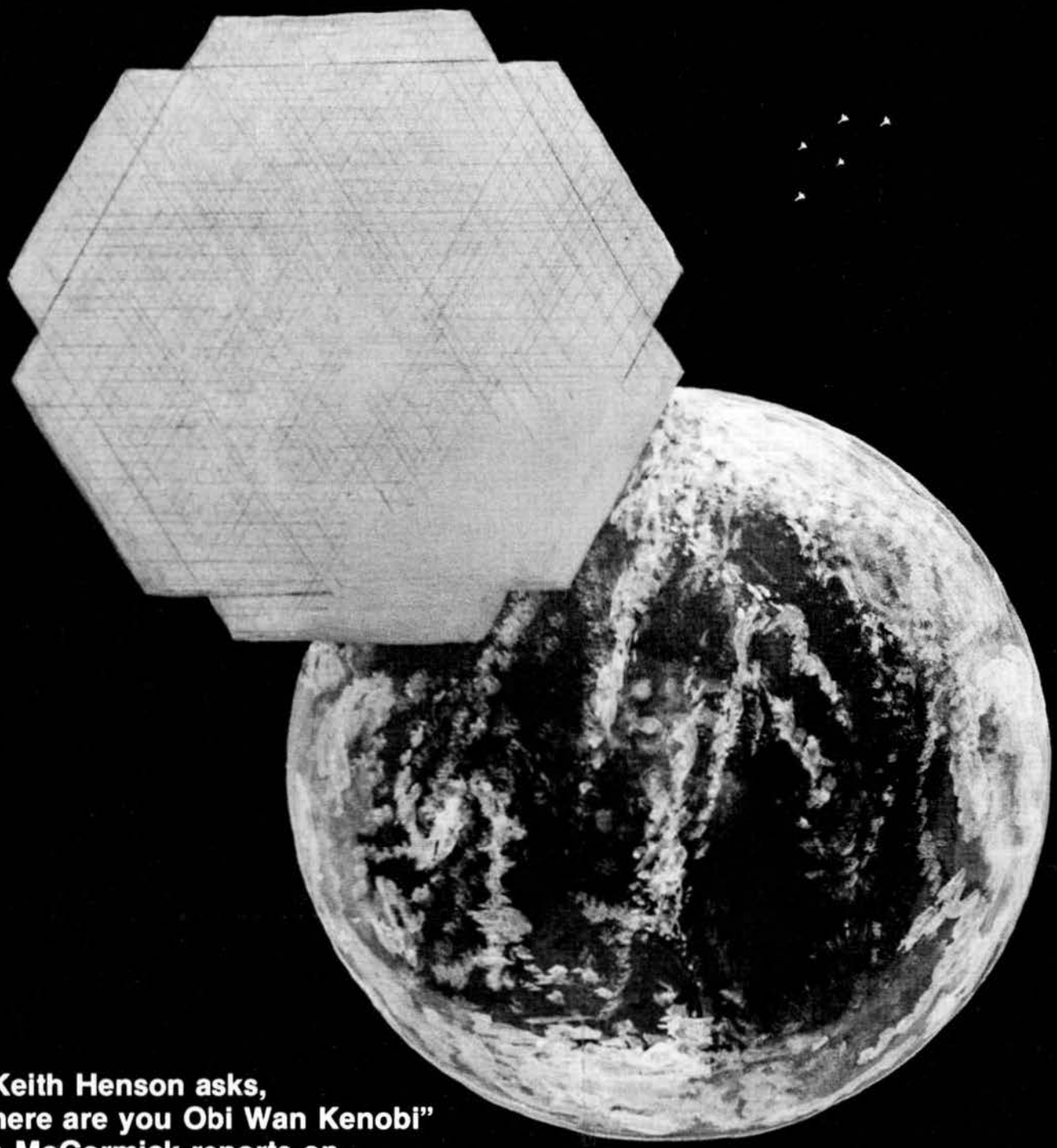
L5 NEWS

June 1979



H. Keith Henson asks, "Where are you Obi Wan Kenobi" Ken McCormick reports on Landsat hearings.

L-5 NEWS

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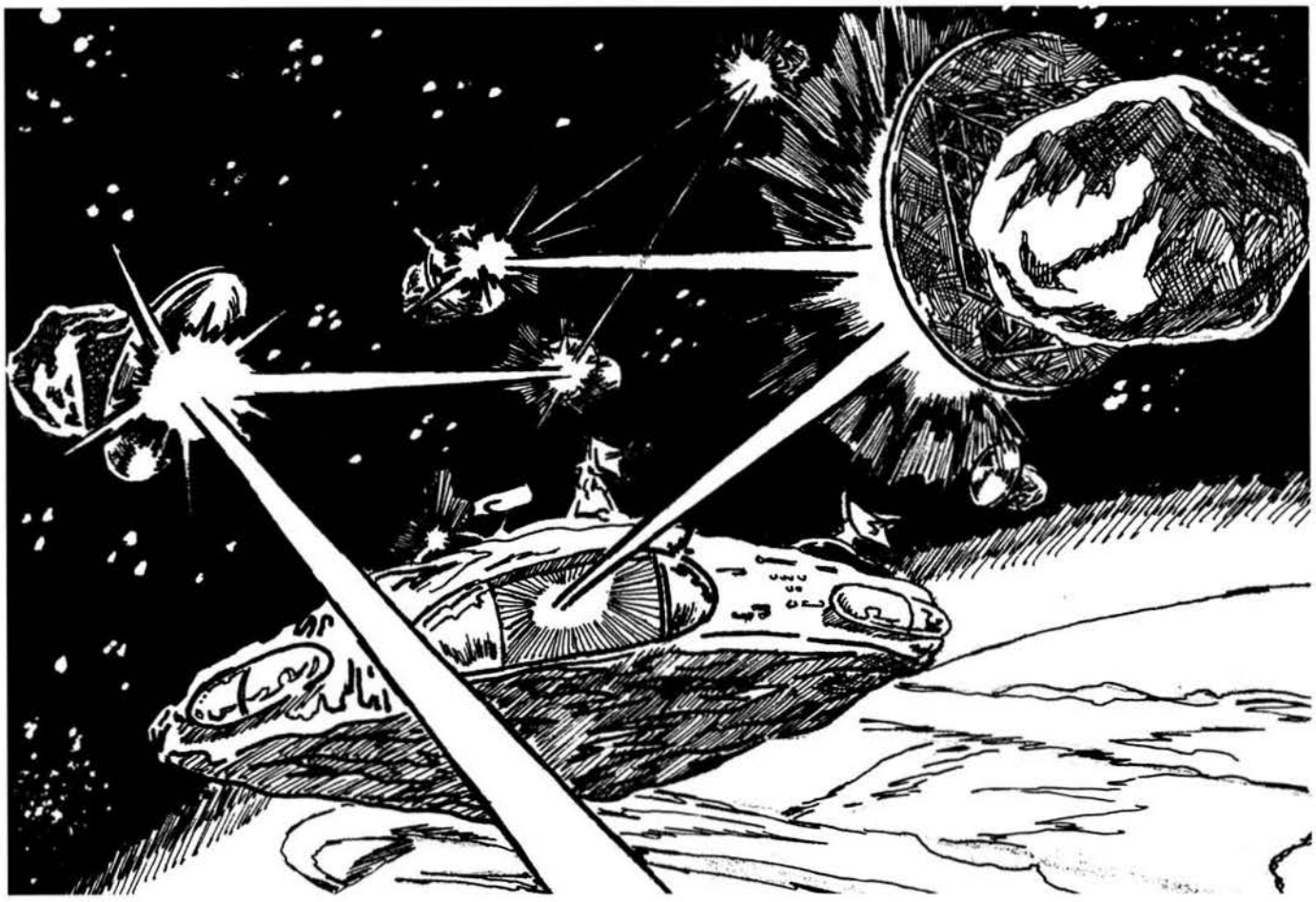


Artwork by James Babcock

Space Forts
or
"Where Are You Obi Wan Kenobi?"

by H. Keith Henson

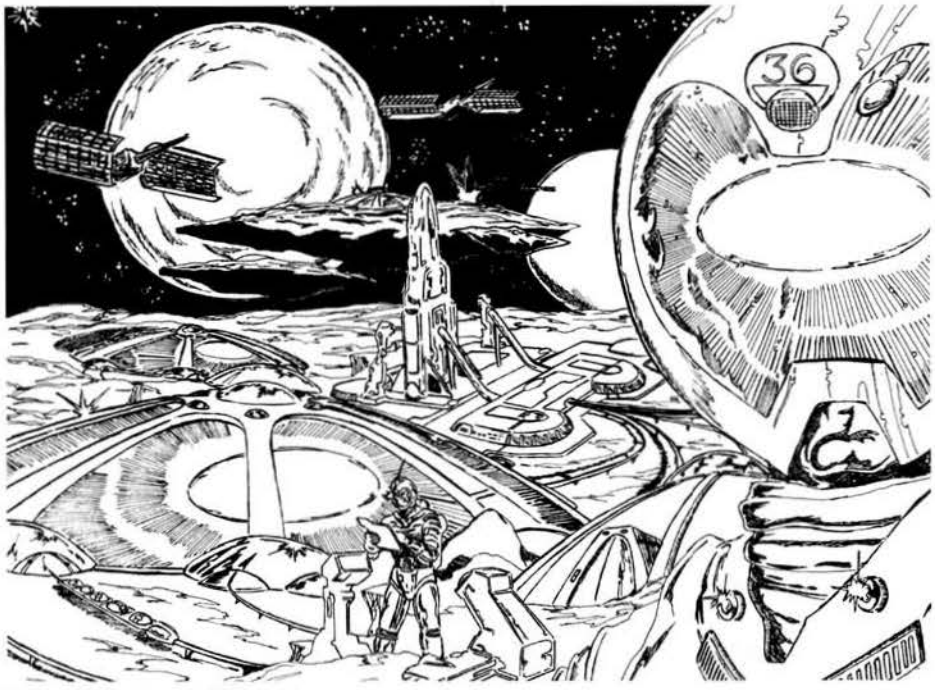
We who have grown up with the bomb can hardly imagine a world without the Sword of Damocles hanging over our heads by a thread. Strategic warfare has been dominated by offense for over 30 years.

Even though it might take 20-50 years, advances in space might swing the balance back toward defense. Here are some wild speculations, hopefully based on engineering realities.

Don't be too surprised if the Department of Defense picks up the slack in NASA funding of mass drivers and solar sails. A mass driver is just what you need to bring most of an asteroid to the vicinity of the Earth by throwing away part of the asteroid for reaction mass. Solar sails would bring them back piecemeal. A million-ton asteroid in high Earth orbit would solve a number of problems such as providing hardening for certain advanced weapons systems and their heat sinks.

"Hardening" is the capacity to take a beating and remain functional.

"Heat sink" is an engineering term which can mean anything from a tiny clip on a transistor to the Mississippi river. It's whatever is used to get rid of waste heat. On Earth, waste heat is mostly carried off by water or air and eventually radiated from the vast area of the planet into the cold (three degrees above absolute zero) universe. Some of you may remember the story by Poul Anderson about a rogue planet (Satan) that was thawed out by a close pass near a star and then kept warm as it sailed back into the dark by industrial



Artwork by James Babcock

waste heat on a grand scale. Getting rid of waste heat without a planet isn't hard, but it isn't cheap either.

Waste heat radiators are a major factor in the design of space industrial facilities, habitats, farms and military bases. For all of these including, in the long run, military bases, the Stefan-Boltzman law relating temperature and radiation rate and the fact that people and their machines function best around "room temperature" implies that the radiator surface area will be about four square meters for every, kilowatt of waste heat.

Military fact #1: in the size we need, waste heat radiators will be very large. Radiators must be filled with something (substitutes for wind and water) to carry the heat. For both physical and economic reasons radiators should have walls no thicker than required to contain the filling material.

Military fact #2: radiators are unavoidably fragile. Something both large and fragile would make a lousy military heat sink. Nobody can cheat on physical laws, but with an asteroid, you would be able (for a while) to use the "Alice's Restaurant Method" of waste heat disposal. Alice, who lived in the belfry of a deserted church and put the garbage downstairs, didn't have to take it out very often.

Two weapon systems, particle beams and lasers, have the potential to end the current offense-dominated Mexican stand-off referred to as "Mutual Assured Destruction," or MAD. (Someone in the five-sided squirrel cage has a sense of humor.) Lasers are getting substantial (about $200 million per year) development money in this country, and particle beams are believed to be better supported in the U.S.S.R. The April '79 issue of **Scientific American** has a disparaging article on particle beam weapons. A good part of their objections would not apply to asteroid-based weapons, but particle beams do seem to have more problems than lasers. (The article, while well worth reading, has some of the flavor of a 1900 essay on the impossibility of heavier than air flight.)

Both particle beams and lasers are line of sight, speed of light weapons. This could make for some mighty short wars! They are very similar in needing millions of kilowatts of power and large heat sinks (because they are not very efficient) and both work better in space. Either method, with enough power behind it and a good enough aiming system, could make short work of ICBM's, submarine launched ballistic missiles and perhaps even bombers and cruise missiles, thereby eliminating all three of the U.S. "triad" at one stroke. (Pretty neat, huh?) Since they are not "weapons of mass destruction" presumably they would not be banned by the 1967 Outer Space Treaty. (The U.S. and the U.S.S.R. are special cases as their ABM treaty binds them to not emplace space-based antiballistic missile weapons and strongly limits ground-based ABM's. The treaty was a smart move for both countries considering the cost (very, very high) to effectiveness (low) ratio of ground based ABM systems. If space-based weapons reversed this ratio, the treaty would certainly be revised, mutually or unilaterally.)

Skipping for a moment the moral and geopolitical implications, (you can make a good case supporting or opposing) how does an asteroid fit into this picture?

First, it's by far the easiest way to get a hardened site into space. Hardening is absolutely essential if the opposition has a similar installation. Otherwise, all the advantages go to "he who shoots first," a situation worse than MAD. An actively defended fort could most likely stop missiles, but there is no way to shoot down a laser beam. However, you need not worry about lasers if you are inside a multimillion-ton asteroid. An MIT study some years ago concluded that even to slightly deflect an asteroid (e.g. Icarus) would take a lot of the very largest hydrogen bombs people make. A laser sized to wipe out missiles would just blow little pock marks in the surface of an asteroid.

Second, to keep the laser cool you need a monster heat sink that a hostile laser won't cut to confetti. Radiators are just too vulnerable, (see above) so the waste heat will have to be stored till the war is over and that means an asteroidal sized mass to store the heat. Even if the laser gasses only make one pass through the laser and then are discharged into space, a substantial heat sink would be needed for the auxilliary equipment and such things as cooling the laser mirrors. For the same reason, all the energy to fight a war will have to be stored inside.

Both particle beams and lasers...could make short work of ICMB's, submarine launching ballistic missiles and perhaps even bombers and cruise missiles, thereby eliminating all three of the U.S. "triad" at one stroke.

If you were facing hostile lasers, diverting a solar power satellite (SPS) to power an antiballistic laser would not be a wise move. Besides that, geosynchronous orbit, the most likely place for SPS, may be higher than ideal for these weapons. It would be easier to hit missiles from a lower orbit, though recent studies claim that aircraft could be powered by laser from geosynchronous orbit. (Seven studies have been made on laser-powered aircraft concepts during 1974-1978; see "Laser Aircraft" **Astronautics & Aeronautics**, March 1979.)

How much energy storage and heat sink

capacity would be needed to fight a hypothetical war between the major powers with space based lasers zapping all the missiles? Unless you complicate things by having the forts try to fight each other to the finish, a few gigawatt hours of beam energy is sufficient to wipe out the warhead delivery systems inventory of the entire world. Altogether there are less than 5000 ICBM's and submarine-launched ballistic missiles. Five gigawatt hours of beam energy would give a little less than a ton of explosive effect for each one.

Because lasers are only about 20% efficient,* and allowing for some safety margin, energy storage might be ten times the beam energy and heat sink capacity about eight times the beam energy. To get a feel for this amount of energy in standard military terms one gigawatt hour is equivalent to about 900 tons of TNT.

The next question is how big an asteroid do you need in order to absorb, say, 40 gigawatt hours? A simple rule of thumb is that a kilowatt second will heat a kilogram of rock about one degree C. Forty gigawatt hours is 14.4×10^9 kilowatts, which means this much energy would heat a million ton (10^9 kg) asteroid 14.4 degrees C. Thermal stress rather than absolute temperature rise may turn out to be a determining factor. To keep a fort ready, you keep it cold.

How would an asteroid fort be constructed that could take considerable pounding from lasers and missiles and still be able to zap ICBM's? The best type, to start, would be the solid nickel-iron variety found in science fiction stories. Unfortunately, that may be the only place to find them. The processes (hotly argued over) that formed these objects may have left fracture-prone weak zones of silicate material between large blocks of solid metal.

For iron asteroids with fracture zones or stony iron (lumps of iron mixed with rock) the first job will be some outside shaping followed by drilling a lot of holes through the asteroid and stringing it together with steel cables. This would probably work with any asteroid that had as much compressive strength as concrete.

Next, a maze of coolant channels would be drilled through the rock or iron. Iron would provide an advantage here because of its much better conductivity. Either rock or iron would be fairly easy to drill through, but a mixture would be more difficult. The laser, control system and power storage would be installed in cavities dug out of the center of the asteroid. My guess is that energy would be stored in flywheels or fuel cells. Primary power could be nuclear reactors or solar cells. Either the solar cells or heat radiators for the reactor would hang outside and you could expect them to be shot off right at the start of any action.

Lastly, the surface would be covered many meters deep with foamed metal to soak up energy from a close nuclear blast or a short laser pulse. Much of the energy from a nuclear blast in space arrives in the form of X-rays which heat the outside surface so fast that a shock wave causes pieces to fly off the inside wall (spallation). A substantial layer of something crushable takes care of this problem.

How much energy storage and heat sink capacity would be needed to fight a hypothetical war between the major powers with space based lasers zapping all the missiles?

To track targets and control the aiming of the laser would require a dispersed phased array radar too spread out to knock out with missiles and too hard to take out quickly with a laser. Verification of target destruction and some tracking would be done optically or with infrared. The radar information would be transmitted over redundant channels to a very large, fast computer in the fort. This part is within the capacity of present day electronics.

Like the Death Star in Star Wars, these space forts would have a vulnerable spot. They could be really messed up if a tightly focused laser beam went in where their relatively diffuse beam went out. Each one might be surrounded with a flotilla of actively controlled mirrors. That way, a fort could take bank shots at the other forts, while avoiding looking directly at them. (A fully focused beam would be so energetic that it would not be reflected, but just vaporize the bank-shot mirror.)

There are many counter and counter-counter strategies including shooting lasers at the forts from the ground, trying to disable all the enemy's reflector flotilla, hardening the bank shot reflectors, and slinging rocks at the forts. None look very promising. Attacking from the ground with lasers looks like it would bankrupt the country that tried it.

Why? Missiles can by destroyed by the energy equivalent of a few kilograms of TNT. A bomber can be wrecked by the equivalent of a few hundred kilograms. But an asteroid would take hundreds of megatons of TNT or millions of gigawatt hours. Not counting laser inefficiency, or the cost of the laser, a million gigawatt hours at one cent per kWh is $100 billion. The lasers would cost a thousand to a million times this much. Hitting a fort with another asteroid would be effective, but would take years due to celestial mechanics considerations. Also, it isn't easy to do secretly. Even the slightest ability of a fort to dodge would make it vastly more difficult to hit.

Fighting it out between forts of similar size looks like a lost cause. The old saying "this hurts me more than you" really applies to space forts because four times as much energy as is in the laser beam must be dumped internally. The vast majority of energy coming in on a laser beam would be reradiated to space from where it struck and do very little heating. Even with limitless energy available, an attacker using lasers would cook itself long before doing much damage to a target fort.

For the same reason, a small amount of hardening would protect a ground installation from attack by a space-based laser. The total energy available within a fort due to laser energy storage is equivalent to only a few hundred to a few thousand tons of TNT. The opposition couldn't hide the size of a fort either. The potential destructive power of a fort would be directly proportional to its observable size.

Schemes to put forts out of action would be less attractive if many countries owned several forts each. If only two countries owned one fort each, a fort being put out of action would leave the owner of that fort in a very bad fix, exposed to ICBM's without any way to retaliate. If a dozen countries owned several forts each, there would be very little point in keeping ICBM's active at all. Of course, some countries would still keep ICBM's around just to force others to spend money on defense. (A major effect of the U.S. bomber fleet is to force the U.S.S.R. to spend a bundle on air defense.)

Whether or not asteroid forts and very large lasers in space would have a major effect on ground warfare is a good question. I am sure that tanks would be much more difficult to take out of action than cruise missiles or bombers. However, if the problems of shooting down through the atmosphere can be solved (adaptive optics won't work because of the distance to the perturbing media), it might accelerate the current trend, started by precision guided munitions, to quickly remove large, expensive objects from the battlefield. I don't think the troops will go back to swords and horses, but automatic rifles, hand-held rocket launchers and motorcycles might be the most expensive items practical on a year 2000 battlefield.

May the force be with you!

*If you believe in higher efficiency, plug in your own numbers. Free electron lasers might reach 50%.

When the Soviets Let Their Hair Down

While Soviet remarks recorded at international conferences and in scholarly journals tend to be guarded, sometimes in the popular press the Soviets let their hair down.

by Dick Fredericksen

Regular readers of **L-5 News** should be experts, of sorts, on what to expect of the Soviet space program. By a casual count, there were five full-scale articles, two commentaries, three news items, and sixteen snippets that bore on this subject in the period from January, 1978 through March, 1979. Jim Oberg and Phill Parker gave technical details of the Salyut-Soyuz program. Tom Heppenheimer allowed that the Salyut-Soyuz hookup qualifies (like Skylab before it) as a "space station"; while Oberg, pulling the evidence together, concluded that the Soviets mean business about human activities in space, and that something BIG is in the works.

As for the Soviets' own representation of what they are about, Jim Oberg provided a long series of translations from the Soviet press, scientific reports, etc. Frederick Osborne, Jr., also conveyed some remarks made by Soviet scientists at an international astronautical conference. An overall summary is that Soviet scientists are cautiously optimistic about space industrialization and solar power satellites. One Soviet scientist has even taken the "O'Neill line" with respect to the use of lunar resources.

However, the remarks recorded at international conferences, in scholarly journals, and the like are understandably rather guarded. L-5 readers may be interested to learn that sometimes, in the the popular press, the Soviets let their hair down. The accompanying article from **Sputnik** magazine ("Energy from Space") is a spectacular case in point. (**Sputnik**, a digest in form and content, cites **Nedelya—The Week**—as the original source.)

A number of observations are worth making. First, note the almost lyrical quality of the description. "To it (the microwave beam from the power satellite), neither the cold of space, nor the thickness of the atmosphere, nor fog, nor dark storm clouds will be an obstacle. It will operate uninterruptedly, day and night." Gosh, remember the U.S. Postal Service?

Secondly, note carefully the list of environmental concerns: "How will the transmission of microwaves impact radio communications?" That's only given as one example of such a concern, but still it seems a significant choice, by way of what it doesn't put foremost. *What about the microwave safety issue?* Soviet safety limits for human exposure to microwaves (.01 milli-watts/cm^2) are more exacting than the United States standard (1000 times higher), and have been frequently cited by those in America who feel an anxiety about microwave proliferation. Notice, though, that at least one Soviet writer doesn't let the microwave willies temper his enthusiasm for SPS (or SKES, as the Russians designate it). There may be more than one school of thought about microwave safety in the USSR as well as in the U.S. Or, it may be that the Soviets do not intend their industrial safety standards to be applied unconditionally (to the exclusion of large-scale economic benefits) or out of context (in a roped-off receiving area).

Scan an article about marshlands, and you'll learn of schemes to make the northern rivers run backwards . . . . Soviet Communists have a fondness for this sort of thing: they love to raise visions of technological revolution . . . .

There is only one surprising note in what otherwise reads like a familiar litany: the allusion to "the bowl of a receiving antenna with a diameter of one kilometer or a bit larger." Bowl? Most of us had been envisioning something more like a field of waving dipoles.

A word of caution is in order. An American reader, knowing that the Soviet press is carefully censored, may infer too much from the publication therein of a pro-SPS article. It may seem to carry official approval. Or, deeply suspicious of all things Soviet, the American may see the article as "disinformation"—a put-up job to mislead Western readers. Either way, the impression could be heightened in the present instance by the fact that the article was reprinted in **Sputnik**, the USSR's slickest propaganda export. Nothing appears there, it is reasonable to assume, without thorough review.

A more relaxed appraisal, however, is available: *scientific bigthink is a fully approved literary genre in the USSR*. Pick up a children's book about transportation in a Soviet bookstore, and you're likely to find (somewhere toward the end) a breathless prediction of hovercars and levitated trains. Scan an article about marshlands, and you'll learn of schemes to make the northern rivers run backward. Read something about space, and—well, you get the picture. Soviet Communists have a fondness for this sort of thing: they love to raise visions of technological revolution, especially if vast public enterprises are required.

How seriously to take it? Well, it's not a commitment for delivery in the second quarter of 1983. Neither resources nor prestige are laid on the line by the mere fact that the Soviets let their hair down and talk about projects that appeal to them. On the other hand, neither is the discussion frivolous; the censors would be unlikely to pass a similiar article that encourages hopes of, say, telekinesis or precognition. The fact that the grandiose vision is published does imply a judgment that it's a reasonable scientific speculation. The fact that the Soviets are pouring resources and efforts into human occupancy of space does say something. And the Soviets do embark upon large-scale projects with long-term payoffs; it is in fact their favorite sort of project.

This article from the Soviet newspaper **Nedelya (The Week)** *exemplifies what Dick Fredericksen terms "scientific big think . . . in the USSR." (See the preceeding article, "When the Soviets Let Their Hair Down," by Dick Fredericksen.)*

Energy from Space

The creation of the orbital system "Salyut-Soyuz," serviced by automated space freighters, opens the way to construction in the cosmos of varied objects, among them orbital power plants.

by Iosif Zorich

The power of the Sun exceeds by 5,000 times the total power of all other sources of energy on Earth. And that source is inexhaustible. However, on Earth the Sun's rays scorch all living things in some regions, while in others they don't peep in for months. But even in the Sahara and Kara-Kum deserts, the Sun disappears nightly for half of the 24-hour cycle. Small wonder, then, that up until lately scientists have treated solar technology without much enthusiasm as an industrial resource for electric power generation.

But there *is* a place where the Sun shines constantly. That's in the open cosmos. There, there's no sunshine or sunset, no clouds, no atmosphere to weaken the sunshine. And now scientists of many countries are arriving at the thought that it's necessary to capture the Sun's energy precisely in space, and send it to the Earth. But is this possible? Yes, it's possible, and if not immediately, then in the not so remote future.

Already today they put photovoltaic panels on satellites and spaceships. These transform solar energy into electricity and feed with it the apparatus and auxiliary engines of the ships. Imagine a space station in so-called geostationary orbit; that is, at a distance of 35,800 kilometers from the Earth. The period of revolution of such a station is 24 hours; it will revolve synchronously with the Earth's rotation. The station will seemingly "hang" over one point of the Earth's surface. Geostationary, or synchronous, orbits are nothing new; in them are found communication satellites, with the help of which telegraph-telephone communications and long-distance television transmission are realized.

Artwork by James Babcock

At such a height, every square meter of the spaceship's panels can constantly receive from the Sun about one and a half kilowatts; from them it is possible to transform roughly a tenth part into electricity. One hundred and fifty watts from a square meter: that, to be sure, isn't much, but then, there's as much free space as you like in the cosmos. There's nothing to prevent spreading panels for tens of kilometers and receiving from them millions of kilowatts of energy. It is calculated that if a solar cosmic electrostation (SKES) is furnished with a pair of wings measuring 6 by 5 kilometers each, then the output of electricity will be 5 million kilowatts.

There is also another way to transform solar into electrical energy: thermal turbines. It is possible to gather solar rays with gigantic mirrors, concentrate the powerful beams, and use them to heat a liquid, turning it to steam. The steam will work in the ususal way: turn a turbine, with which a generator is connected, producing electrical current.

Fantasy? No, Reality!

However, there arises a problem of transporting the electricity to Earth. Not along wires, that's for sure! Two means of transmitting power over long distances without wires are being proposed: the first with the help of a laser beam, and the second—microwaves. The second, perhaps, is the more practicable.

Microwave technology has developed broadly in recent decades. It is precisely in this centimeter wavelength range that they carry out the observations of radioastronomy and implement high-frequency radio communications. The possibility of industrial transmission of large quantities of electricity via microwave channels is also under investigation. The first ideas in this area are attributed to the distinguished Soviet physicist, academician Peter Kapitsa.

This capacity promises humanity enormous benefits: it will be possible to pump electricity along waveguides—pipes laid under the ground like oil and gas pipes. But that's in terrestrial circumstances, whereas for the transmission of electricity from space, even pipes will be unneeded. A microwave bridge with a span of tens of thousands of kilometers will unite the SKES with the planet. To it, neither the cold of space, nor the thickness of the atmosphere, nor fog, nor dark storm clouds will be an obstacle. It will operate uninterruptedly, winter and summer, day and night. On Earth, the bowl of a receiving antenna with a diameter of one kilometer or a bit larger will be able to take the microwave radiation, transform it to the usual AC or DC current, and distribute this energy to consumers.

Fantasy? No! Grandiose as it is, such a project is based upon the practical ground of calculations and experiments. Such figures, for example, characterize the scale of the project. The weight (more accurately, the mass, since we're talking about conditions of weightlessness) of all the equipment of an SKES with a capacity of 10 million kilowatts, using photoelectric cells, comes to about 35 thousand tons, while for an SKES using turbogenerators, it's more than 100 thousand tons. All these materials, assemblies, and modules will have to be conveyed to space, mounted, tested, and set in operation. The assembly of such a station will be carried out in near-Earth orbit, located at a distance of 200-300 km from Earth, with the help of people and special robot-manipulators. After assembly and check-out, the plant can be conveyed to geostationary orbit. Hundreds of engines, placed along all areas of the station, are turned on, and it begins a cosmic trip stretching tens of thousands of kilometers. On that trip, half a year will go by, probably, or maybe a whole year. The station will need auxiliary engines even in geostationary orbit. They will orient the solar cells toward the Sun, compensate for displacements arising from the action of the "solar wind", and assure a strict orientation of the station relative to the receiving antennae on Earth.

Granted, a multitude of problems remain to be solved before it will be possible to set about creating space electrostations. But all of these have technical, rather than a principled character. However, there is an obligation to examine also the economic, social-legal, ecological, and other aspects of SKES creation. How, for example, will the transmission of powerful microwaves impact radio communications? How to distribute sections of geostationary orbit among countries and guarantee equal rights and equal opportunities for all countries?

"Shuttle" Ships in Space

And now we raise a question, paradoxical at first glance, nullifying everything said above: is it necessary to transmit energy from an SKES to Earth? Under terrestrial conditions, it's often easier and cheaper to transport raw materials than energy. Mightn't we take the same route in space? Might it be more expedient to build enterprises in some fields right in orbit, in a single complex with SKES? "Shuttle" transport ships will convey raw materials out and bring back processed materials, or even finished goods; passenger runs will transport service personnel, working in shifts. That will yield a mass of advantages.

First and foremost, it will significantly reduce the outpour into the Earth's atmosphere of the byproducts of the "dirtiest" productive processes. In the second place, in space, under conditions of weightlessness and almost absolute vacuum, it's easier than on Earth to obtain especially pure substances or materials with uniform distribution of dopants, and to grow large cyrstals with given properties.

Soviet cosmonauts have laid down the beginning of a space technology which, beyond any question, will develop and be perfected, crossing from the realm of experiments into the realm of industrial exploitation. The Soviet "Soyuz" space ships and "Salyut" orbital space stations not only serve the here-and-now needs of science and the national economy, but in no lesser degree work for the future of humanity. And one of the pressing problems in that future will be the opening up of an energy frontier in space.

Shakespeare Quoted At Senate Hearings

Reprinted from L-Forum, the Newsletter of the Northwest L-5 Society.

The February 12 and February 19 issues of **Aviation Week and Space Technology** contain editorials that will be of particular interest to L-5 members. They are taken from testimony by James Michener before the Senate space policy hearings, and from an address by Norman Cousins before an AIAA space policy panel. Both men eloquently defend space exploration as imperative to the growth and evolution both of the nation and of the human race. Michener's theme is primarily a historical perspective and a warning on what happens when a nation loses the "energy and commitment to lift it into the next cycle of experience." He offers a most apt quotation from William Shakespeare:

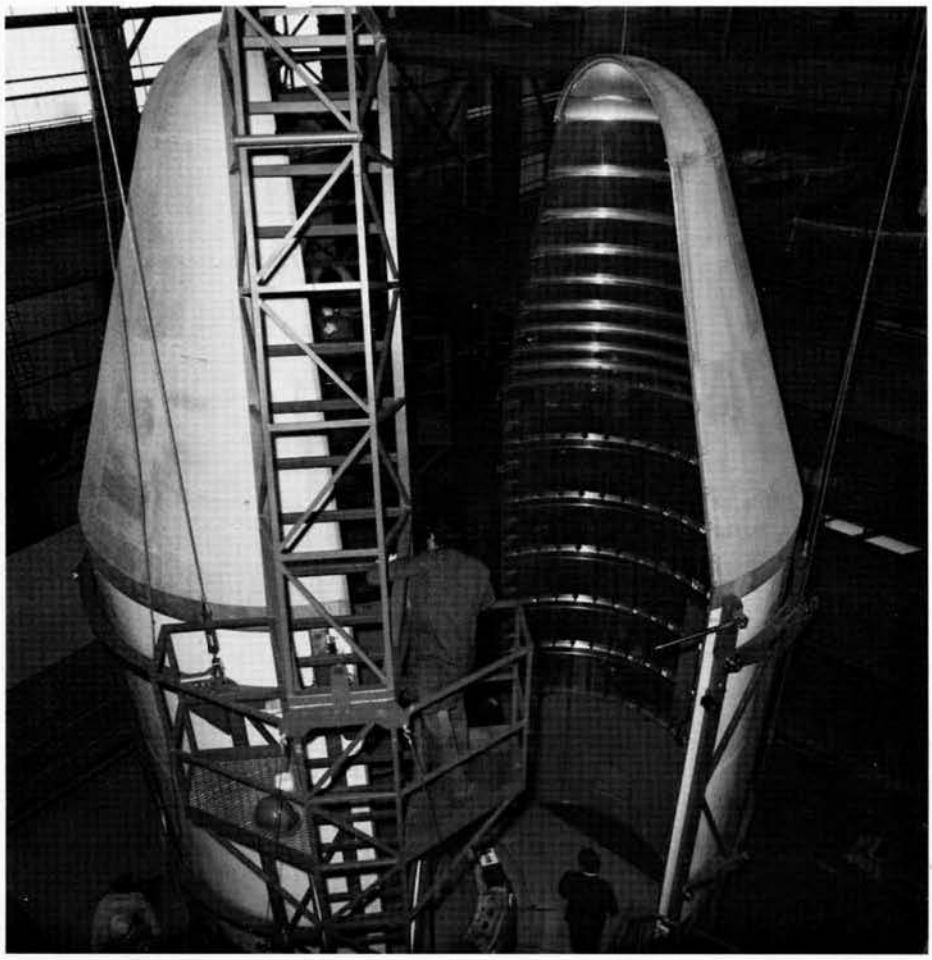
> There is a tide in the affairs of men,
> Which, taken at the flood, leads on to fortune;
> Omitted, all the voyage of their life
> Is bound in shallows and in miseries.
> On such a full sea are we now afloat,
> And we must take the current when it serves,
> Or lose our ventures.

Cousins sees the issue of space exploration in terms of the conflict between "those who have a constricted view of human potentialities and those who define infinity as that which takes place in the human mind." He perhaps oversimplifies things, but still makes a point. Where Michener quotes Shakespeare, Cousins quotes Whitehead:

> There is now no choice before us. Either we must succeed in providing a rational coordination of impulses and the guts, or for centuries civilization will sink into a mere welter of minor excitements. We must produce a great age or see the collapse of the upward striving of the race.

Ariane Ahead of Schedule

by Randy Clamons



Workers prepare Ariane fairings for testing at the Aerospatiale plant in Les Mureaux, France. (Photo courtesy of ESA)

ESA Sets Launch Date

The European Space Agency (ESA), a combined effort of fifteen countries mostly in Europe, has nearly completed the qualification firings of all three stages of the Ariane launch vehicle. An explosion caused by the faulty ignition of an engine at the end of November, 1978, which damaged the third-stage propulsion bay, has suspended developmental testing of this stage with flight tanks.

ESA does not feel as though this jeopardizes the project and will continue testing the third-stage with battleship tanks through June of this year. These tests will be carried out simultaneously when testing of the flight tanks resumes in May.

The Ariane launcher, originally designed to place a 1500 kg payload in a transfer orbit of 200/36,000 km, is scheduled to make four test flights between November 3, 1979, and October, 1980, well ahead of the initial program target. The first operational launch has been requested for April, 1981.

The first of the test flights will carry only the technological capsule and ballast. The other flights will carry a radio-amateur satellite (Amsat), a Max Planck Institute experiment (Firewheel), a European meterological satellite (Meteosat-F-2), an Indian experimental communications satellite (APPLE), and a European maritime communications satellite (MARECS-A). The Ariane launcher has the capability of placing two satellites in orbit from the same launch.

Upon completion of the tests the ESA plans to begin production of the Ariane launcher. Including space systems to which Europe is already committed and systems expected to be implemented, ESA projects a requirement of 40 to 50 launch vehicles over the next ten years.

Ariane to Compete With Shuttle?

Even though both the Ariane launcher and the Shuttle will be used to launch applications satellites, the uses of the systems could differ greatly. The Shuttle seems suited best to low orbit missions, since it requires an additional powered stage to reach geostationary orbit (GEO). The lift-off mass of the Shuttle to GEO is ten times that of the Ariane, but it performs only twice as well. Ariane is particularly suitable for the sun-synchronous orbits required for Earth observation satellites.

All three of the complete flight configuration tests of Ariane's three stages took place in December, 1977, and January, 1978, at nominal thrust. The first test of the Shuttle main engine at the beginning of the year was unsuccessful. The failure of one of the four Ariane qualification tests, says ESA, would have little impact on its operational availability. ESA, in view of the planned use of a single Orbiter for all six qualification flights of the Shuttle system, claims that one in-flight accident could be catastrophic to the NASA program.

The cost of launching satellites with the Ariane system is slightly less than the cost of the Shuttle launch. A satellite of the Intelsat V class could be launched, according to NASA, for 22.5 million dollars (mid-1977 prices). The marginal cost of a similar Ariane launch is very close at 22 million dollars (mid-1977 prices), which includes 10% for an insurance policy that provides a free reflight in the event of a failure.

ESA does not feel as though the Ariane and the Shuttle will compete for the satellite launch market. In the words of an ESA report, "It is fair to assume that the coexistence of Ariane and the Shuttle on the applications satellites market of the next decade should not prove detrimental to either system."

The Ariane will be used only for launching information retrieving satellites, while the Shuttle is designed to

be piloted and re-usable. This will mark the true difference of the application of the two systems. Proposed plans to uprate the Ariane system include a reduction of production costs, raising the capability of the launcher to 2300 kg and a study of parachute-aided re-use of the L140 first stage.

ESA and NASA Combine Efforts

The most important program on which ESA and NASA cooperate is Spacelab, an inhabited re-usable space laboratory designed to be placed in orbit by NASA's Space Shuttle. The two agencies share equally the energy and crew time of this mission scheduled for 1981. ESA ordered the manufacture of the first flight model in March, 1978.

Spacelab is being built modularly to provide greater flexibility in its use. This system uses a module-pallet configuration as well as modularized subsystem elements. This will allow a greater payload by eliminating the unnecessary equipment, assuring dynamic design possibilities for future missions.

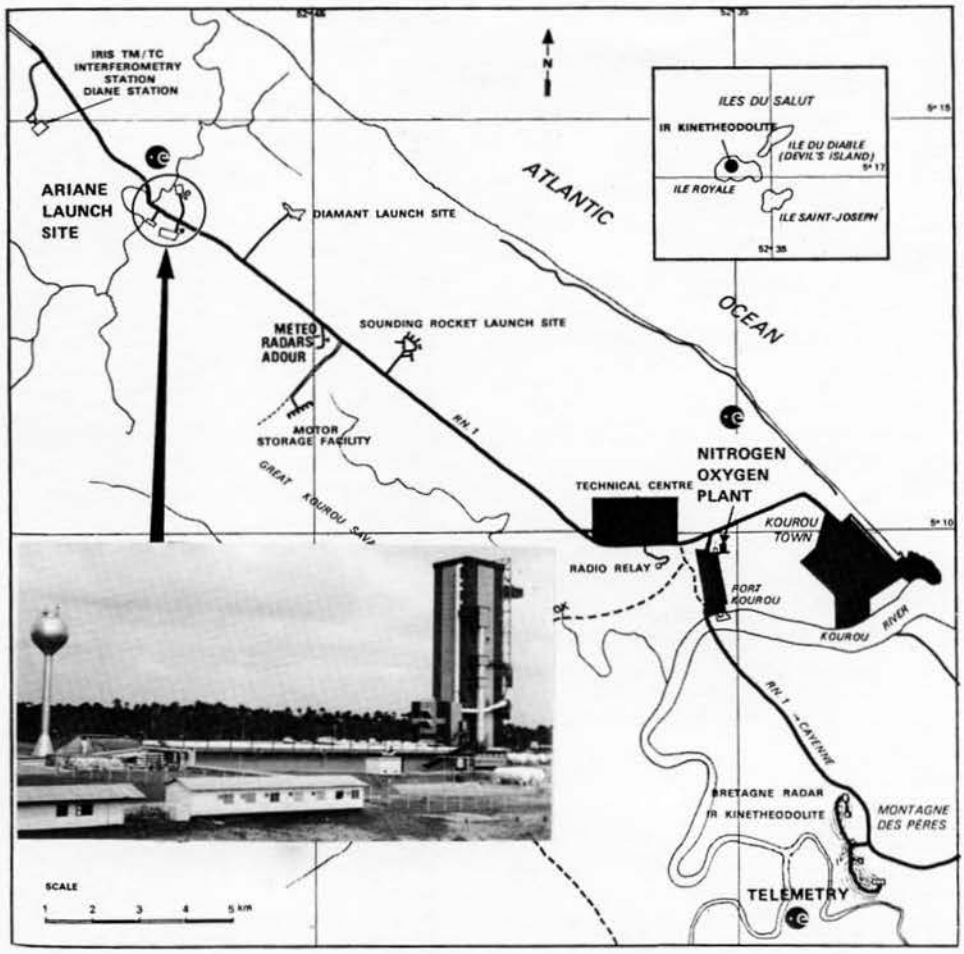
ESA and NASA have chosen 76 scientific and technological experiments — 60 European, 15 American, and one Japanese. The main advantage of this mission over those previous will be the presence of trained scientists as well as astronauts.

Some possible fields of experimentation include:

- High energy astrophysics
- Ultraviolet, optical, infrared and X-ray stellar, planetary and solar astronomy
- Atmospheric, ionospheric (plasma) and magnetospheric physics
- Life sciences (including biology, biomedicine, behavior)
- Remote Earth-sensing (meteorology, land-use, planning, resources, pollution control, etc.)
- Material sciences (e.g. crystal growth, pure metals and alloys, composite materials and fluid physics)
- Processing and manufacturing in space (e.g. electrophoresis, high-strength materials)
- Communications and navigation

Some 222 investigators from 16 countries will participate in Spacelab's first mission. Approximately 135 of the investigators are from twelve European countries (Austria, Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom), and 81 are from the United States.

The final launch date of Spacelab now depends mostly on the development of the Space Shuttle.



The Ariane Launch Site, situated within the Guyana Space Center.

Guyana Space Center

Launchings of the Ariane will be from the Guyana Space Center ("Centre Spatial Guyanais" — CSG) in Korou, French Guyana. This space was chosen by the European Launcher Development Organization in 1966 because of its equatorial location. At 5.23 degrees North, 52.75 degrees West, CSG is an advantageous location for launches into synchronous orbits. Since becoming operational in April, 1968 CSG has been responsible for the launching and the tracking operations of 12 satellites and about 350 sounding rockets and balloons.

Telemetry reception facilities include three stations of CSG and two cooperating stations, a Brazilian station near Natal, Brazil, and the NASA/DOD facility on Ascension Island. The Galliot station at Korou, the Montabo station near Cayenne, French Guyana, and mobile station to be located near Belem, Brazil, comprise the CSG part of the network. Tracking stations are at Meteo, Korou; Leblond, Korou; Montabo, Cayenne; Natal and the DOD station on Ascension Island.

Since the highly successful completion of the Diamant BP4 launcher program in September, 1975, CSG has been mainly oriented towards making adjustments to accomodate the Ariane program requirements. The Ariane facilities and launch site are owned by the ESA, whose member states have contributed some 70 MAU (million accounting units, 1AU = $US 1.08) to the cost of running and renewing the range. ESA participates in the planning, financing, and control of CSG through an agreement signed with the French government on May 5, 1976. This agreement guarantees ESA and its member states access to and use of the Ariane launch site for purposes of the program.

The Landsat Hearings

by Ken McCormick

Schmitt and Stevenson's legislation for a remote sensing operational system has won support from federal agencies, but Carter is still dragging his heels.

At an April 9, hearing on remote sensing, presidential science advisor Frank Press told members of the Senate Subcommittee on Science, Technology and Space that the Carter Administration is "committed" to moving experimental Earth resources remote sensing satellite programs to an operational system. But he maintained that uncertainties about how to establish an appropriate institutional framework for acquiring and distributing remote sensing data dictate that the Administration will have to spend more time studying the situation before taking action. Senators Harrison Schmitt and Adlai Stevenson III did not agree.

Remote sensing satellites provide useful data for such things as . . . the locating of mineral resources such as oil, gas, and coal.

Schmitt said at the end of the hearings on April 11 that "everybody agrees, except for the Administration witnesses, that we ought to act now. We've studied this thing to death. Anybody who's been in this business for any length of time at all believes that we've been at dead center for many, many years."

Sen. Stevenson pointed out that two years ago, when the subcommittee had considered legislation to establish an operational remote sensing system, Dr. Press had said that plans for such a system were premature and had promised that a cabinet-level group would study the issue and make recommendations. Stevenson said that the issue has since been studied by a number of groups, and that none had proposed further delay.

Federal agencies which were prepared to support legislation authored by Harrison Schmitt and Adlai Stevenson for a remote sensing operational system had been ordered by Carter's Office of Management and Budget to only go so far as to express a desire to work with Congress in the future to arrive at a satisfactory arrangement. This prompted Stevenson to say that "everyone in the Carter Administration wants to get on with remote sensing except one person — Carter."

"It appears," said Stevenson, "that the Congress is more ready to solve the institutional question than the Administration. If there is much more delay, we will legislate an end to the apparent indecision in the Executive Branch."

Remote sensing satellites provide useful data for such things as large area crop inventory, urban planning, forestry, water quality assessment and planning, flood control, surface water inventory, and the locating of mineral resources such as oil, gas and coal. The cost, time and labor required by more conventional techniques for gathering this data are often prohibitive. Sen. Stevenson has estimated the potential market for satellite data at one-half to one billion dollars in the early 1980's.

Daniel J. Fink, General Electric vice president, appeared before the subcommittee to support Sen. Stevenson's bill, but to express serious doubts about Sen Schmitt's bill to set up a private corporation for Earth resources information which would be modeled after Comsat. "I have taken the position," said Frank, "that what was good for the communications business with its long-established markets, mature user operating practices, and accepted international agreements, would most likely be bad for Earth resources observation, a new, untried venture with technology and markets that are still developing and proliferating." Fink preferred the approach of Sen. Stevenson, who would locate the service within NASA for a transition period of no more than seven years, after which the service would move to the private sector or some other agency or be left within NASA.

Schmitt argued that the private sector approach would be viable from the beginning because the government would be the purchaser of most of the data at first, and that this economic guarantee would allow sufficient time for the corporation to do the work of aggregating and developing for the non-government market. Schmitt acknowledged uncertainties about establishing the intrinsic value of the data, setting rates which will not exclude data acquisition by certain users, how to tailor the service to user needs, and how to provide enough redundancy for reliability of continuity of data. He maintained, however, that these questions would never be completely answered as long as the service were left within the government as an operational unit.

"It appears," said Stevenson, "that the Congress is more ready to solve the institutional question than the Administration."

Sen. Stevenson said that although he

feels that NASA is the best lead agency, we should be moving "under a congressional mandate towards operation by the private sector . . . I would like to see as much involvement as possible, and as early as possible, by the private sector, and still contemplate, in whatever the interim period is, operation of the system by the private sector."

Dr. Robert K. Vincent, president of Geospectra Corporation, a small company which now provides remote sensing services utilizing satellite data from the government, felt that if the U.S. is to maintain its lead in this technology, a compromise version of Schmitt's and Stevenson's bills must be passed as quickly as possible. Vincent expressed a desire to see, as soon as possible, a transition from a government operation to a corporation such as that described by Schmitt because "industry's profit motive and competitive nature will assure better performance than any government agency or non-profit institution."

John L. McLucas, executive vice president of Comsat Corporation, proposed a compromise approach in which Comsat would be designated as the entity responsible for the establishment of the remote sensing data service. Under the plan, NASA would continue the already-approved Landsat programs, and Comsat would contribute a satellite system to provide high-resolution stereoscopic data.

Although the White House says that assessments of how to proceed with an operational system should be completed this summer, Senators Schmitt and Stevenson both feel that it is necessary to continue pressing Carter on this matter in order to get any action. Said Stevenson: "I think after hearing the testimony from the Administration, that the only way we'll get it to act is to act ourselves. That means . . . (reporting) a bill soon from the Commerce Committee, and perhaps withholding action on the Senate floor until such time as the Administration will act . . .

"We've waited a long time already. I think it would be irresponsible for us to wait any longer.

"The Congress in a sense is ready, and the institutional problems, at least in the interim, should not be very difficult for anybody to resolve.

"So we ought to go ahead and do it. And if they (in the Administration) want to join us, that'll be their opportunity. They'll have a chance to do it.

"If they don't, then the Congress will have the opportunity to act early in the next session, at the latest, and I'd be very surprised if it didn't."

Hail Columbia

by Frederick H. Osborn Jr.

GARRISON, New York, April 6, 1979—(after a visit to Kennedy Space Center, Cape Canaveral, Florida, March 6, and several subsequent phone conversations with Dick Young, Public Information Officer at KSC.)

Columbia, Space Shuttle Orbiter 102, rollicked into Cape Canaveral, Florida, March 24 at 11:03 a.m. two weeks late. Patched and band-aided like a debutante dragged through brambles, she rode her sleek 747 to a gentle landing, heard welcoming speeches by Dr. Robert A. Frosch and other NASA notables in front of her crew, headed by John W. Young and Robert L. Crippin, and 3750 Kennedy Space Center employees, and was hooked up to the nearby demate device where technicians labored lovingly the night through. By 6 a.m., dismounted, wheels solidly on the ground, she was hauled away to the Orbiter Processing Facility for a full scale physical exam.

Her forward reaction control system will be checked out at Kennedy's Hypergolic Maintenance Facility this month (did you know that hypergolic means "igniting upon contact of components without external aid"?). Her right and left orbital propulsion systems will be similarly checked out in May.

Electronic and avionics experts will check her computers. Mechanics will test and install the three mighty main engines that are due to arrive April 10, April 29 and May 15, and 400 specially trained Rockwell technicians will work around-the-clock to finish clothing her tender underparts with 7,800 more thermal protection tiles.

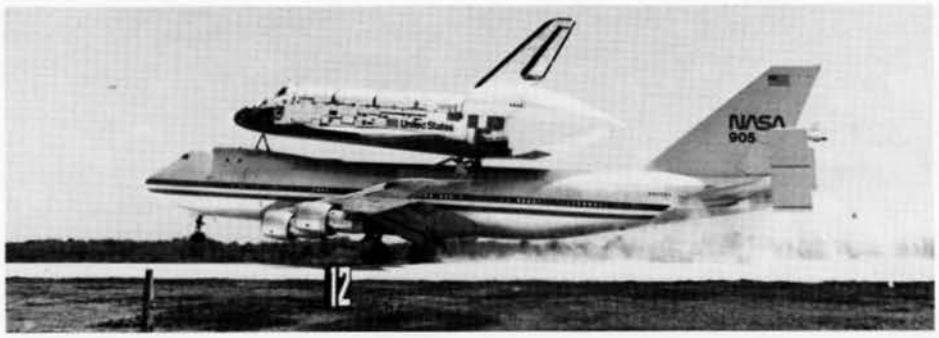
An Integrated Test Program is scheduled for July 9 to verify that all subsystems are working, and, if all goes well, she will be moved into the 52 story Vehicle Assembly Building to mate with her external liquid fuel tank and twin sold rocket boosters July 30th. After further testing roll-out to the pad at Launch Complex 39-A is scheduled for August 20. Testing and processing at the pad will take about 12 weeks. Engines will be tried out, flight and ground crews will conduct dry runs. The final check-out is scheduled for November 2, leading to a November 9 launch.

With Columbia's arrival, the corridors in the great KSC headquarters building, which for the past several years have echoed hollowly to skeleton crews rustling papers at each other, are bustling again. As if with returning spring, the air is becoming electric. Would that a whiff of this enthusiasm could be wafted to the White House and NASA headquarters in Washington!

It is expected that Columbia will be launched on her maiden voyage in daylight from pad 39-A into a 172.5 statute mile (277.5 km) circular orbit with an inclination of approximately 40.5 degrees. On reaching an altitude of 30 miles (48 km) her solid rocket boosters will drop off, parachute to the ocean 150 miles off Cape Canaveral and be towed back for refueling. About 69 miles up the external liquid fuel tank will be jettisoned and fall into the Indian Ocean.

Columbia will stay in orbit 54 hours while orbiter systems, operations, aerodynamics and other characteristics are checked out. She will re-enter the atmosphere at about 17,000 miles per hour and descend to Edwards Air Force Base in California, landing at the dry lake bed runway at 215 miles per hour.

After check-out she will again be mated to her 747 and flown to Cape Canaveral. There will be five more orbital test flights before the Space Shuttle will be regarded as operational some time in 1980.



The 747 jet transport with its cargo, the Orbiter Columbia

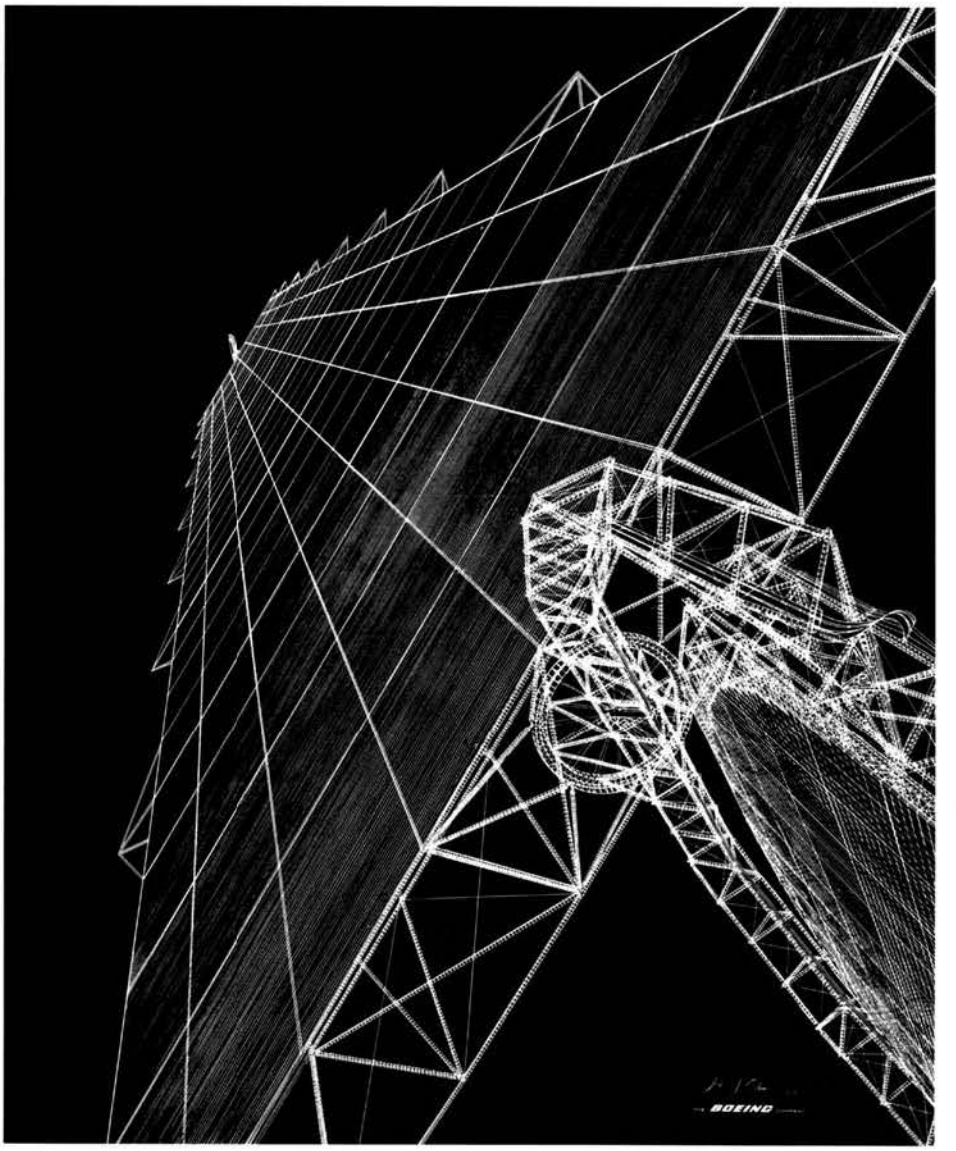
High Frontier Politics

by Ken McCormick

In discussing legislative issues with members of the L-5 Society, I have become aware of certain widely-held ideas on the politics of space which seem to me to be rooted in misconception. I would like to challenge here a few of the more destructive of these ideas. One disclaimer I suppose I should make before proceeding is that although I have worked on some special projects for the L-5 Society, my own views expressed here are by no means a statement of L-5 Society policy.

What is undoubtedly the worst misconception that I have encountered (and encountered frequently) is that a Solar Power Satellite (SPS) construction program would not be important to the early achievement of a large-scale use of nonterrestrial resources and space settlement as described by Gerard K. O'Neill. This belief is often held by L-5er's who complain that SPS is a shaky and unpopular proposition and would well be ignored by high frontier enthusiasts. Since it is fairly well-agreed upon that no one is likely for purely spiritual reasons to provide the billions of dollars needed to build space colonies, anti-SPS space colony buffs tend to look to other areas of space industrialization to provide the economic incentive for investment in large space habitats. It is often stated that other space manufacturing ventures would be better stepping stones to O'Neill's goals than would SPS.

...no other project on the horizon even comes close to offering the spur to space colonization that SPS offers.



What is wrong with this belief is that no other project on the horizon even comes close to offering the spur to space colonization that SPS offers. Science Applications, Inc.'s study of space industrialization opportunities, published April 15, 1978, provides some indication of the relative importance of SPS to other now-anticipated space manufacturing projects. SAI estimated the cumulative revenues which might accrue by the year 2010 from the space manufacture of pharmaceuticals, semiconductors, fiber optics, special metals and other products, and came up with a total of 64 billion dollars. Using the same general assumptions, they also estimated the cumulative revenues from an SPS project over the same period at 200 to 600 billion dollars.

I believe it is evident that the investment of tens of billions of dollars in a large-scale nonterrestrial materials (NTM) utilization capability and in the construction of large space habitats would be more attractive as a part of a project capable of producing 600 billion dollars than as a part of a project capable of producing 64 billion dollars. I might add that Dr. O'Neill believes that SPS produced according to his own plan could ultimately provide all the world's new electrical generating capacity, and therefore would be producing revenues of at least $200 billion per year.

The simple comparison of revenues which can be expected to be produced by various projects is, I will admit, a very crude approach. There are many other things to be considered. The consideration of economic factors is something that many L-5'ers seem to have overlooked, however, and it is of primary importance. The human race will move civilization into space only as quickly as it can afford to do so. The need to explore and open new frontiers, alone, will not lead to the coloni-

zation of space any more quickly than it has led to the colonization of the Antarctic continent or to the construction of cities beneath the sea.

NASA has recently sought to determine what projects could be more economically accomplished using nonterrestrial resources than by launching the necessary materials from the Earth's surface. Only one project could be found which showed great promise. It was SPS. Restrictions were placed on the design of an NTM utilization project which many people feel are unduly stringent, but the fact that SPS *was* accepted as a possible incentive for an NTM investment is, I believe, significant.

Less conservative NTM utilization project design assumptions make NTM more attractive for use in space manufacturing endeavors other than SPS. Using only 13 Shuttle-loads of material, a scaled-down lunar mining facility could be established for as little as 6 to 10 billion dollars. This would be an absolutely minimal operation, and would deliver only a fraction of the raw material to orbit that the operation envisioned in SPS project designs would, but it would be designed for the capability of being expanded over time. This plan is often described as the "foot-in-the-door" scenario for NTM utilization.

The fact that the thrust of NTM utilization work has gone from the original "high frontier" scenario for lunar soil use in the construction of SPS to the "low profile road" to space manufacturing to the "foot-in-the-door" scenario does not necessarily imply that the foot-in-the-door approach would be the best stepping stone to space colonization. The foot-in-the-door scenario may very well be similar to the approach that is finally taken, but we should not now let a scaling-down of the requirements for NTM utilization lead us to a scaling down of our expectations.

The foot-in-the-door project would lead to at least a modest use of extraterrestrial materials. But NTM utilization is only half of the high frontier concept. The other half is probably more striking to most people; it is the prospect of thousands of ordinary men and women living and working in space within the next two or three decades. To arrive at *that*, it looks right now as though we will need SPS. NTM utilization only for products other than SPS would lead to a much more gradual build-up of the human presence in space. Unless some unexpected big project appeared on the horizon, what could be properly described as space colonies might not come into being for decades beyond the time frame for SPS.

I have sometimes heard the view expressed by L-5 Society members that there is a parting of the ways shaping up between one camp of SPS proponents, led by Peter Glaser, who support only the concept of ground-launched SPS, and another camp of proponents, led by Gerard O'Neill, who support only the concept of SPS produced from nonterrestrial materials. The belief is often held, moreover, that a ground-launched SPS program would be very destructive to any hope of achieving the goal of O'Neill's "high frontier," and that L-5'ers should therefore oppose the concept of ground-launched SPS.

This seems to me to be an example, on the amateur enthusiast level, of the "corrosive atmosphere of conflict" which was so well described in Eric Drexler's very excellent article on "The New Space Program" in the July 1978 **L-5 News**.

...Dr. O'Neill believes that SPS produced according to his own plan could ultimately provide all the world's new electrical generating capacity... producing revenues of at least $200 billion per year.

It is true that Dr. Glaser has not been as outspoken in his support of the nonterrestrial materials (NTM) option as some of us would like him to be. He has not yet incorporated the NTM option into his design or economic studies of SPS. He apparently feels, as do all of the SPS proponents within Congress and within NASA with whom I have spoken, that an SPS program can proceed more rapidly at this time with the NTM option on a back burner. Perhaps after ten long years of struggle to gain a measure of acceptance in NASA and in industry for the SPS concept, Dr. Glaser does not now relish the prospect of spearheading a similar drive to gain acceptance for lunar mining and space processing.

He does, however, support Dr. O'Neill's plan as one of the options to be considered for the construction of the satellites. A thoughtful reading of his reply to Rep. Albert Gore's inquiry about the NTM option for SPS last April may provide a degree of insight into his approach: "I am looking at a near-term development, and as such, I am looking at the things that I can describe in a reasonable certainty in reports based on analysis, design and experiment. I do not believe that (for) the kind of program that NASA and industry envisage for developing a solar power satellite, we need to *now* be concerned (with) whether or not to go to the Moon. *However*—once we have a commercial solar power satellite capability demonstrated, and it is seen as being of major global benefit, I believe at *that* point, examination and detailed studies and perhaps doing this lunar mining may be a *very* excellent way of reducing costs."

In the Senate last August, Dr. Glaser had this to say about the concept of the high frontier: "The SPS development program will focus development efforts on space processing, fabrication, assembly and maintenance, human habitations in orbit, space transportation efficiency, and the possible use of extraterrestrial resources, thus setting the stage for achievements which may transcend anything that heretofore has been achieved by the human species. I believe that we are here on the verge of a new evolution—an evolution that can take us into space in ways which we have dreamed about for many years."

Perhaps Dr. Glaser has been overly conservative in failing to incorporate the NTM option in his design studies; perhaps he has not. From what I have seen of the Washington power structure's attitude towards the idea of NTM utilization, I can certainly understand his reluctance to more strongly link it to his concept of SPS. I can also better appreciate the degree of support that he *has* given to Dr. O'Neill's ideas.

The theory that investment in a ground-launched SPS construction program would actually lead away from the "high frontier" is debatable at best. It can be argued that even that kind of SPS program would lead us, because of the great economic importance of SPS, to the use of nonterrestrial materials and to space settlement. This is clearly Peter Glaser's feeling on the matter. As he testified before Congress last August: "A prerequisite for deployment of the SPS is development of a truly economical capability for transportation to orbit and for large-scale construction in space; the possibility therefore arises of other forms of space industrialization and, eventually, of human settlement off Earth."

Both Dr. Glaser and Dr. O'Neill have indicated to me that they will continue to cooperate closely. Dr. Glaser, for example, will deliver a paper at the Princeton conference on space manufacturing, and will also be contributing a chapter to a book on space industrialization now being put together by O'Neill's close associate, Dr. Brian O'Leary. Dr. Glaser and Dr. O'Neill will also collaborate on a paper on SPS for the Vienna U.N. conference on science and technology for developing countries.

Some difference remains, of course. Dr. O'Neill would like to see more serious investigation at this time into the NTM option for SPS; Dr. Glaser feels that the

question of *whether or not* to build SPS must be investigated further before an investigation of *how* to build SPS is undertaken. This difference certainly does not constitute a "parting of the ways," however. As time goes on, the two positions should draw closer together, not farther apart.

Some L-5'ers seem to feel that it is necessary to point out that Congress cannot realistically be expected to commit the nation to O'Neill's concept of NTM utilization for space industrialization. I believe that those people have managed to correctly assess the present situation, but I hope that pessimism will not silence their advocacy of the high frontier. The national mood is not totally immutable. With an SPS evaluation program favorably completed and a commercial SPS capability demonstrated, and thorough studies indicating that NTM and large space habitats could dramatically reduce the cost of SPS, Congress might very reasonably be expected to commit us to O'Neill's "high frontier." At this time, L-5'ers should certainly not be coy when it comes to advocating O'Neill's SPS plan as an option to be considered.

I have found many L-5 Society members who have an interest in political action to be distrustful of existing space legislation and to feel that the introduction of bills at the behest of L-5 pressure groups is the most effective course of action on the high frontier which is open to the citizen lobbyist. It seems to have become an article of popular wisdom that bills which do not mandate funds are nothing but an empty gesture.

The space policy bills of Senators Schmitt and Stevenson are good examples of bills which do not mandate funds, but which definitely are of value. As a matter of fact, it is a good rule of thumb for the citizen lobbyist to assume that any space bill which progresses through committee is designed by a member of Congress to be of some value.

Members of Congress must budget their energies carefully. It requires a certain amount of energy to really push a bill, and a very large expenditure of political energy to get a bill through committee. If someone is willing to expend the energy to do that, it is a pretty safe bet that he or she expects to accomplish something with that bill. Inevitably, some L-5'ers will question whether the member of Congress has the wisdom to know what will achieve something and what will not. Since most politicians have more political savvy than most L-5'ers, though, it behooves most L-5'ers to defer to the judgement of most politicians.

Citizens' groups will sometimes prevail upon congressmen to introduce legislation which deals with some issue that the group is interested in. However, the congressman will usually do so only as a gesture, and most bills of this type are buried in committee. The space movement is not large enough to demand action and get it. Fortunately, there are enough congressmen who see space as being in their own self-interest to make this kind of action unnecessary.

Letter writing, grassroots efforts in public education, and support of prospace politicians are not as dramatic as a visit to one's congressman to demand action, but they really do influence Congress. We can go a long way at this time by supporting and encouraging legislation which members of Congress truly want, and by working constantly to acclimate the establishment to the concept of the high frontier.

X-3 Shuttle Development

by Paul Geyer, TEI Astronaut Corps

Bob Truax's X-3 Space Shuttle developmental tests continue as Truax Engineering Inc. (TEI) has its first major financial backing. The first of three 24 foot, four engine vehicles is about 80% complete and the components for two others are on hand.

The X-3, a nongovernment sponsored vehicle, was conceived by Truax as a ballistic rocket, built from proven components from other space projects, which will take an astronaut on a 50-60 mile high flight in a suborbital trajectory with a range of 5-10 miles. Peak velocity will exceed 2,000 mph.

Bob Truax, a former space engineer, feels that the current NASA shuttle is using an "overkill" expensive technology and that ballistic vehicles are the most efficient for piloted flights. By cutting the reliability down from 99% to a few percent less, the cost factor becomes substantially reduced. In fact, some of the heavy lift launch vehicles for solar power satellites use large ballistic type boosters to transport material into initial low Earth orbit. A ballistic spacecraft is less complex and therefore less expensive and less hazardous than a "spaceplane" configuration.

The X-3 is powered by four Atlas/Thor verniers with a total thrust of 4,000 lbs. Considerable bench testing and developmental work is being done and at least one unpiloted test shot will be required before the vehicle is human-rated. Private financing of the project insures a true effort at flight by "Project Private Enterprise" which would result in the first nongovernment supported piloted space mission.

Total cost of the development through initial flight testing is estimated at over $800,000 which is a fraction of NASA costs even on an unpiloted mission. The supporters of the project will be honored by a "space honor roll," a scroll with contributors names to be ejected at the apex of the flight. Certificates will also be issued to supporters.

The project is far from a dangerous stunt. The X-3, when operational, could fly for $10,000 per mission. It could be a piloted vehicle for space research and even see use as an unpiloted reusable sounding rocket capable of lofting 400 pound payloads. Truax has a corps of 30 astronauts from which the pilot for the initial mission has yet to be selected. Obviously, the best qualified will fly and future opportunities await the others—flying for Truax or piloting the vehicle on a research mission

Speculation exists that the first shuttle mission for NASA may slip into 1980 due to engine problems and crew training problems (complex problems with the "space plane mission simulations"). It may be possible that an X-3 development flight may be launched before the orbiter.

According to Truax, scheduling depends on the level of funding but the program is proceeding well. Truax has commented, "The . . . program involves captive firings of the rocket, low altitude drop tests of recovery systems, high altitude drop tests, unmanned launchings, astronaut training, etc." Obviously safety will not be compromised for the sake of sensation-making headlines. The age of space flight by non-NASA astronauts may be much closer than we think.

NEWS BRIEFS

OTRAG, the private West German rocket firm, has been expelled from its Zaire launch facilities. The expulsion followed Soviet charges in an African radio broadcast that OTRAG had launched missiles with chemical warheads with the collusion of the U.S. Central Intelligence Agency and West Germany. The Soviets also accused OTRAG of signing an agreement with the South African Republic to provide them an air base. Hints were made that the Zaire missile test range would become the site of South African A-bomb tests.

Otrag's recent request for United Nations monitoring of its Zaire facilities came too little and too late.

The $25 million Solar Power Satellite Research and Development Act was voted out of the U.S. House of Representatives Science and Technology Committee May 15, just under the wire for the appropriations deadline. The voice vote was overwhelmingly favorable.

June 6 the U.S. Department of Energy (DOE) will conduct a briefing on solar power satellite alternatives. Jerry Grey of the AIAA will describe thermal cycle powersats. Ken Bellman will make a case for the "solaris"concept of simply reflecting the sunlight in space to Earthside solar power plants. Max Hunter will explain the potentials of laser power transmission, and Gerard O'Neill will describe how powersats could be constructed from extraterrestrial materials.

Later in this briefing the L-5 Society will present its members' comments. DOE expects to make major decisions on the thrust of its power satellite project. A favorable decision on any of the alternatives being presented at the briefing would translate into big government spending.

The North American Air Defense Command (NORAD) estimates that Skylab will crash sometime between June 20 and July 4. Most likely date is predicted to be June 26.

The 77.5 ton space station is expected to hit the ground in at least 500 pieces. The biggest are the 5,175 pound airlock shroud, a 3,901 pound lead film vault, six 2,736 pound oxygen tanks and a 1,578 pound bulkhead. The film vault is expected to have the highest impact velocity of 405 feet per second.

NASA's hopes of controlling Skylab's descent to end in an uninhabited area were dashed on April 23 when a control-moment gyro failed.

Those who worry about being caught by the hail of Skylab debris can call Johnson Space Center at 713/483-5111 for the latest NORAD predictions on the time and location of the impact. Predictions will be updated daily, then issued at 12, 6, 4, and 2 hour intervals as Skylab's firey demise approaches.

DOE Undersecretary Dale D. Meyers resigned June 1. His successor must be nominated by President Carter and confirmed by the U.S. Senate.

The Undersecretary of DOE has responsibility for development of new energy sources, including power satellites.

Marshall Space Center has begun a study of strap-on rocket motors to increase the space shuttle's thrust. This system would upgrade the shuttle's launch capability to 14,500 kg in a 277,800 km circumference circular polar orbit. The strap-on rockets are expected to be about 11 meters long, ¼ the length of the shuttle's solid fuel boosters.

4th Biennial Princeton Conference

Sixty-eight papers were heard by one hundred and sixty-nine participants at the space manufacturing conference.

by Frederick H. Osborn, Jr.

The 4th Biennial Princeton Conference on space manufacturing held May 14th-17th, 1979 was sober and practical, as if the decision for adventure had been made and the time had come to assemble and test the gear for the trip.

This is powerful and heady stuff, as Roy Gibson, Director General of the European Space Agency remarked in his brilliant keynote address.

Director Gibson's concerns were reflected in 68 papers heard by 169 participants in the 12 sessions of the conference. The participants were a widely representative group, ranging in age from under a year to well over retirement age. There were 60 academicians, 35 businessmen and women, 27 representatives of foundations, institutions and societies, 13 government workers (including 7 from NASA), 9 foreign nationals, 7 writers, 4 lawyers, and 14 other interested citizens. While there were only 17 women, the quality of their contributions more than made up for their limited numbers.

Michael Michaud, currently on leave from the US Department of State, was the first of many speakers to profess that the views he expressed were his own, and not necessarily those of his employer. He noted that as Administration support for NASA's programs declines, armed services expenditures for rockets and satellites are rising to equal NASA's budget. He suggested, paradoxically, that we might begin looking to the Department of Defense for humanization of space!

Rashmi Mayur, just arrived from Bombay, India, emphasized humanity's needs in developing nations for the services space programs can provide in disaster warning, education, resource surveys, agriculture, communications, medicine, and new materials development. People in the developing nations, he said, are more alert to what space can provide than people in industrial nations.

Irwin Pikus and Edward Finch reported steady progress in the growing body of international space law, despite problems, cited by Pikus, as to whether the Moon treaty should apply to all celestial bodies, whether advance notice should be given of space missions, how to define the common heritage of humanity and the boundaries between air space and outer space, and how to control the use of geostationary orbit and the high frequency radio communications spectrum. Finch, a firm believer that outer space holds the key to world peace, urged flexibility and keeping options open.

There were 8 excellent papers on materials processing, particularly processing of lunar materials, 4 on mass drivers, 6 on new technical concepts, and 8 on fabrication and products. These showed a healthy trend toward maturity, from theory to experiment, bench hardware, and demonstration.

The cooperation between the natural scientists and the humanists who share an interest in these great endeavors, which has always been close, is getting still closer.

Further evidence of maturity was the inclusion of sessions on enviromental effects (5 papers), anthropology and psychology (3 papers) a mind-stretching session on asteroidal resources (6 papers), and, for the first time, present on the sidelines, an opportunity for speculative private investment. Christian Basler's International Satellite Industries, Inc.

The American Institute of Aeronautics and Astronautics will soon publish **Space Manufacturing** Volume No. 3, containing the papers presented at the conference, plus many of the questions and answers arising from their presentation. But that volume will only be able to express a part of the warm friendly feeling and the wealth of information exchanged at coffee breaks and after hours.

Freeman Dyson of the Institute for Advanced Study at Princeton had delivered a brilliant analysis of the Pilgrims' voyage across the Atlantic and the Mormon expedition across the Great Plains. He enumerated the tonnage of materials transported, the costs and the problems and compared them to O'Neill's High Frontier space migrations, to Island One and to the asteroids. Alas, by his analysis Island One seems to be beyond historical individual resources, but the asteroids seem to be well within. It was a rousing speech which stirred latent visions of the American Dream and brought a standing ovation.

Below the Woodrow Wilson Auditorium, where the technical sessions were held, giving on an underground lobby where coffee was served at morning and afternoon breaks, are half a dozen low-ceiling classrooms, closed in like catacombs. White walls on which slides and viewgraphs could be projected recall that cave described by Socrates on the 7th book of Plato's **Republic**. Half the conference participants gathered in one of these rooms Wednesday night, the third night of the conference, to hear Eric Drexler, an MIT graduate student, amplify his views on solar sails.

At this informal session, 11 month old Valerie Aurora Henson, refreshed from an afternoon nap, rejoiced as she crawled about under the tables which formed an open square in the center of the room. There were not enough chairs or space around the edge, so adults crawled under the tables too. (Christian Basler, distinguished president of International Satellite Industries, was the first to join her under the tables.) With each new arrival, Valerie Aurora cheered.

Gerry Driggers of Southern Research Institute introduced Eric, who stook against the wall where the slides illustrating his lecture were being projected.

Eric's idea was fascinating. A new Mayflower with ultra gossamer sails, moved by the gentle breath of the Sun's light to navigate the solar system. There was an awareness among the audience that space pioneers in the near future might be following the footsteps of the Pilgrims.

They are a hearty and very human lot, these space pioneers. They stayed the course through an excellent summary the following morning by doctors Grey,

O'Leary, Vajk, Cheston and Kolm. Professor O'Neill, in his concluding remarks, observed that clean solar energy is available full time in space, that lunar soils, embodying materials for power satellite construction can be lifted from the Moon for 1/20th the energy needed to raise an equivalent mass from the Earth, that after 5 years of increasingly intensive review the science of the High Frontier seems to be sound, the engineering practical and within reach. The cooperation between the natural scientists and the humanists who share an interest in these great endeavors, which has always been close, is getting still closer. Metals and silicon are awaiting us high above the Earth. Now is the time to build a clean electric energy system. Space is where it's at!

Inside the L-5 Society

Errata

The following errors appeared in the May 1979 **L-5 News** in the article "Breakthrough" by Carolyn Henson:

Page 6, subhead "Solar Sail Uses"—the research and development price tag for solar sails could be as low as $100 *million*, not $100 *billion* as stated.

Page 7, in the quote from Eric Drexler—sail transportation costs from Apollo objects, at substantial traffic levels, should fall below *50¢*/kilogram not $50.

L-5 Montréal

L-5 Montreal is now a reality!
L-5 Montréal existe!
Officers for 1979 are:
Les membres de L'executif pour 1979 sont:
Président: François Coallier
Secrétaire: Daniel Fritzpatrik
Our business address is:
Notre addresse d'affaire est:
L-5 Montréal
A/S François Coallier
1816 Ducharme
Outremont, Québec
Canada H2V 1H4

Announcements:

Remember the Future

On July 20th, 1979 it will have been ten years since Neil Armstrong's famous words, "that's one small step for a man, one giant leap for mankind," echoed across the vastness of space to the waiting peoples of planet Earth. The Apollo program represented humankind's first small step into the ocean of space, but sadly, ten years later we still have not taken the much heralded "giant leap."

To keep you fully informed about space developments, the San Francisco/Bay Area Section of the American Astronautical Society invites you to a two day commemorative conference of the tenth anniversary of the Apollo 11 lunar landing with an emphasis on future programs. The conference will begin on Friday, July 20th, with a banquet featuring a retrospective look at Project Apollo. The following day, Saturday July 21, conference attendees will be given a chance to view both political and technical aspects of a giant leap into space.

Papers on a broad range of future space topics are invited, as well as organizational contributions from qualified individuals. The conference will be held at the San Francisco Airport Hilton.

For more information write—The San Francisco/Bay Area Section of the American Astronautical Society, P.O. Box 7205, Menlo Park, California 94025, or call Ed Stearns at (408) 742-2385.

First National L-5 Chapters Conference

Local chapters are the basis for grassroots support within and without the L-5 Society. Often they are the only contact the general public has with the L-5 concepts. While space industrialization is presented on television and in magazines, it is through chapter events that the public can have all their questions answered on a personal basis. A father can discuss his concern that microwave radiation may be harmful to his children. A executive might learn how space manufacturing could offer new opportunities for his or her firm. The chapters are vehicles for making the fantastic idea of space colonization real to the lay public.

Each month sees the formation of new L-5 chapters, each with its own goals, each with its own strategies. As their numbers increase, the need for close communication and coordination grows. Activities are planned often in ignorance of what neighboring chapters are doing or what they could offer in the way of help or suggestions. Too often mistakes are repeated, opportunities missed.

In an effort to coordinate chapter activities and open lines of communication the Houston Chapter will host the First National L-5 Chapters Conference August 18 and 19. The theme of the Conference will be the running of an L-5 Chapter (its care and feeding). There will be lectures and workshops on just what goes into organizing an active chapter, how to work with the local media, what is involved in creating a successful newsletter and other topics of interest to L-5 activists. Chapter members from around the country are invited to make presentations so others may learn from their experiences.

The conference is also intended to be a social event. Close ties are often formed by simply sitting down and getting acquainted, exchanging ideas, discussing problems and generally finding out what the other guys are up to. Personal contacts may prove to be the best way to establish a sense of unity and interdependence among members from distant chapters.

Those chapter members or L-5 members not associated with a particular chapter, wishing to attend should write to:

Robert G. Nichols
L-5 Houston
907 Timber Cove Dr.
Seabrook, TX 77586

To a large degree the success of the Conference will depend on the participation by chapter members from around the country. Their experiences can contribute greatly to the success and development of other chapters. Those interested in taking part in organizing workshops or making presentations should submit a brief outline of their topic.

Those planning on attending should write at the earliest opportunity. Information will be mailed out concerning events and times, registration fees and accommodations. This conference can only be a success with the cooperation and representation of all the chapters. L-5 is your Society. It can only grow and prosper with your support.

Ontario Wake Up!

There are quite a number of L-5 members in Ontario, more than Quebec, Nova Scotia and British Columbia put together, but there isn't any chapter there! Where are the dedicated L-5 members ready to invest their time in starting to organize local activities?

Members of L-5 Montreal share the desire for the Canadian local chapters to organize a **Canada L-5** and send a representative to the board of directors of the L-5 Society. With the sanction of L-5 headquarters, this would form a coalition of Canadian members to represent their interests at board policy meetings. The L-5 Society is an organization with an international potential. We in Canada, along with members in other countries, should help transform the potential into a full reality. So . . .

François Coallier
President, L-5 Montreal

Letters

In regards to the Oberg review (**L-5 News**, April 1979), I have only one brief comment which goes to the heart of the issue. I fail to perceive the distinction being made between "illusory" gaps and "lying" about bomber missiles, or ASAT gaps. The point of revealing the "gaps" between alleged Soviet superiority and actual Russian capabilities is not *necessarily* to accuse U.S. officialdom of being dishonest (though the Pentagon Papers, CIA domestic operations and Watergate affairs prove this is hardly impossible), but rather to show that the Pentagon alarmists have repeatedly been *wrong*. The various "gaps," of which the "throw-weight" gap is the latest, have certainly been "fictitious" in that they have been untrue. Even to be charitable, one must realize that these "gaps" have not been based merely on what is *known* about Soviet capabilities, as Oberg asserts, but rather on what is extrapolated in worst-case scenarios from estimated Soviet capabilities. While some might argue that the DOD might not be crying "wolf" this time in regards to ASATs, the historical record warns us to be more cautious before we throw more money and energy into elaborate new weapons systems and new—and as yet unproved—areas of conflict. I think we would all agree that national boundaries don't exist in outer space.

On one small point, I would caution the author on dwelling on particle beam weapons. As the published work of an MIT group of physicists, including SANE Board member Kosta Tsipis, and of IBM's Richard Garwin suggests, PBW's are infeasible and not worth attention.

Jeff Philips
SANE
Washington, D.C.

Dear Mr. Philips,

The brief comment of yours which you claim "goes to the heart of the issue" does not do so. It does demonstrate a set of assumptions which portray a gap far wider than the weapons gaps referred to. For example, your statement that "Pentagon alarmists have repeatedly been wrong" is in marked contrast to a documented claim by Francis P. Hoeber (president of a defense and economics study in Arlington, Virginia, author of "Six Myths About the Defense Budget," **Air University Review** *Sep-Oct 1978) that "Far from exaggerating the size of the Soviet threat, throughout the 1960s and the early 1970s, the official predictions of the Soviet strategic forces were below the numbers that turned out to be actually deployed." And surely you do not assert that Great Britain in the 1930s should not have built up the RAF until the Germans had actually begun to bomb London, do you? That is not a stretched analogy—not nearly as off target as your motherhood cliche that "I think we would all agree that national boundaries don't exist in outer space," a fact which has nothing at all to do with* any *of the points in dispute, since national sovereignty and responsibility does indeed extend into outer space as recognized by several United Nations treaties.*

The Tsipis study in Scientific American is interesting but, I'm afraid, flawed nearly as badly as the STAR WARS REVISTED pamphlet (and by the way I do note that you do not *dispute my criticisms of the pamphlet's lousy logic and phony facts—just as I did not dispute your conclusions that it would be a good idea to refrain from outer space arms races).*

I am still serious about discussing the issues of war in space, leaving aside your platitudes and generalizations. Can we begin?

James E. Oberg
Dickinson, TX

As a regular reader of L-5 News I have found only one blemish in an otherwise excellent magazine; namely, a continuing naiveté about the military mission in space. James Oberg's critique of "Star Wars Revisited" (**L-5 News**, April '79) was a welcome exception. The military advantages of space are many and varied, and to believe these advantages will be ignored or that they are insignificant is truly INSANE (absolutely no pun intended!). There will always be a place for antiwar idealists both on Earth and in space, but it will be the realists that pragmatically cooperate with the military who initially settle space. Indeed, without DOD concurrence and active support NASA's space shuttle would still be in committee. Similarly, the SPS concept will never be seriously pursued without the blessing of the military (How do you defend such a structure? It is more complicated than lasers and particle beams!)

The military currently spends a great deal on space programs, and much of the technology gained will be used by NASA and space settlers alike to conquer the heavens. I sincerely hope that L-5 members everywhere will come to look on the military as a friend and ally worthy of your cooperation. After all, the goals of the military and L-5 aren't so very different: L-5, to seek out and build new worlds; the military, to keep peace on the old.

J.M. Sponable
Lompoc, CA

I have an idea that might improve L-5 as well as save time and money. After the pressure hull is completed and spin has been started, subway lines, electrical conduits, and sewage lines should be laid on the inner surface of the pressure hull (i.e. floor) and fastened in place. No attempt should be made to do more than secure them in position, *laying on top of* the pressure hull. This is known in radio as a "breadboard" layout. Then the entire inner surface is covered with waste slag crushed to cobblestone size to such a depth that all installations are completely buried. Enough slag should be used so that it covers all installations to a depth of several feet. A layer of baseball sized slag should then be laid on top of the base slag, followed by one of pea-sized gravel, and topped by a layer of fine crushed sand.

On top of this surface houses are built, roadways laid, and it becomes, when fertilized, a well drained artificial soil good for growing vegetables, baseball fields, and (best of all) flowers. Houses could easily be constructed on this medium and attached to the underground utility lines. If we wished to alter the surface layout, removal and reconstruction would be relatively

easy.

Also, the many feet of slag would be as good a radiation shield as a ring of cast slag on the outside of the pressure hull. Metal casting in space will be difficult enough without the added problem of casting slag plates. The irregular pieces left from the metal casting could easily be crushed by running through a small mill. Of course, *any* rock, refined or not, could be used with good results.

Finally, it becomes a matter of aesthetics. Would we rather spend our lives on a metal deck with boxes for flowers, or be able to see a wild flower grow, not because it was planted, but because a seed fell on the soil and found it good?

Ed Altenritter
Flint, MI

I've been reading some pretty disturbing stuff in **Aviation Week & Space Technology** recently. The recently-disclosed arms race between us and the Russians to develop super laser and/or particle beam weapons to zap satalites and ICBMs could lead to bigger and better balance of terror. Laser-armed orbital "Battle stations" (Honest! That's what the Army calls 'em, just like the Death Star in *Star Wars* . . .), killer satellites, and the proposed USAF "Space Command" all raise the specter of war in space.

The recent invasion of Shaba Province in Zaire has been interpreted by some experts as a space war of sorts here on Earth; the best way to deny access to space is to prevent the enemy from getting off the ground in the first place, which is just what the USSR, working thru friends in Africa, was trying to do to OTRAG (There were other "legitimate" reasons for the Zaire affaire, from the Soviet point of view, but the elimination of free-enterprise capitalism in space would have been a very useful long-range by-product). Meanwhile the Soviet space program is in high gear with manned space stations, a potential space tug, a small space shuttle in development, and some academicians talking enthusiastically about piloted missions to Mars and beyond in the next decade . . . I guess they don't have any Proxmires in the Kremlin.

And now NASA has abandoned all hope for Skylab; they're just going to let it fall to earth, some time during the summer of '79. According to an earlier NASA evaluation, even if we asked the Russians to help save Skylab, which seems doubtful, they wouldn't be able to.

And on top of that comes word that the NASA budget for Fiscal Year 1980 will be so tight that NASA will not be able to start any new flight programs and may even have to drop the Halley's Comet probe, The 25-kw power module, which would provide energy for materials processing and other good things in orbit (not to mention paving the way for solar power satellite technology), has been moved back to FY'81 where it will compete for funds with planned thrust augmentation for the Space Shuttle. Thrust augmentation is required to launch and recover 32,000-lb. USAF recon satellites (and in light of increased military interest in space, can you guess which program will have the higher priority?). And the first launch of the Shuttle keeps getting moved back farther.

On the brighter side, Senators Schmitt and Stevenson are supposed to be introducing some very interesting bills which could change things considerably, and even NASA is becoming marginally aware of the generally favorable public opinion in this country toward Space. Committee Hearings will be starting up in the near future . . .

I hesitate to suggest the obvious, but I will: the time has come once again for a serious, large-scale letter-writing/political action/lobbying campaign to save the Space Program from being slowly strangled to death by the Potomac paper-pushers. Those short-sighted so-called public servants of ours are messing around with *our future!* We have to stress to the Congress and the Administration (which includes NASA and OMB) that more money for NASA is beneficial. The Space Program (and more specifically Space Industrialization) is not just another rat hole down which the bureaucrats pour our tax dollars; it is a high-yield *investment* which has and will continue to pay huge dividends. The OMB is nickel-and-diming our dreams to death. We have to make them realize that the kinds of projects the L-5 Society supports are different from a new weapon system, for example, or a change in the Social Security tax structure. Full utilization of the High Frontier can help to solve basic economic problems here on Earth so that we may be able to eliminate the *need* for new weapon systems and also be able to afford *any* social program we want.

In conjunction with efforts to achieve official State recognition of July 20, 1979, as "Space Day", we should mount an all-out effort to obtain *more* funding for NASA. We should also do whatever is possible to get space development out of the hands of the politicians and out into the Market where it belongs. Otherwise, we'll continue to see smaller and smaller budgets each year, and the only activities in Space will be those of the Soviet Union and our own Pentagon . . .

If any L-5ers are interested in helping to mount such a campaign (or if you are already doing so and would like my help and money), please contact me as soon as possible. Maybe the latest oil price increase and a long, cold winter will help stir renewed enthusiasm for solar power satellites? One can only hope.

Waiting for feedback,

Robert G. Lovell
1754 Park Ave.
Baltimore, Maryland 21217

Rejoice members—we are finally being taken seriously!!! On April 5th during an ABC news special entitled "Energy: Crisis and Questions" the use of solar satellite power stations as an alternative energy source for this country was referenced. This reference is monumentous in that the highest rated network in this country nationally proclaimed that SPS's are a probable future energy source "that could be developed in only 10-20 years." Even more important is that for many Americans it was the first time they had even heard of this type of *practical* use of space by NASA.

Let's all help keep up our public exposure, for it can be one of our greatest assets in gaining support to further fund our space program.

Steven J. Hoeser
Eau Claire, WI

Harrisburg seems a plus for space energy. I am truly surprised to discover that Ms. Huddle and the 60's and 70's style activists turned out to be right about something. Still, in the intermediate term, the Harrisburg incident will put an energy/budget crimp on hardware like the Shuttle. In the long run . . .

David Murphy
Carterville, Illinois