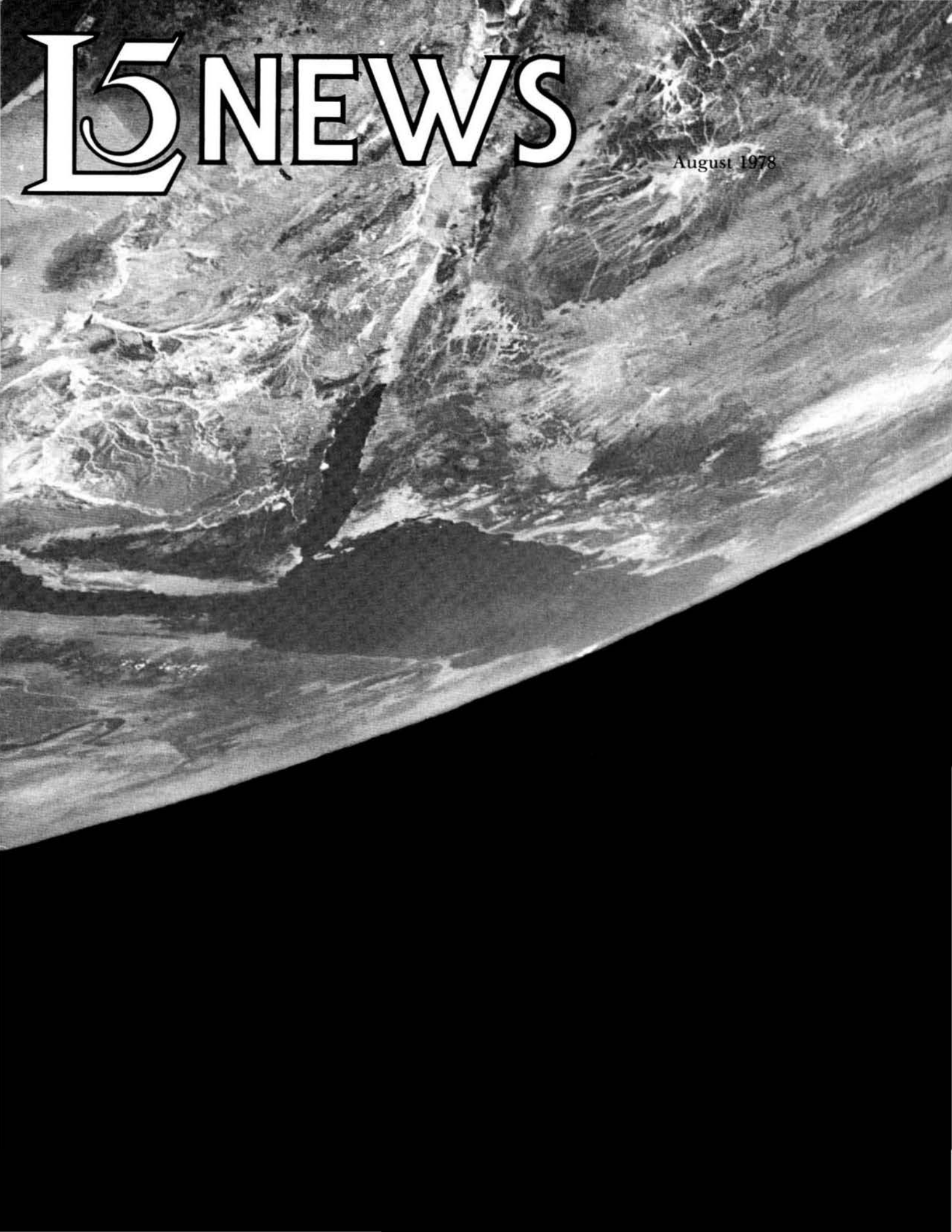


# L5 NEWS

August 1978



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Cover: The planet Earth. Above the "L" is the Mediterranean; above the "W" is the Dead Sea.



# Skyhook!

by Hans Moravec

*A satellite in low circular orbit has two huge tapered cables extending outwards and rotating in the orbital plane, touching the planet each rotation. The tip velocity cancels the orbital velocity at the contacts, as in a rolling wheel. It can gently lift loads from the surface and accelerate them to escape velocity, and capture and lower speeding masses. Taper is minimized when the satellite's radius is one third the planet's, and for Mars and the Moon is reasonable with existing materials such as fiberglass and Kevlar.*

The idea of a planet to orbit transportation system involving an enormous tapered cable extending from a synchronous satellite to the ground has been in the literature for almost two decades (1, 2, 3.). It has hitherto been considered applicable only in the distant future, when materials stronger than any now available come into existence.

This report points out that the combination of a new material, Kevlar (4) and a new, less expensive, satellite skyhook configuration (5, 6) makes skyhook transportation feasible now on bodies as large as Mars. On the moon, in particular, a Kevlar skyhook has enormous advantages over rockets for the supply and crew rotation missions envisioned for

space industrialization efforts (7).

A synchronous skyhook is made by lowering a cable from a synchronous satellite to the surface, balanced by an even longer cable extending outwards from synchronous orbit. Anchored to the ground and put into tension by a ballast at its far end, it would be a cosmic elevator cable, able to deliver mass to high orbit

with extreme efficiency, also providing a means for extracting the rotational energy of the planet. Such a structure cannot reasonably be built on Earth given existing structural materials. It would be possible if a cable with 10 times the strength/weight ratio of steel, or  $\frac{1}{3}$  the theoretical strength/weight ratio of crystalline graphite could be fabricated. A graphite cable with a density of  $2.2 \text{ g/cm}^3$  and a tensile strength of  $2.1 \times 10^{11} \text{ dyne/cm}^2$  could be fashioned into a synchronous terrestrial skyhook which had only 100 times ground level cross section at synchronous orbital height. At any one time it could support one powered elevator massing  $1/6000$  of the cable mass (6).

Mars has a much shallower gravity well, and a synchronous skyhook for it is almost reasonable with conventional materials. Kevlar is a new superstrong synthetic from the DuPont Co. With a density of  $1.44 \text{ g/cm}^3$  and a tensile strength of  $2.76 \times 10^{10} \text{ dyne/cm}^2$  it has about 5 times the strength/weight of steel. Stressed to half this, to build in a safety factor of two, Kevlar can be used to construct a synchronous martian skyhook with a taper of 16,000:1, able to support  $10^{-6}$  of its own weight at a time. The numbers for the Moon, which has little gravity, but rotates very slowly, are 17.5:1 and  $1/13,000$ .

The concept of a non-synchronous skyhook is illustrated in Figure A. A satellite in low circular orbit is elongated enough to just touch the surface in certain positions. It spins so that, like a rolling wheel, its rotation cancels its tangential velocity during the contacts with the surface. Such a structure can be constructed to orbit at any height, and a synchronous skyhook is a special case.

In very high orbits the forces on the cable must be integrated over long distances, resulting in large tapers. For very low orbits, the satellite must spin rapidly to keep the contact points stationary, and the quadratic dependence of centrifugal force on rate of spin results in a large taper in the limit. The taper is minimized between these extremes, when the radius of the skyhook is about  $1/3$  the radius of the planet.

An optimum size skyhook of this kind touches down six times per orbit. It is much smaller than the synchronous variety for the Earth, Moon, and Mars, but its length is still enormous by conventional standards. Because of its scale, its motion near the ground during touchdown is purely vertical. It appears to descend with a constant upward acceleration, coming to a gentle momentary stop, then ascending again. This acceleration is 1.4 gravities on Earth, 0.28 g on the Moon and 0.5 g on Mars.

A load attached to the bottom end of such a skyhook during a touchdown will be accelerated to a maximum of 1.6 times escape velocity at the highest point of the cable end's trajectory. Launching a mass in this manner extracts rotational and orbital energy from the skyhook, and lowers the orbit. Conversely, a high velocity craft which rendezvous with and attaches itself to the upper end of the cable, and is then decelerated and lowered to the ground, injects a similar amount of energy. Simultaneous docking of equal masses at both ends of a skyhook would leave the orbit essentially unchanged. The most plausible way to operate a device like this may be to have the cable ends merely approach the surface at a safe distance. A small rocket could be used to match the relatively tiny velocity and position differences between the cable tip and the ground. It would then be possible to borrow and deposit small amounts of orbital energy without risking collisions of the cable and surface.

Table 1 lists parameters for optimum size fiberglass and Kevlar skyhooks for some solar system bodies. Fiberglass is assumed to have a density of  $2.5 \text{ g/cm}^3$  and a tensile strength of  $2.41 \times 10^{10} \text{ dyne/cm}^2$ . Kevlar has a density of  $1.44 \text{ g/cm}^3$  and a tensile strength of  $2.76 \times 10^{10} \text{ dyne/cm}^2$ . Orbital period is how long it takes the skyhook to make a full circuit of the body. The liftoff acceleration is the vertical acceleration experienced by a skyhook payload near the ground, not including the surface gravity of the planet. It gives an indication of how long the touchdown lasts. "Taper" is the ratio in cross sectional area between the center of the skyhook, where it is thickest, and the tips, where it is thinnest. The "Mass" columns give the ratio between the mass of the skyhook and the largest payload that it can support at one time at each end. Thus a lunar Kevlar skyhook can lift  $1/13$  of its own mass. The numbers assume the skyhooks are stressed to at most half the strength of the material of which they are made, thus incorporating a safety factor of two.

Evidently Earth and Venus are too large for Kevlar skyhooks. Kevlar is strong enough for Mars, Mercury and all the moons of the solar system.

Some current plans for space industrialization call for transport of large quantities of equipment and people to and from the Moon. The proposed linear accelerator mass driver (7) is ideal for launching ore from the Moon. However, it provides no way of bringing payloads down to the surface, and with its 1000g accelerations and small mass unit is unsuitable for launching bulkier and more delicate loads.

A Kevlar lunar skyhook is able to lift and deposit  $1/13$  of its own mass every 20 minutes, and subjects payloads to a maximum of 0.45 g of acceleration. It would seem to be a desirable alternative to expensively fuelled rockets for routine supply and crew rotation missions to the Moon's surface.

#### References and Notes

1. Y. Artsutanov, *Komsomolskaya Pravda*, July 31, 1960 (contents described in Lvov, *Science* 158 946 [1967]).
2. J.D. Isaacs, A.C. Vine, H. Bradner, G.E. Bachus, *Science* 151 682 (1966) and 152 800 (1966) and 158 946 (1967).
3. J. Pearson, *Acta Astronautica* 2 785 (1975).
4. J.H. Ross, *Astronautics & Aeronautics*, 15-12 44 (1977).
5. The central idea in this paper, of a satellite that rolls like a wheel, was originated and suggested to me by John McCarthy of Stanford.
5. H.P. Moravec, *Advances in the Astronautical Sciences*, 1977, also *J. Astronautical Sciences* 26 (1978).
7. G.K. O'Neill, *The High Frontier, Human Colonies in Space* (William Morrow & Co., New York, 1976).

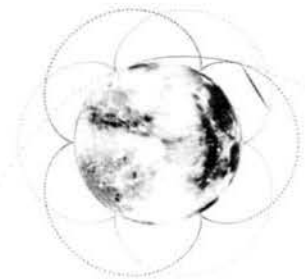


Fig. C. A trajectory which takes a mass launched parallel to the lunar surface by a mass driver to a rendezvous with the tip of an optimum sized lunar skyhook. At the instant of contact the position and velocity of the mass and the skyhook end are identical. Only the accelerations differ. By catching such a mass and releasing it at a later time the skyhook gains or loses varying amounts of orbital and rotational energy. The starred and dotted paths mark the trajectories of the two ends of the skyhook. The dashed line is the orbit of the launched mass in case it is not caught by the skyhook. The solid portion of this orbit is the actual path from the mass driver to the skyhook. The skyhook is shown at the instant of capture. It is then about 1 degree off horizontal.

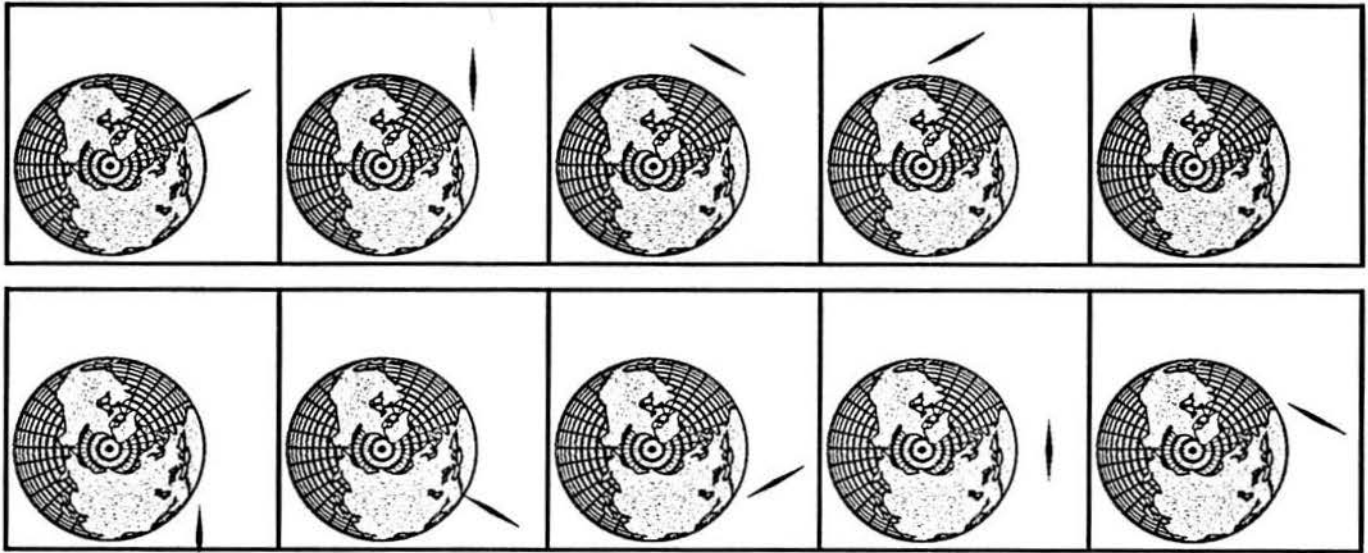


Fig. A. A non-synchronous skyhook's progress around a planet: two spokes of a giant wheel.

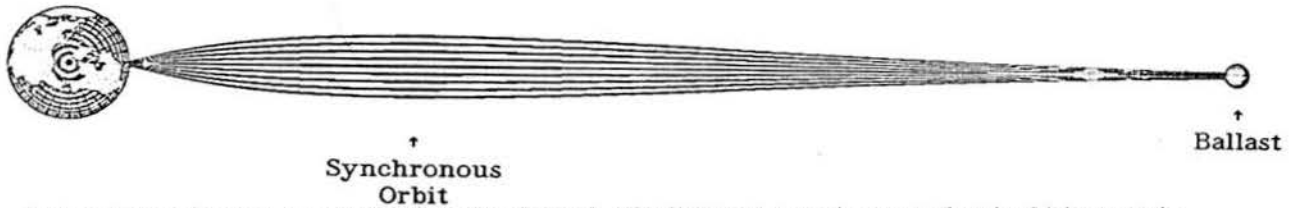


Fig. B. A view of a synchronous graphite skyhook for the earth. The diagram is to scale, except that the thickness of the cable has been greatly magnified.

TABLE I. Parameters for Optimally Sized Skyhooks

Body	Orbital Period (hr.)	Liftoff Accel (g)	Fiberglass		Kevlar	
			Taper	Mass	Taper	Mass
Mercury	2.37	0.57	2200	23000	49	350
Venus	2.37	1.39	$1.2 \times 10^{20}$	$3.0 \times 10^{21}$	$1.3 \times 10^{10}$	$2.3 \times 10^{11}$
Earth	2.16	1.40	$7.2 \times 10^{21}$	$1.9 \times 10^{23}$	$1.0 \times 10^{11}$	$1.9 \times 10^{12}$
Moon	2.78	0.28	13	72	3.6	13
Mars	2.62	0.49	17000	200000	136	1100
Ganymede	3.41	0.26	35	240	6.0	28
Titan	3.39	0.26	29	190	5.4	24

## New Space Treaty Back in Limbo

The meeting of the UN Outer Space Committee June 26 to July 7 consigned the "Agreement Governing the Activities of States on the Moon and Other Celestial Bodies" back into limbo. This came as a relief to those space industry researchers who consider some provisions of the treaty draft to be untenable.

One of the members of the U.S. delegation to the Outer Space Committee told the L-5 News that it is unlikely that a

final version will be reported out of the Committee for at least two more years.

For a detailed discussion of the treaty draft, see "Responses to 'Space Mines'", July 1978 L-5 News.

Delegations of the US and the USSR held consultations in Helsinki from June 8 through June 16, 1978 to discuss questions in connection with limiting certain activities directed against space objects and

incompatible with peaceful relations between states, including the means and systems for conducting such activities.

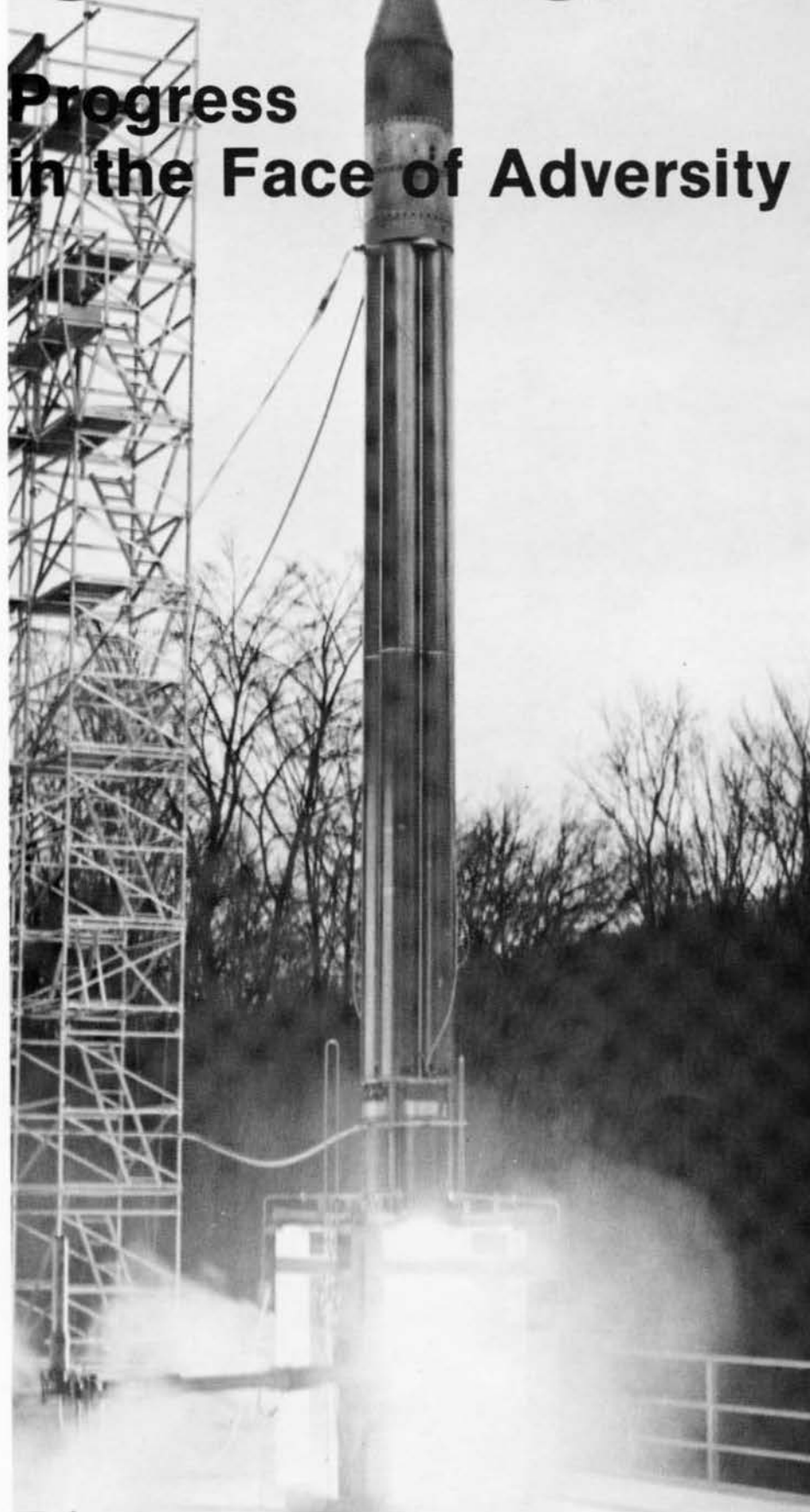
The US Delegation was headed by Ambassador Paul C. Warnke and the USSR Delegation was headed by Ambassador Oleg N. Khlestov.

The consultations were of a preliminary nature, and enabled each side to understand better the views of the other on these questions.

These discussions will be continued. The exact date of the next session will be determined through diplomatic channels.

# OTRAG

## Progress in the Face of Adversity



by Carolyn Henson

The primitive wooden gantry used for their first rocket launch, May 17, 1977, has been upgraded to a steel structure. But OTRAG's 100 plus employees make their homes in thatched huts, and the two Argosy airplanes that link them to the outside world still lumber down a dirt runway. The OTRAG compound atop the Manono plateau in the Shaba province of Zaire seems an unlikely place to be the focus of a controversy spanning four continents and embroiling the world's superpowers.

### Target of Shaba Invasion

For nearly a year the Soviet Union and allies have been attacking the West German private company OTRAG (see "German Space Capitalist Under Attack", *L-5 News*, December 1977). The U.S. publication *Penthouse* joined the chorus December 15 with a rewrite of an article from the French marxist publication *Asie Afrique* which alleged that OTRAG was a cover for a German/U.S. cruise missile development facility (see "OTRAG News", pp. 12, 13, *L-5 News*, April, 1978).

This May the attacks became a bit more physical. Announcing that OTRAG is "a serious and permanent threat to the whole of Southern Africa", Soviet-financed General Nathaniel Mbumba led his FNLA troops in an invasion of Shaba province. Although the fighting never got closer than Kolwezi, 150 miles from the OTRAG launch site, the *London Observer* reported that OTRAG had evacuated shortly after their successful second test launch May 20. That vehicle, composed of four 12 meter long tanks of three tons thrust each, achieved an elevation of nearly 80 km.

Shortly after NATO troops quelled the invasion OTRAG geared up for a third "Volksrocket" test. Zaire president Mobutu Sese Seko was on hand to witness its June 5th launch, as well as reporters from *Time* and *Newsweek*. As the accompanying photos show, the visiting dignitaries were treated to some unplanned, albeit peaceful, fireworks. OTRAG engineers pronounced the test a success (shades of Cape Canaveral back in 1958!).

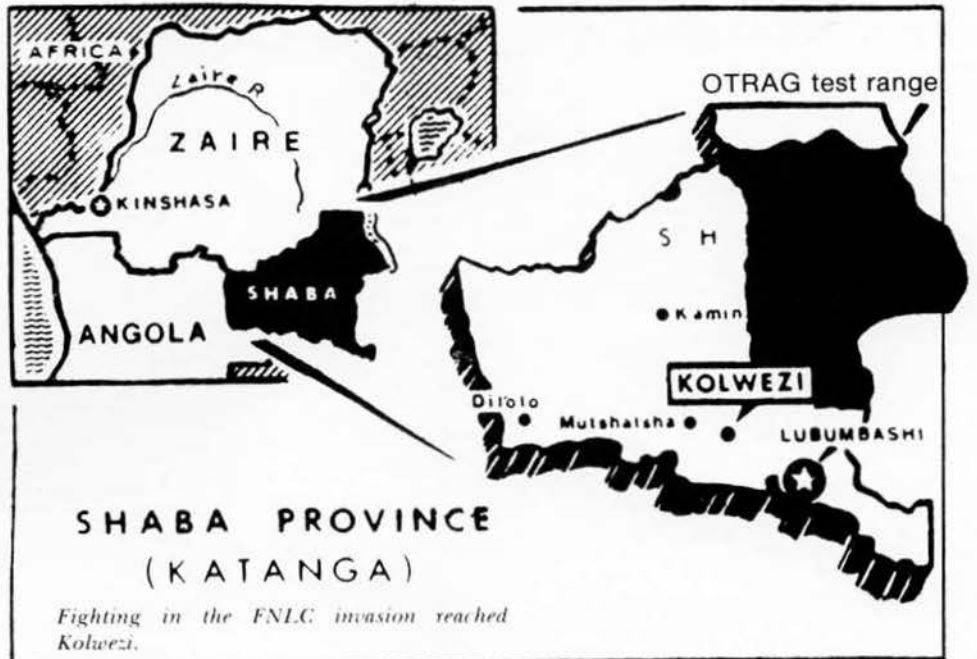
### A NATO Front?

Meanwhile, in a speech before the UN General Assembly June 1, Angolan prime minister Lopo do Nascimento (who is believed by some to have engineered the Shaba invasion) asserted that "...the West

German testing range is the barrel of a pistol aimed at the heart of Angola". Over in France, *Le Monde* charged that the NATO intervention in the FNLC invasion of Shaba was motivated by a desire to protect OTRAG. TASS, the Soviet news service, claimed that "...the speeded-up implementation of an extensive program of rocket tests in the testing range in Zaire is part of a unified plan drawn up in NATO...".

What connection does OTRAG have with NATO governments? Lutz Kayser and a group of five other engineers received \$1.8 million from the West German government over a three year period for rocket research. In 1974 his funds were cut off. Undaunted, Kayser fired up OTRAG and convinced retiring Kennedy Space Center director Kurt Debus to become chairman of the board. OTRAG investors were given a special tax break by the Bonn government, which has aided them in raising \$40 million to date. Kayser expects to need another \$200 million before OTRAG lofts its first commercial payload into orbit in 1980 or 1981.

However, *Aerospace Daily*, June 2, pp. 183-4 reported that, due to export delays and a recent souring of their relationship with the German government, OTRAG has established a Paris branch; L-5 correspondent Theo Pirard also reports formation of a New York branch. But their German problems pale before the uncertainties of their situation in Zaire. The Coco Beach, Florida paper *Today* reports Kurt Debus as saying OTRAG is "...actively looking for a new launch site...", adding that "I can't tell you where the sites are, but I will say one which is under consideration is in South America."



*A stuck valve in one of the four clustered engines caused the third rocket launched to arc over for a spectacular crash in the Luvua river valley.*



**Поливочные работы.**

Country is Zaire, helmet is "NATO", letters on missile are "OTRAG" and the caption is "WATERING". (This clipping from the June 27, 1978 *Pravda*, pg. 5 is courtesy James Oberg.)



*The OTRAG launch facility, located on the Manono plateau. Below is the Luvua river valley.*

## The Chinese Connection

Some observers speculate that the motivation for the Soviet/FNLC campaign to eliminate OTRAG is the rocket firm's agreement to launch reconnaissance satellites for arch-rival China. The Soviet camp's fears of the Chinese connection were strengthened by the visit of Chinese foreign minister Huang Hua to Lumbumbashi, capital of Shaba province, shortly after the fighting ceased. *Newsweek* reported that the Chinese now plan to beef up Zairean defenses with "small arms, mortars and artillery pieces, and perhaps even Chinese instructors".

The Soviets were predictably outraged. TASS charged that Peking, "...instead of condemning NATO's intervention in Zaire, has slandered the Soviet Union and Cuba by accusing them of 'interfering' in the affairs of African peoples...The imperialists and Maoists are playing the same tune in an attempt to confuse the African people with plainly false music".

The international furor OTRAG has aroused stands as a warning to would-be space entrepreneurs. Pioneering has never been easy. Yet throughout history people have met the challenge. What will historians write about the pioneers of space?



*Housing for OTRAG employees.*



*Sophisticated rocket tank transportation method.*



*Director of OTRAG and inventor of its "space truck", Lutz T. Kayser.*



*"Argosy" airplanes, used by the OTRAG Range Air Service.*



## Zaire Missile Story Exposed As "Disinformation"

Claims of West German cruise missile tests in Zaire are a fraud, according to the July issue of **Reason Magazine**.

The magazine, responding to a story by veteran reporter Tad Szulc in the March issue of **Penthouse**, presents evidence of a joint U.S./Soviet disinformation campaign on the subject, about which Szulc was apparently unaware.

**Reason** editor Robert Poole, Jr., author of the article "African Deception," says that the purpose of the disinformation campaign is to preserve a two-power monopoly on reconnaissance satellites.

"This is another shameful attempt by government to manipulate the press," says Poole. "What Washington cannot accomplish by straightforward means, it is seeking to bring about by 'leaks' of lies and distortions."

Szulc's story, citing U.S. intelligence sources, claimed that the West German government is secretly testing cruise missiles at a base in Zaire's Shaba province. Its cover, the **Penthouse** article asserted, is a private company called OTRAG, ostensibly researching weather satellites.

Poole's article documents numerous

errors and inconsistencies in Szulc's piece. Szulc claims that OTRAG's operations are veiled in secrecy--yet its first launch was broadcast on German television and promoted by a PR firm. He lists the size of OTRAG's test range as "a 100,000 square mile area (the size of Colorado)"--when it is actually only 100,000 square kilometers, about one-third that size. His evidence that West Germany has produced a cruise missile is limited to a photograph displayed at the 1977 Paris air show--which more than likely depicted a German remotely piloted vehicle (RPV).

Checking further into OTRAG's "cover story," Poole learned that the company's intent is not to research weather satellites but to provide a commercial satellite launching service. Its intended customers are Third World governments that wish to launch satellites for communications and reconnaissance purposes.

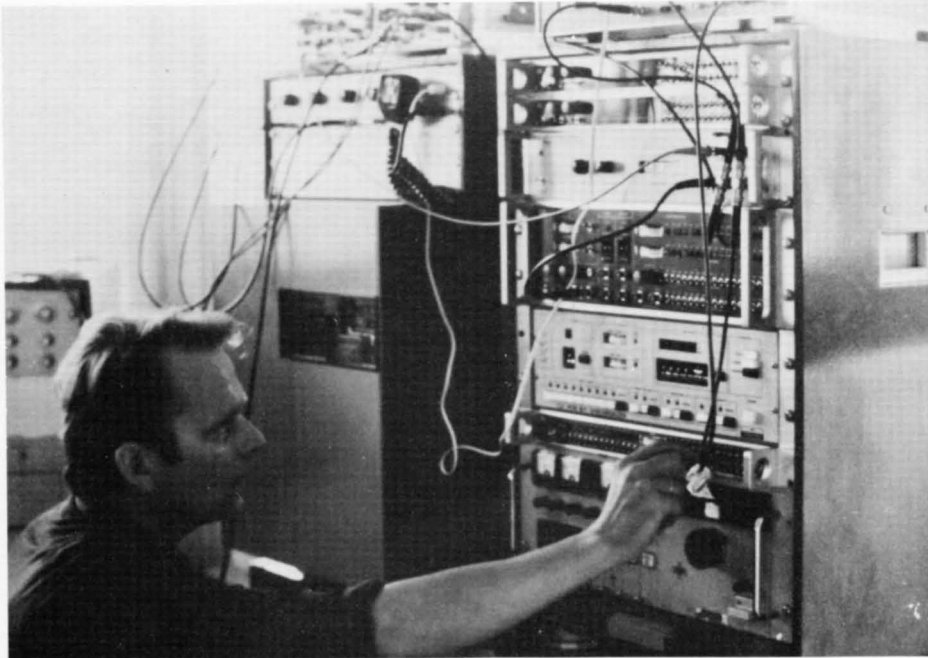
If OTRAG succeeds, notes Poole, it would be competing directly with NASA's Space Shuttle and the European Space Agency's Ariane booster. OTRAG has also aroused fears of the Soviet Union, which has stridently denounced it as a front for West German military missile testing.

Szulc wrote that he had been told the same thing by his contacts in U.S. intelligence circles. Yet neither the U.S. nor the USSR--both of which have closely observed Zaire via reconnaissance satellite--have produced any evidence that military missiles are being tested there.

Why, Poole asks, would U.S. officials leak such a story, given the solid evidence that OTRAG is actually a commercial enterprise? The answer, he claims, stems from OTRAG's willingness to launch reconnaissance satellites for any and all customers. The firm has been approached by the Chinese government, and has said that it would have no objections to launching a Chinese reconnaissance satellite. OTRAG could thus break the monopoly on launching such satellites shared by the U.S. and the USSR.

Officials of both powers have proposed steps to limit the reconnaissance data available to third parties. The USSR is even pushing for a UN treaty to ban any other nation from launching reconnaissance satellites.

"But if reconnaissance satellites become available to all nations, the Big Two will no longer be able to dominate international affairs as completely," says Poole. "In every recent Middle East crisis, for example, U.S. intelligence has supplied the Israelis with up-to-date



*OTRAG control center.*



*OTRAG rocket assembly team.*

reconnaissance data from its Big Bird satellites. The ability to *withhold* such information provides an incalculably valuable lever for influencing the affairs of others. Reconnaissance satellites give new meaning to the old adage that knowledge is power."

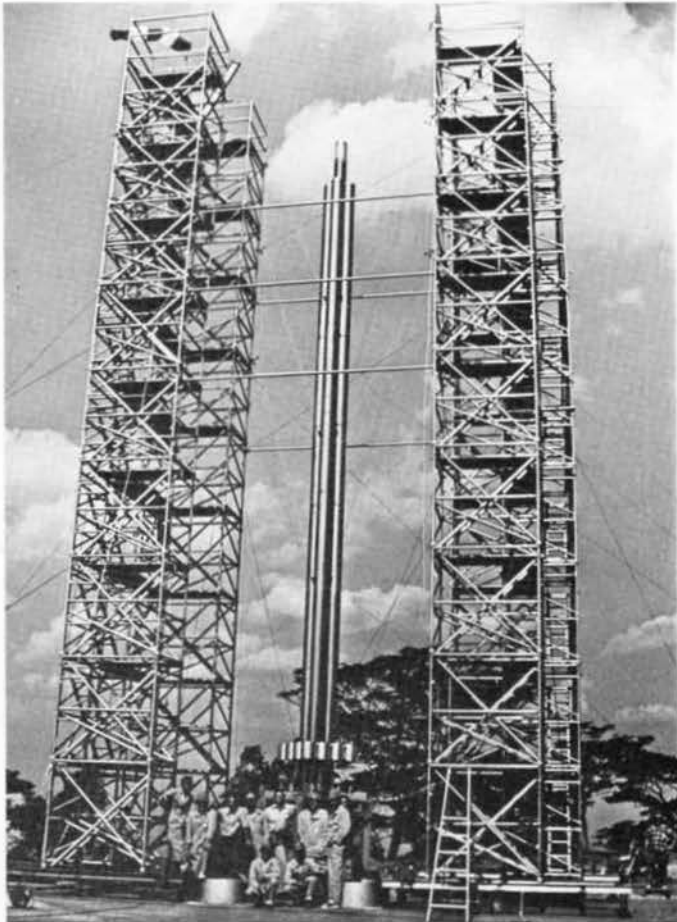
Hence, claims Poole, it is not at all surprising that U.S. officials would leak disinformation about OTRAG to Szulc, to protect the two-power monopoly. Poole urges U.S. officials to "back off from their disinformation campaign" and "firmly oppose the Soviet proposal to prevent other nations from acquiring reconnaissance satellites." Poole thinks the chances for peace will be increased "when Israel and Egypt, Greece and Turkey, Iran and Saudi Arabia, Peru and Chile all have their own reconnaissance capabilities."

**Reason** is a monthly magazine of analysis and commentary on current issues. Editor Robert Poole, Jr. holds two degrees in engineering from MIT and has worked for several aerospace and defense firms.

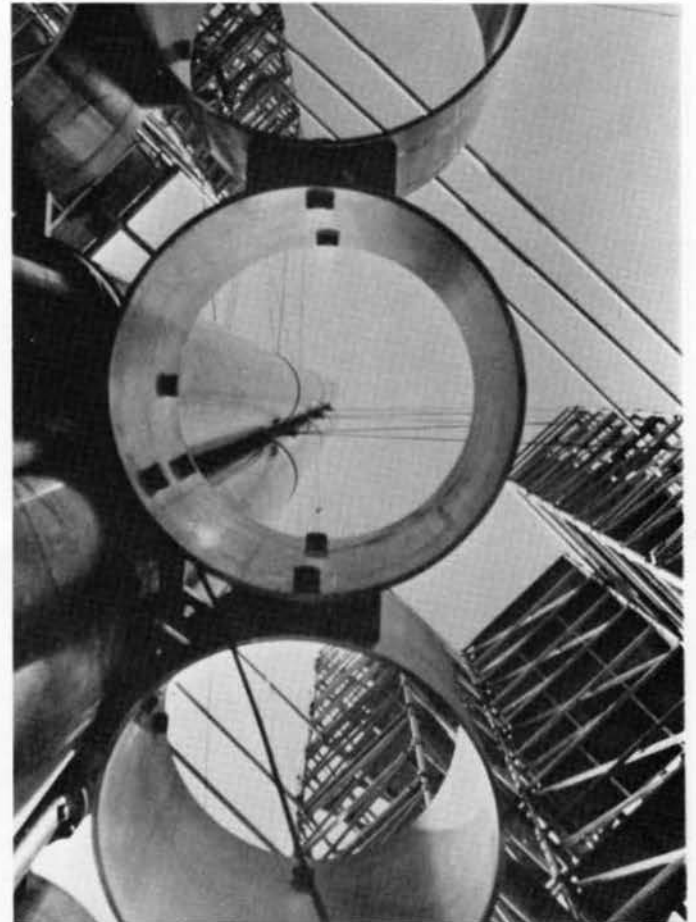


Propellant storage tanks in foreground contain nitric acid and kerosene. Center is the new gantry; to the right is a relic of OTRAG's earlier days.

*All photos with this article were provided by Theo Pirard, of the Centre D'Information Spatiale, Pepinster, Belgium.*



The third OTRAG test rocket.



Mass produced tube fins for aerodynamic stability.

# Space Settlements Conference

by Taylor Dark III

"We've been through an extremely rugged year, politically. I think we've turned the corner. It's (the space settlement movement) become established. I think it's safe to say that the work cannot be cut off, although we are far from the situation where there's a big political push to move ahead. But the more pressure we build up with these kinds of expert technical studies, which we heard about today, the more there will be the readiness so that when the political key goes into the lock, the lock will be well oiled and will open easily. And that, of course, is what we all hope for."

So said Gerard K. O'Neill in an impromptu speech at the conclusion of the Jet Propulsion Laboratory/Caltech Conference on Space Settlements. Held in late July, the conference consisted of nine speakers who described various aspects of space colonization and industrialization.

Several participants, including former astronaut Brian O'Leary, discussed at length the advantages and disadvantages in using either the asteroids or Moon as a source for materials from which to obtain Earth independence. O'Leary called asteroids "the most abundant source for materials (from which) to obtain Earth independence." O'Leary felt the asteroids could supply enough metals so that eventually processed metal could be transported down for use on Earth. Others contested his claims, though, saying that the asteroids were either too far away for immediate use or lacked enough of the proper minerals.

In a presentation entitled "Steps to the High Frontier", Jim Burke of JPL divided the future of space utilization into three areas. First was scientific investigation, second was technological development, and third was the loosely defined category of "leadership". Within this, Burke called for commercial space entertainment to heighten interest, as Star Wars did, in the space program; and for increased education, publicity and political action. He also supported genuine training and support for those already involved in the space program, and for a reduction in defense spending between the U.S.S.R. and the United States so more money could be used constructively in space.

The final speaker was J. Peter Vajk, who made a presentation that was geared for those in the business world interested in the concepts of solar power satellites and

space manufacturing. In a step-by-step fashion, Vajk outlined exactly how and in what amount of time each phase of a space industrialization program would be carried out.

## Careers in Space

Do you want a career researching space settlements, industries or solar power satellites? Where can you study these? The following colleges and universities have research projects or teach courses on these topics.

Massachusetts Institute of Technology  
Dept. of Aeronautics and Astronautics  
Cambridge, Massachusetts  
Contact: Rene Miller

Topics: large space structures, solar power satellites, space habitat construction, mass drivers

California Institute of Technology  
Pasadena, California  
Contact: Eleanor Helin

Topic: asteroidal resources  
Jet Propulsion Lab  
Contact: R.M. Dickinson  
Topic: microwave power transmission for SPS

University of Arizona  
Environmental Research Lab  
Tucson, Arizona  
Contact: John Phillips, Annita Harlan  
Topic: space agriculture

Georgia Institute of Technology  
Chemical Engineering Dept.  
Contact: John Cardin  
Topic: space agriculture

Rice University  
Physics Dept.  
Houston, Texas  
Contact: John Freeman  
Topic: solar power satellites

Princeton University  
Physics Dept.  
Princeton, New Jersey  
Contact: G.K. O'Neill  
Topic: mass drivers

Georgetown University  
Graduate School  
Washington, D.C.  
Contact: Stephen Cheston  
Topic: social aspects of space settlements

California State University  
Sociology Dept.  
Northridge, California  
Contact: B.J. Bluth  
Topic: social aspects of space settlements

**SPACE - ORIENTED INDIVIDUALS** are invited to send resumes for eventual consideration for employment with wide ranging project. We anticipate several job openings in the coming year. No aerospace or technical background required. All fields welcome. Send to: Sabre Foundation, Earthport Project, 221 W. Carillo St., Santa Barbara, CA 93101.

## Pioneers

Have the elder races halted?  
Do they droop and end their lesson,  
weary'd over there beyond the seas?  
We take up the task eternal, and the burden  
and the lesson,  
Pioneers! O pioneers! . . .

O resistless restless race!  
O beloved race in all! O my breast aches  
with tender love for all!  
O I mourn and yet exult, I am rapt with  
love for all,  
Pioneers! O pioneers! . . .

Lo, the darting bowling orb!  
Lo, the brother orbs around, all the  
clustering suns and planets,  
All the dazzling days, all the mystic nights  
with dreams,  
Pioneers! O pioneers!

—Walt Whitman

"Today . . . as other nations aggressively pursue space initiatives, I detect a reluctance on our part to establish future goals and clear directions that will assure our leadership 5, 10, 15 and 20 years from now.

"Our present course, if not altered, may well cost us the leadership posture in space science and technology that we have attained—at no small expense. We are on the verge of frittering away this unique opportunity."—Senator Adlai Stevenson

## Soviet Powersats?

Do the Soviets have a solar power satellite program? At a recent conference in honor of Soviet cosmonauts' record-breaking stay in the Salyut-6 space station, pilot-cosmonaut Konstantin Feoktistov discussed the SPS concept. He stated that the idea is "not unrealistic" and proposed that they may become a reality "within several decades". He reminded listeners that SPS will require the moving of millions of tons of materials and equipment into space and hundreds of people on the scene to maintain them.

## Space Colonies Inevitable?

Space colonies are inevitable, according to Iosif Shklovsky, a Soviet astrophysicist and member of the Soviet Academy of Sciences. Writing in the journal *Social Sciences*, he bases his prediction partly on his belief that solar power satellites will provide an impetus for the creation of human settlements in space.

Following what is often called the "O'Neill line", Shklovsky pointed out that it would be necessary to use raw materials from the Moon and asteroids.

## Update on Space Shuttle Schedule

Since 1973, the first shuttle orbital flight has been officially scheduled for the second quarter in 1979. An internal NASA working schedule of March 1979 was set the same time.

Most of the major elements of the program are between two and three months behind the target schedule of March 1979 but are still able to meet the commitment schedule of June 1979. The one element of the system which could cause the June date to slip is the main engine. Though the June date allows sufficient time to complete the engine hardware and necessary engine development and qualification tests, it does not allow any slack for additional major main engine test failures. The Space Shuttle main engine tests scheduled between May and September 1978 should provide NASA with sufficient insight on potential engine problems to reschedule in September 1978, if a rescheduling is required.

# Close Encounter, Soviet Style

The Soviets nearly had a space fatality last December when Cosmonaut Yuriy Romanenko took an unauthorized space walk.

At a press conference held at Moscow State University fellow Salyut-6 Cosmonaut Georgiy Grechko revealed "... some details we did not report to Earth ... I hope the flight directors will not be offended, but we concealed (the fact) that not only the flight engineer went out into space, as was called for in the program, but also Yuriy Romanenko. It was very difficult, naturally, for him to restrain himself. Yura, it is true, had forgotten to fasten his safety line, and I had to take hold of this line and restrain the commander".

If Grechko had not caught the tether, Romanenko would have drifted off forever in his own lonely orbit.

What caused Romanenko's close encounter with death? *Time* magazine, July 3, 1978, speculated that he was overcome by "space rapture". However, an expert on the Soviet space program at Johnson Space Center, Jim Oberg, speculates that "He stood up (at the control panel inside the open hatch) and lost his grip, while just intending to have a peek."

Oberg concludes, "The *Time* story is garbled and dramatized but essentially accurate—the Russians nearly had a space fatality last December".

## Shuttle Vibration Tests

The first phase of the Space Shuttle ground vibration test series began May 30 in a tall test tower at NASA's Marshall Space Flight Center. The tests followed installation in the stand recently of the Space Shuttle's external tank and orbiter *Enterprise* in late April.

The tank and the orbiter were "soft-mounted" inside the stand through use of a system with air bags and cables that suspends the vehicles from a large overhead truss installed like a crossbeam between two test stand walls. It was the first time these two major components of the Shuttle have been mated as they will be for actual flight.

Engineers then installed the system which applies vibrations to the Space Shuttle as it hangs vertically in the test stand. Called the "shuttle modal test and analysis system," the computerized system can provide the required vibrational cycles and force inputs as well as acquire the response information from the vehicle.

The term "vibration" could mislead—the system does not shake to learn how strong the vehicle is. Instead engineers apply vibrations to the exterior with exciters powered by amplifiers similar to those found on home stereo sets. Sensors then record the characteristics of the vibrations as they pass from one area of the vehicle to another.

## Space Shuttle Main Engine Test Successful

Three Space Shuttle main engines roared to life May 19 in the first major test firing of the Shuttle's main propulsion system. Orange flame and a huge cloud of white steam and smoke poured from beneath the test stand in which the cluster was held firmly to Earth during the noisy 15-second run.

That running time was considerably longer than the cluster's only previous firing, a one-second ignition test on April 21. The engines reached 70 percent of their rated power during this test.

Bob Lindstrom, Space Shuttle projects manager at NASA's Marshall Space Flight Center, where the engine is being developed, said after the firing that everything went as planned. "We haven't evaluated all the data," he explained, "but from what we can see, we have a very successful test."

The test firing took place in Bay St. Louis, Miss., at NASA's National Space Technology Laboratories. The test program is managed by the Marshall center and conducted by the Rockwell International Space Division.

During the next several months, additional tests will increase the duration of firing and the engine thrust levels until they are fired at 109 percent of rated thrust for about eight minutes at a time. This will simulate an actual Space Shuttle mission into space.

# Space Processing: the "STAMPS" of Disapproval or Space Processing Takes it in the Ear?

By Leonard David *FASST News Service*

A special study by the National Academy of Sciences (NAS) has concluded that the prospects for economical space manufacturing are "limited and need to be better defined on a case-by-case basis." Further, the NAS Committee on Scientific and Technological Aspects of Materials Processing in Space (STAMPS) reports no examples of "economically justifiable processes for producing materials in space," could be found. NASA should not emphasize this area of materials technology, recommends the Committee. The study was funded by NASA.

The NAS report was developed by an interdisciplinary group, comprised of members from national laboratories, universities and industries. A majority of the group had little or no previous involvement with NASA. The 12-member team was led by Dr. William P. Slichter, Director of Research for the Bell Laboratory's Materials Science and Engineering Division. An earlier draft of the final report was even more critical of the space processing concept.

In effect, the STAMPS study has slapped NASA's hand, pointing out that early work by the space agency in processing materials in space "has suffered from some poorly conceived and designed experiments, often done in crude apparatus, from which weak conclusions were drawn and, in some cases, over-publicized." Although not contained in the report, it is known that Committee members included the production of perfect ball-bearings in zero-gravity as being completely over-sold. This should be particularly interesting to the German company Volkswagen. Volkswagen is in the process of developing experiments for space production of bearings for use in an automobile with a 200,000 mile engine guarantee!

The NAS Committee stressed two points that emerged from the testimony of its advisors and from previous materials experimentation in space. "First, the space environment usually contributes at least as many problems as it solves. In sophistication, reliability, convenience, and cost, terrestrial experimentation is generally superior to what can be expected in space. Second, space experimentation will have little value unless its planning is founded on substantial Earth-based

information and unless the results are coupled to those of complementary terrestrial programs."

The report indicates that some space environments, such as the level of vacuum, temperature, or high-energy radiation can "be realized better and more easily on Earth." The best advantage of the space environment is, of course, the long periods of low gravitational acceleration, only achieved through orbital flight. But even in this instance, cautions the NAS Committee, future "zero"-gravity Space Shuttle processing experiments may be jeopardized by several factors. Among these are: gas venting, fluid dumps, use of evaporators, crew motions, and perturbations of the Shuttle orbit itself. These factors could induce accelerations, creating small forces of gravity, in turn affecting the low-gravity requirement of space processing.

Single out in the report were commercial space processing of vaccines using electrophoresis (the separation of particles of different mass/charge ratios in an electric field) and growing silicon crystals for use in electronics. The NAS study found no clear-cut advantage in either case over terrestrial processes. In the case of electrophoresis, use of the technique on Earth has not yet been optimized.

But all is not grim in space-processing land. After the year long study, Committee members report that some valid experiments can be conducted in space. Concludes the study group, low gravity appears to offer certain capabilities in studying the properties of boiling, combustion and melting, processes which are not now well understood. The prospects for containerless processing, to avoid contamination and increase purity, may hold great promise, feels the Committee. But even these possibilities must be subject to critical evaluation of comparative costs and likelihood of success. The NAS study group indicated that the commercial utilization of such understanding lacks promise.

Reaction to the STAMPS report by NASA is mixed, with one official stating "we found nothing objectionable in the study." Others felt that NASA did not get its \$180,000 worth, pointing out the study group's inability to gather and review

previous reports on space processing experimentation. James Bredt, Manager of Space Processing Applications for NASA, views the STAMPS review as a "kind of non-comment." The fact that the STAMPS Committee did find some good science can be conducted in space "is a victory" feels Bredt. "We faced a hanging jury and got acquitted," concludes Bredt.

The organization and management of future space processing should include the use of the Space Shuttle as an orbital national facility, suggests the Committee. This facility would include use of the Spacelab by scientists and engineers working in universities, government laboratories, or industrial concerns. User rates will be established, but not designed to cover the total real cost of operating the facility.

However, such a plan can be instituted only after a period of perhaps five or more years of careful experimentation—to develop and demonstrate significant material processing techniques. The cost of such early research should be paid for by NASA, felt the NAS panel members. To this end, the Committee suggests certain technical and management changes to improve the effectiveness of the NASA materials space processing program.

The NAS Committee will meet again within a year to evaluate progress of NASA in implementing the study's recommendations.

*Leonard David is Program Director for the Forum for the Advancement of Students in Science and Technology (FASST).*

## First Spacelab Science Team Selected

Two Americans have been named by NASA as part of an international group of five scientists who will serve as payload specialists during the first Spacelab mission which is scheduled for the latter part of 1980.

The American payload specialists were nominated and selected by the Investigators Working Group (IWG).

which is composed of scientists representing all investigators.

The selectees are:

● Dr. Michael L. Lampton, 37, of Berkeley, Calif., a space physicist at the University of California, Berkeley.

● Byron K. Lichtenberg, 30, of Natick, Mass., a vestibular researcher at the Massachusetts Institute of Technology, Cambridge, Mass.

One American and one European eventually will be selected to fly aboard the Earth-orbiting space laboratory and operate the science instruments.

Payload specialists are new to the space program. Their responsibilities will be to perform experiments in space aboard NASA's Space Shuttle, which will carry the European-built Spacelab into Earth orbit. Payload specialists are not pilots, and are not to be confused with mission specialists. The latter are crew members responsible for *all* aspects of the Shuttle flight except piloting.

The three payload scientists who are not chosen to fly in space will act as backup specialists, participating in ground-based mission activities at NASA's Johnson Space Center during the flight. That choice will be made some months before the flight.

The American payload specialists named this week were selected from a list of six finalists. The European scientists, announced last week, were selected by the European Space Agency (ESA) from among thousands of applicants in its member states after parallel screening programs were conducted in Europe.

The three payload specialists selected by ESA are:

● Ulf Merbold, 36, German, a scientist at Max Planck Institute, Stuttgart, West Germany.

● Claude Nicollier, 33, Swiss, a scientist and pilot at the European Space Technology Center (ESTEC), Noordwijk, Netherlands.

● Wubbo Ockels, 31, Dutch, a physicist at Groeningen University, Netherlands.

The first Spacelab will be launched aboard the Shuttle from NASA's Kennedy Space Center in Florida. It will orbit the Earth at an altitude of 250 kilometers (155 miles). At the end of the seven-day mission, the Shuttle will return for a runway-type landing at the Kennedy Center, be serviced and readied for other missions.

NASA's Marshall Space Flight Center is responsible for the payload specialists' training activities as part of its overall management responsibility for the Spacelab mission. ESA's Spacelab Payload and Coordination organization in Europe will manage training activities in Europe.

# BIBLIOGRAPHY UPDATE

by Conrad Schneiker

"Lasers: One Answer to Sending Solar Power", Thomas A. Gorski  
**NSI Newsletter**, April 1978

Builds a case for using laser beams instead of microwaves for energy transmission from solar power satellites. A long list of potential advantages are cited. First, much smaller satellites are used. This greatly reduces military vulnerability and greatly reduces start-up costs—very important points. Ground receivers are small (10-20 meters) and power can be delivered closer to consumers. Beams may be easily split to serve smaller markets. The large number of small transmitters provides greater redundancy, minimizing effects of breakdowns. Public fears of safety may be reduced by not using microwaves and the use of physically small optics can make military diversion impractical. Its claimed use of 2 micron (infra-red) wavelengths can eliminate danger of eye damage and minimize atmospheric and ionospheric absorption. Light cloud cover will not affect the system adversely and really bad weather can be circumvented by the existing power distribution network. Special sensors and adaptive optics can react "instantaneously" to eliminate danger to spacecraft and satellites. As for efficiency, when the initial conversion of sunlight into microwaves is included in overall efficiency calculations, the laser power system's overall efficiency looks about the same. Dr. John D.G. Rather of Schafer Associates proposed this idea and estimates that 2 or 3 space shuttle flights can deploy a complete power module. A fantastic idea if it's really as good as it's made out to be. It would be even better if it can be used to directly drive laser amplifiers for earth-to-GSO laser-launch systems. Note that the test ground receivers (the DOE's solar towers, etc.) are already built and stand waiting to be used every night. If any reader can dig up more information on this subject, please forward it to me c/o **L-5 News**.

"Should The U.S. Switch To Solar Power?"  
Ray Connolly

**Electronics**, April 27, 1978

Describes congressional committee debates on the pros and cons of solar power satellites. It's interesting to note that people on both sides of this issue generally concur that the technology is already

available and the major (but tractable) engineering problem is the in-orbit assembly of large space structures. An editorial in the same issue of **Electronics** comments on the reluctance of DOE to accept money (!) to accelerate SPS R&D. As one Congressional staffer put it: "I don't get it."

"Sunny Future for Power Satellites"

Ian Ridpath

**New Scientist**, May 25, 1978

A short article describing Earth-launched solar power satellites.

"Advanced Launch Vehicle Systems And Technology," M.W. Jack Bell

**Spaceflight**, April 1978

Escalating costs, increased competition, and pollution worries all motivate the search for post-shuttle launch vehicles. This article examines second generation launch system concepts and identifies the required technology. Although the basic capability now exists to initiate development of an advanced launch vehicle aimed at cutting cargo costs by an order of magnitude under those of the space shuttle, the author notes administrative go-ahead will probably not be forthcoming. Looks like the shuttle claims yet another victim.

"Biosphere for 10 Billion People Predicted"  
**L.A. Times**, May 28, 1978

Reports Soviet astrophysicist Iosif Shklovsky's predictions of space colonies supporting 10 billion people within 250 years. He notes the necessity of employing extraterrestrial resources, a la O'Neill.

"Report On The National Scene/Let The SPS Shine Through", Patricia Jefferson  
**Astronautics & Aeronautics**, May 1978

Interesting commentary on the politics of developing inexhaustible energy resources. The capricious and inane fumbblings of ERDA, DOE, AEC, NASA and the OMB as they relate to SPS R&D are exposed. One such gem: while arguing that funding should be lowered for energy forms still awaiting demonstration of feasibility, DOE is pouring \$460 million into nuclear fusion R&D in FY79. I can't help adding that fusion hasn't even demonstrated scientific breakeven, nor will it be anywhere near as clean (radioactively) as the DOE would have you believe.



## BOARD ELECTION RESULTS

The annual meeting was held 2 PM July 15th at the L-5 office in Tucson, as announced in the May L-5 News. Ballots were counted. Everyone on the ballot was elected. The votes for Directors are tabulated below:

Total ballots cast: 504

Asimov	487	Vajk	459
Hubbard	475	Kantrowitz	455
H.K. Henson	472	Parker	453
Goldwater	468	Weigle	452
Chapman	468	Finch	450
C.M. Henson	467	Smith	437
Woodcock	463	Hopkins	435
Dannenberg	461	Salmon	428
Heinlein	460	Huddle	417

Write-in votes

G.K. O'Neill	15	Timothy Leary	7
Gov.		Jerry Pournelle	6
Jerry Brown	11	Eric Drexler	5
Arthur C. Clarke	10		

Receiving three votes each were:

Ray Bradbury	Rusty Schweikart
T.A. Heppenheimer	Rep. Olin Teague
Nichelle Nichols	Robert Anton
Sen. William	Wilson

Receiving two votes each were:

Petr Beckman	John Denver
Marc Boone	Buckminster Fuller
Ben Bova	Sir Fred Hoyle
Pete Conrad	Hon. Barbara Jordan
Jacques-Yves Cousteau	Robert Lovell
Kurt Debus	Ken McCormick

Carol Motts	Thomas O. Paine
Larry Niven	Ronald Reagan
Andrew F. Nimmo	Gene Roddenberry
Kerry O'Quinn	Alan B. Shepard
Jim Oberg	Jesco von Puttkamer

Receiving one vote were:

Buzz Aldrin	Lutz T. Kayser
Bill Angevine	Gerry Kitzman
Poul Anderson	Karl Konkell
Gary Barnhard	Leo J.G. Little
Christian O. Basler	Tom McCall
Sen. Birch Bayh	Paul McCready
Chesley Bonestell	George McGovern
Piet Bos	Brian O'Leary
John W. Brauc	James W. Porter
Lillian Carter	Frank Press
Steve M. Cohn	Ayn Rand
Michael Collins	Jon Ratner
Doris Cooper	Judy Resnik
Philip K. Dick	Larry W. Roeder
James C. Fletcher	Robert K. Rose
Rep. Ronnie Flippo	Roger Sansom
Gerald Ford	Conrad Schneiker
Harry Gray	Allan Jay Silver
Michael T. Harrell	Gloria Steinem
Eleanor Helin	A.E. Van Vogt
Gale Henson	Paul Verbois
John Holt	Sen. Harrison Williams
Richard D. Johnson	Rep. Larry Winn

We would like to welcome aboard new Directors Arthur Kantrowitz and Phillip Chapman, and thank past Directors Romualdas Sviedrys, Carol Motts, Dave Fradin, Leonard David and Magoroh Maruyama for their work for the Society.

## Membership Drive

The current length and quality of the L-5 News is as much as we can afford to put out given the membership fees charged by L-5. (Please note that even putting out as much as we do we rely on writers contributing free articles, and on editing

and layout being done for only \$3/hour.) However, there is a way to greatly increase the content and quality and add color pictures to the L-5 News: we can carry advertising.

Alas, advertisers want lots of readers. The L-5 News circulation is only just barely topping 3,000 this month.

On the basis of the percentage of Tucsonans who have joined the Society, we can project a US membership of 45,000. A test bulk mailing to electrical engineers has to date resulted in over 2% joining the Society. Given the population of US electrical engineers as about 200,000, that's 4,000 potential L-5 members.

However, it is next to impossible to run ads and make direct mail appeals which can bring in enough money to both pay for the advertising and support the expenses of maintaining the new members. (Even given plenty of volunteer effort, supplying the L-5 News costs \$14 per member per year.)

"For profit" magazines get off the ground by raising heaps of capital and running a deficit for many years before they build up circulation to the viable point. Non-profit organizations rely on donations and long term loans to accomplish the same thing. If you would like to see the L-5 Society's membership multiply ten fold in the next year, and the quality of the L-5 News increase correspondingly, please send in your donation earmarked "Membership Drive". If you wish to learn more about how it would be put to use, please let us know and we will discuss with you the direct mail and advertising proposals we are hoping to finance.

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

NAME: \_\_\_\_\_

ADDRESS: \_\_\_\_\_

CITY/STATE/ZIP: \_\_\_\_\_

AFFILIATION/TITLE OR POSITION \_\_\_\_\_  
(OPTIONAL)

I am \_\_\_\_\_ am not \_\_\_\_\_ interested in being active locally. Phone (optional) \_\_\_\_\_  
 \_\_\_\_\_ Please enroll me as a member of L-5 Society (\$20 per year regular, \$15 per year for students). A check or money order is enclosed. (Membership includes the L-5 News, the monthly magazine of the L-5 Society. Subscription of \$12/year included in membership dues).

L-5 Society members who sign up for the Space Legislation Hot Line option receive frequent first class mailings on the actions of Congress and the President which affect the space shuttle, space colonies, solar power satellites, space exploration and other space projects.

\_\_\_\_\_ Sign me up for the Space Legislation Hot Line.

## MEDIA GROUP

by Howard Gluckman

Do you want to get a lot of interest in L-5 going in your area? Try science fiction conventions. Space Science Media Group, an organization set up by L-5 members John Sigwing, Steve Miszencin, and myself, did just that at Phantasmicon '78, May 26-29, at Los Angeles' Bonaventure Hotel.

With an exhibit room and several speaking times, we carried L-5's message to people with lots of interest but no way to direct it. We presented an L-5 panel discussion, two space colony slide shows, a search for extraterrestrial life show, and discussions of future possibilities from science fiction writer Dr. Jerry Pournelle and physicist J. Ray Dettling, both L-5 members.

For our exhibit room, we had displays on loan from Rockwell International, Jet Propulsion Laboratory, and the California Museum of Science and Industry. We also had literature for people to read, including some to take with them (and large stacks of L-5 applications).

Don't undertake something like this without help. Aiding us in many capacities were members Ralph Webster, B.J. Bjornen, Charles Carr, Alan Katz, Randy Reidel, Ru Emerson, Martin Rothblat, and Bob Manson.

## Letters

Congratulations to the L-5 Society and Carolyn Henson! Your article: "HR 1061: FOCUS OF CONTROVERSY" was printed just as I was in the process of composing one of the nastiest, poison pen letters ever written to the editors of **Mother Jones**.

One of the most incredible things about the article in **Mother Jones** is the ignorance required of a reader to believe this kind of criticism. For example, the point that they try to make about the solar power satellite being a "potentially lethal weapon" still makes me laugh when I think about it. Using a little common sense and knowing a few simple facts can punch holes in this argument in no time. A solar power satellite is large—several miles on a side—which was carefully emphasized in the **Mother Jones** article. How could one conceal such a satellite from detection? And since it (the SPS) was designed and constructed in weightless space, what kind of acceleration could such a satellite withstand? Certainly not much more than .01 G's, if even that. Compare that with your average ABM missile, which can



Media Group exhibit at Phantasmicon

easily withstand 50 gravities of acceleration. Could an SPS hope to outrun a missile?

The point is this: any small country under attack could invest a few million dollars on a missile. Since an SPS is virtually impossible to defend (as I just demonstrated) it would be easy to destroy the SPS. So, for a few million you could destroy a satellite worth billions and which would also be a major power supply for the enemy. Any military strategist could tell you that the SPS is not a weapon.

Along with faulty reasoning, Mr. Hochschild (the author) makes many statements which are simply lies. And he also makes the assumption that all the SPSs would be launched from the ground, and he ignores the Space Colony alternative. This is most unfair of him because he does know about the work of Gerard O'Neill and he proves it by mentioning Mr. O'Neill's name. The most unkind cut of all comes when he makes a vague reference to "some O'Neillians who want to bomb the moon." (nuclear mining technology.) The use of the word "bomb" shows what simple propaganda this is. It was the likes of Mr. Hochschild who were behind the Nazi propaganda machine in WW2.

I regret having to end this letter by condescending to the level of the editors of **Mother Jones** and by encouraging others to do the same, but it appears that the use of one of **MJ's** recommended policies is in order. It appears that a boycott of **MJ** magazine is required to stem the flow of

such malicious ignorance.

Matthew Swass  
South Orange, NJ

*In all fairness to Mr. Hochschild, it should be pointed out that he was referring to Kraft Ehrlicke's proposal to mine the moon using nuclear bombs. For an analysis of the shortcomings of his proposal see "Nuclear Mining", June 1976 L-5 News—CH*

Your readers may be interested in a new free "mini-magazine for educators", **Air & Space**, published by the Smithsonian Institution. A subscription may be obtained by writing the National Air and Space Museum, Room 3569, The Smithsonian Institution, Washington, D.C. 20560.

Jay S. Huebner  
Jacksonville, FL

Where did NASA administrator Frosch get a \$500 billion figure for SPS? I thought NASA's own studies had it pegged in the \$50-200 billion range. Was this a deliberate attempt to scare the Senators present (at the Future Space Program hearings)?

Michael C. Strong  
Swartz Creek, MI

*Our NASA sources insist that no study on SPS has come anywhere near Frosch's \$500 billion estimate. Apparently he came up with it on his own — CH.*