not opened for state signature until revised." The Foreign Relations Committee would ultimately have to approve the treaty before it could be accepted as the law of the land in the United States, even if the President signs it.