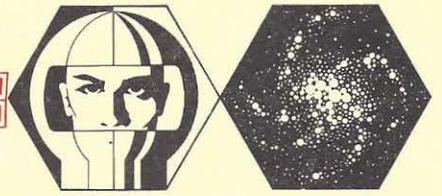


COMMERCIAL SPACE REPORT



HIGH POWERED LASERS IN SPACE: THE PAYOFF IS SPECTACULAR

Several Candidate Lasers Offer Potential for Low Weight, High Performance and Commercial Operations

High power lasers in space have the potential to revolutionize both space industrialization activities as well as the industrial and consumer marketplace on earth. Such a revolution may be only a few years away, and can encompass diverse fields such as electricity, process heat, fabrication of goods, communications, remote sensing and transportation. Even more hopeful is the prospect that such activities will occur at a level which would permit their establishment by private sector interests.

Laser light from orbiting platforms can be used, for example, to improve the resolution and specificity of sensors on satellites which are scanning the earth. Such systems, with laser power in the tens of hundreds of kilowatts, will further improve the business potential of remote observation of resources, including crops, mineral deposits, and food sources in the ocean. Further, these lasers will permit the measurement of atmospheric aerosols and particulate concentrations, as well as allowing scientists to measure the temperature of the atmosphere at many different points, through both

altitude and diverse geographical regions at low cost and with great speed and accuracy.

The use of laser beams for high data rate communications is presently under study, primarily by the U.S. Air Force for secure, tight beam telephone and computer interchanges. A laser on every rooftop could be the result, as the communications revolution gets into full swing by the turn of the century. While microwaves will still be used for most comsat purposes, it may

be that lasers will have a unique role to play as high bandwidth carriers of information such as holographic teleconferencing and video data transmission.

However, both of these uses are generally low power applications. Much higher powers are both possible and desirable, with laser powers in the tens and hundreds of megawatts feasible before the end of the century. Before we begin description of the many commercial projects which may be implemented with lasers (that description will be in part two of this article next month), it is necessary to examine the means by which energy is converted into laser photons so that an estimate of the cost of operation of high power lasers (HPLs) can be obtained. Additionally, the level of technological sophistication necessary to establish

Part One of Two Parts

TEN YEARS AFTER

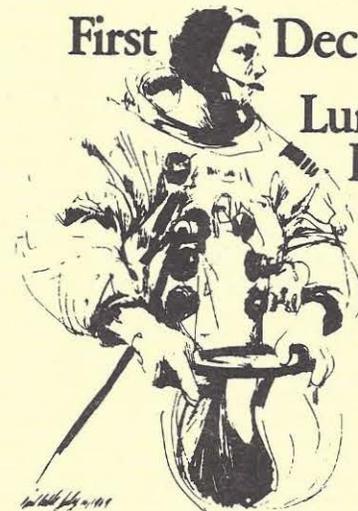
by Gary C. Hudson

I cannot tell you how many times I have begun to write this editorial, and, in a very uncharacteristic way, failed to get beyond the second paragraph. Since I often write articles and reports in a single draft, this has disturbed me no end, yet it is in fact symptomatic of the wider problem that I wish to address.

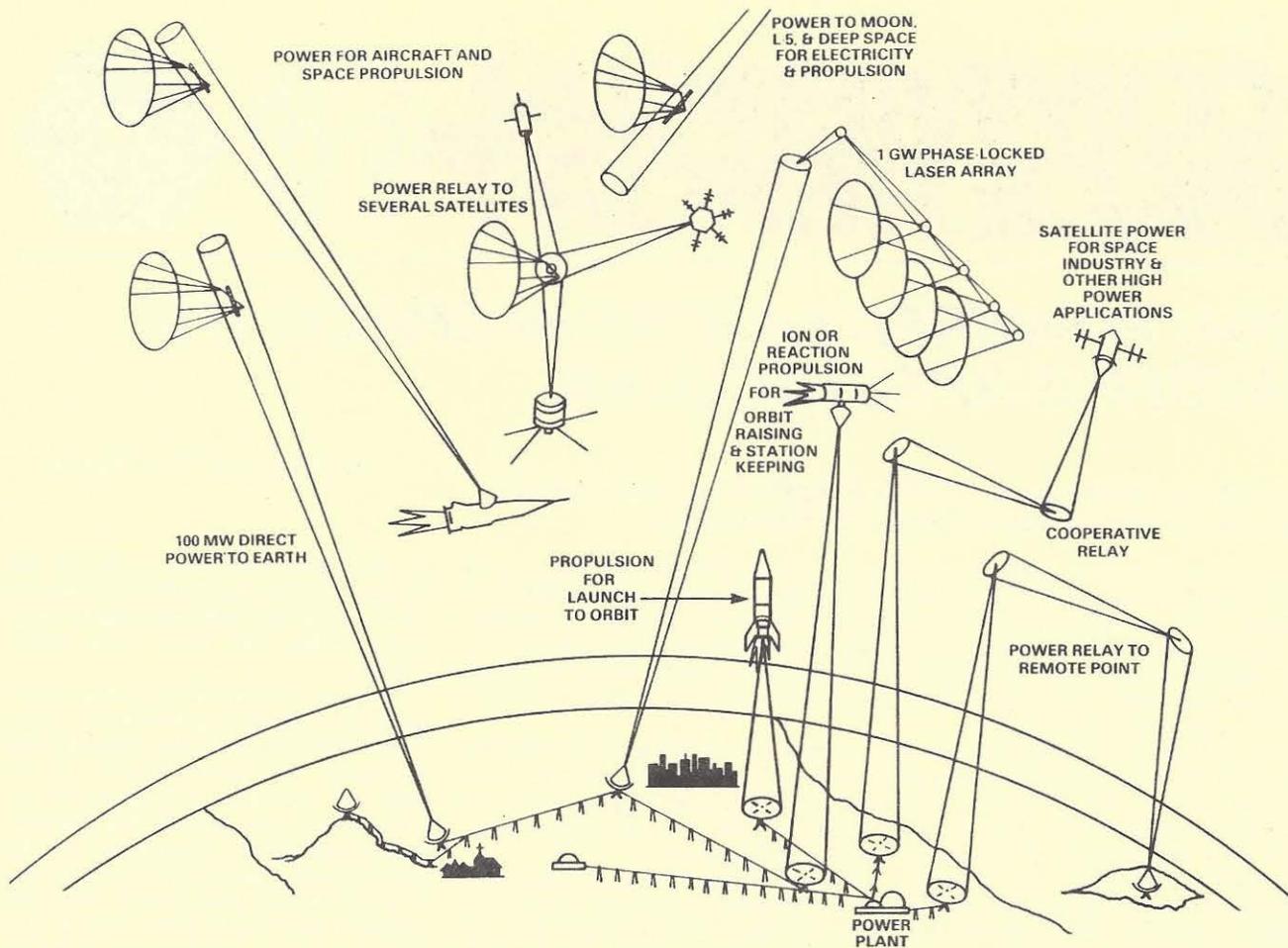
As a nation, one full decade after humans set foot on earth's moon, we also cannot begin at our tasks. Grippled by an awful indecision, we collectively blunder about with only a baleful eye to the future, and an unhealthy remembrance of the past. We are running scared.

There once was a time, however brief, when the citizens of this nation thought that all problems had solutions. Citizens of other nations turned to us for wealth, knowledge, and a helping hand. Lamentably, the consensus seems now to be that all solutions have problems . . .

First Decade...
Lunar
Landing
1969-1979



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various laser concepts in space will, of course, determine the speed with which the lasers can be brought on-line in private projects.

Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. Using principles first described by Albert Einstein at the turn of the century, the laser converts inputted energy (which may be in the form of non-coherent light, electricity or electrons circulating in a storage ring, or chemical energy) into coherent photons, or a light beam of a single frequency. Very resistant to spreading, this beam can travel long distances and deposit the coherent photons in a small area. The intensity of the beam can be highly increased by focusing, which, because of the quality of the light, can occur at either the source or near the target of the beam. A drawback to many kinds of lasers is the relatively low efficiency with which the conversion to coherent light occurs. The best lasers operating today achieve about 20% conversion efficiency.

Lasers have been made with a wide variety of lasant materials, including crystals, liquids and gases. Among the highest power lasers operating today, gas lasers are preferred and operate at the highest conversion levels. Most gas lasers operate on the principle of electric discharge, where the source of energy is a electron beam. Chemical lasers have also reached power levels

quoted in the open literature of in excess of one hundred kilowatts, however they obtain their energy from the combustion of chemical fuels much like a rocket engine. This makes them unsuitable for use in space on a continuous basis, like providing power to the ground, because the propellant for the lasers would have to be lifted from earth.

The obvious source of energy in space for a laser is the sun. Some scientists have proposed the use of lasers using carbon dioxide or carbon monoxide gas in place of the microwave transmitters of a conventional satellite solar powersat concept. Microwaves have been preferred because of the high efficiency with which they may be reconverted on the ground back into electricity, but they also have problems, including the use of large areas of land for the receiving antennas, the potential hazards of disruptive effects of beam, and the inflexible large power level of the transmitting antenna to achieve commercial feasibility. Lasers have been suggested as an alternative since they can deliver the energy to the user at small power levels with little land use. The efficiency of present lasers argues against this application at first glance, but later we shall see that a redesign of the concept may remove this barrier.

If one uses the sun as the power source in space the energy from the

(Above) The uses of high power lasers in space are manifold. Besides the obvious application of the lasers to electric power generation on the ground, the high power beams might be used for earth-to-orbit transport, orbital transfer, aircraft prime propulsion, and space industrialization activities. This illustration copyright and courtesy of Dr. J. Rather and The BDM Corp.

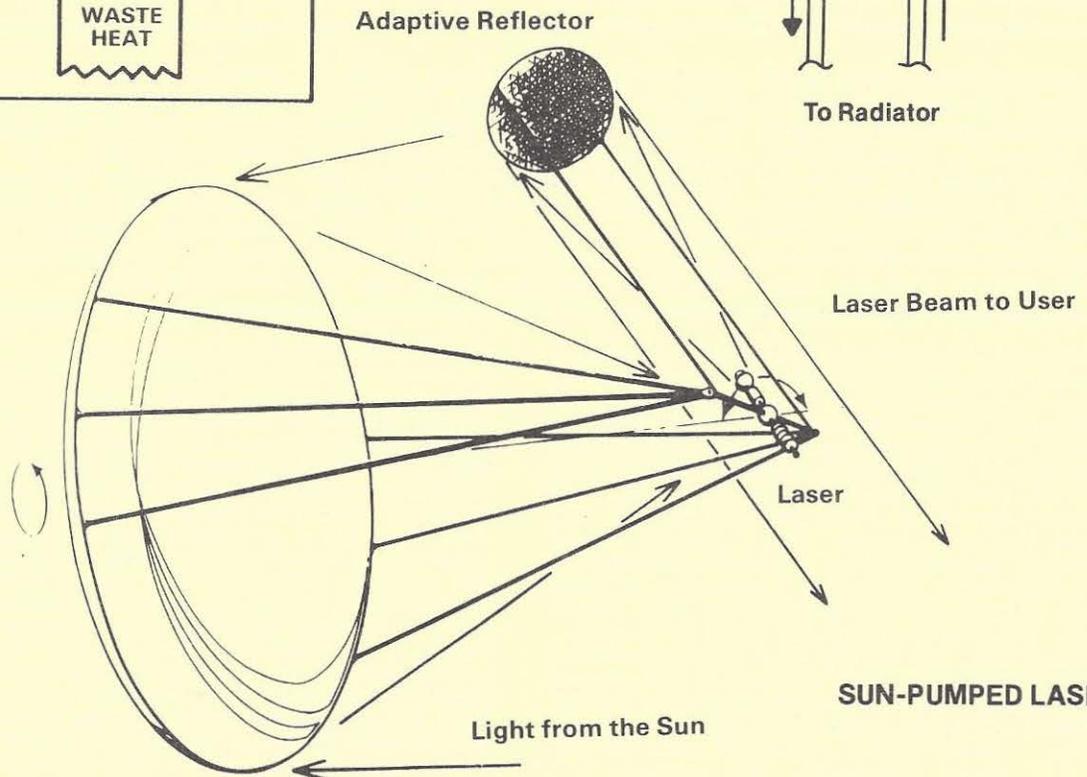
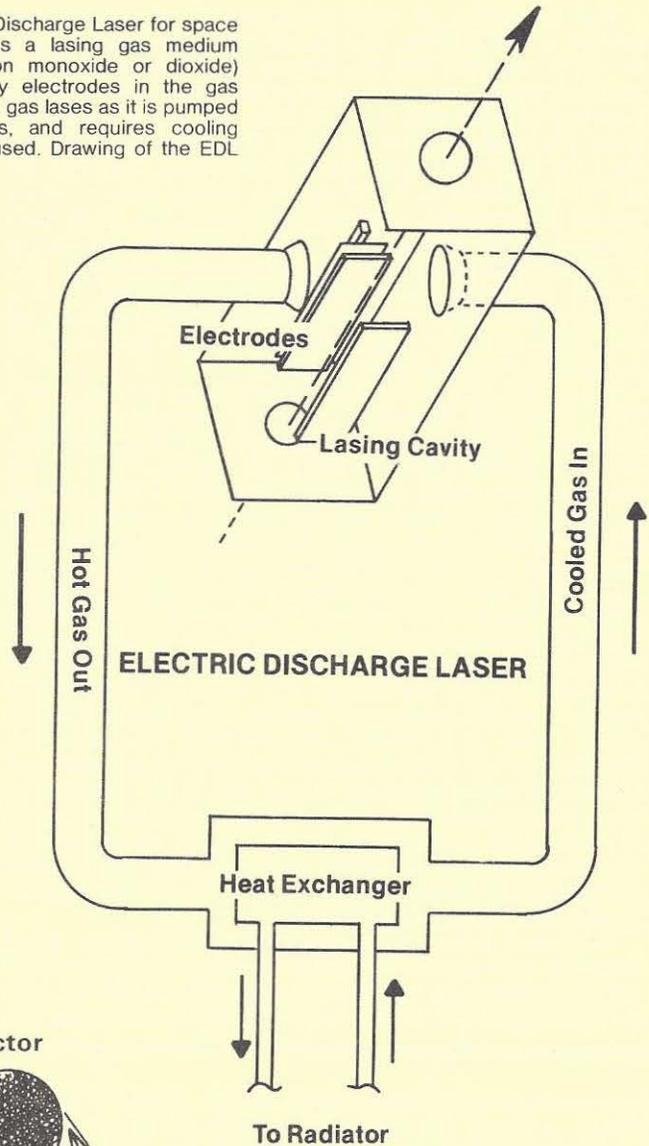
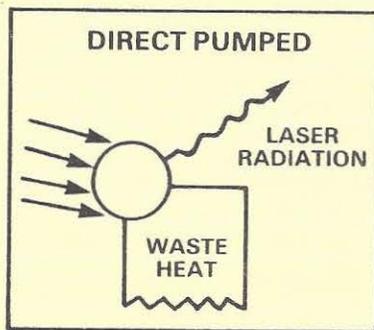
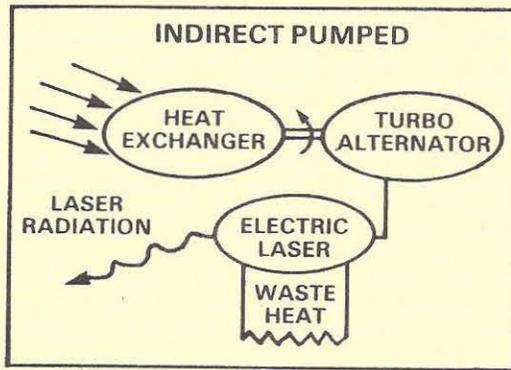
sun must either be converted into electricity for use in EDLs or used directly in sun-pumped lasers. Since the conversion process is wasteful of energy, it would be very desirable to use solar photons to directly stimulate laser photon emission, and in fact, such a concept has been suggested. Writing in the March 1979 issue of *Astronautics and Aeronautics*, Edward T. Gerry (W.J. Schafer Associates, Inc.) and John D. G. Rather (The BDM Corp.) suggest such an idea. According to the authors, this system would have low mass on orbit due to the simplicity of the laser and associated systems. This simplicity can obviously translate into improved reliability and availability which will be important for commercial applications.

Basically, the sun-pumped laser consists of a large, lightweight (and possibly inflatable) reflector which

continued

(Below) The sun-pumped laser concept of Rather (known as STAG: Solar Tracking Adaptive Geometry). The sun-pumped laser would be conceptually simpler than EDL systems, as is indicated by the diagrams to the left. Schematic representations and STAG drawing copyright and courtesy of Dr. J. Rather, and The BDM Corp.

(Right) The Electric Discharge Laser for space applications contains a lasing gas medium (for example, carbon monoxide or dioxide) which is excited by electrodes in the gas medium. The excited gas lases as it is pumped past the electrodes, and requires cooling before it can be reused. Drawing of the EDL by Tom Brosz.



The capability to solve problems is, of course, not unique to Americans, and so we are being shown daily in world markets. But the unique combination of a less restrictive and parasitic government than most and the freedom to think and to profit from one's actions led to, if not the birth, then the fostering of the industrial revolution. Yet even with this legacy, there seems no place for the United States in today's world. Rather than a potent center of invention, progress and profit, we have been reduced to an international beggar, seeking allotments of energy resources and crumbs of raw materials. Perhaps I am being too pessimistic. But the trend is in a frightful direction, and it seems that there is nothing we can do to stem the long slide back, which may come, if not in my generation, then the next.

What has this to do with having gone to the moon? Well of course, everything. The last manned mission to the moon, Apollo 17, marks the point as well as anything, that the nation began to slide. Of course, there is not necessarily a direct connection; but later I will attempt to make one. However, we can use the period from the first to the last lunar mission as a historical marker, and one which no doubt will be employed by historians centuries from now. The U.S. was at the height of its power when the missions to the moon were conceived for starkly political reasons at the beginning of the sixties. And as the technicians and engineers and the occasional scientist labored to fulfill the dream, the country reached new levels of wealth, power and prestige. Yes, we did beat the Soviet Union to the moon, and the race was very real. But even as we were doing so, the seeds of inflation and discontent were beginning to root and bloom. Sapped by wars at home and abroad, the will of the nation as a whole to accomplish great things faded. Soon it came time for reassessment and allocation of blame. Next would come allocation of energy. Finally, as it must under such circumstances, allocation of freedom.

Even so, I have not yet spoken to the question. What does this state of affairs have to do with going to the moon, and by implication, with an expansion of our efforts, both public and private, in the realm of space exploration and

exploitation? Surely I do not claim that if we were still flying to the moon we would not be waiting in line for gasoline. The conventional cautious answer is "of course not". Being suspicious of conventional wisdom, I think I might answer "but of course". Let me explain my opinion. The type of decision that was made to go slow in space is a reflection of decisions which are made in other areas of endeavor. If we had respected the accomplishment of the lunar missions (with more acknowledgement than "If we can go to the moon why can't we brew a good cup of coffee . . .") the natural course would have been to seek solutions of a similar nature to problems present and anticipated. While there have been "Project Independences" and the like, it has been very obvious on the surface that these were but phony attempts at palliative measures to lend the public to believe that we were actually doing something about their serious concerns. At least, this is what media has told us, and of course, we believed.

Whether it be energy, gasoline, nuclear power, food, transportation or whatever, I have seen hundreds of workable solutions to problems. Never have I seen a serious problem for which there is no answer. Does that make me unique? While I would like to think so for ego's sake, I know that I am not. What then? Does this mean that I am basically naive? Perhaps. But I prefer to think that I and others, many others, merely know how to think. And perhaps our system of government has a fatal flaw after all . . . those that are willing to think originally and act on their thoughts are perhaps not part of the set who would seek positions of public power to force their ideas on the general population. You may see where this would lead us. Public servants (read public masters) cannot be expected to solve our problems. We cannot let them.

We must take it upon ourselves to think and to act. We must do so without hesitation and with the conviction that reason brings us. And we must look to the model of Armstrong, Aldrin and Collins, including those who came before and after who made Apollo possible. For whatever reasons they choose, ones with which we may have arguments or not, they succeeded. So may we. That is an easy enough lesson to learn, ten years after.

concentrates solar photons as its focus. There, a large, low pressure optical cavity filled with laser gas converts the solar photons to laser photons, which can be directed via mirrors to the ground or to other users of power in space or in the air. To make the system weight as low as possible, Gerry and Rather propose that the large

reflector be coated in such a way as to select the "best" solar photons for the laser. This can be done by determining the optimum frequency of solar photons and selecting a coating material which will selectively reflect only those photons, allowing all others to pass through the film of the mirror. This clever scheme means that the

laser can be very efficient, leading to reduced heat production in the lasant and thus to much smaller radiators to keep the gas cool.

Once we have the laser light, what do we do with it? That, and the overall commercial feasibility of HPLs in space, is the subject of next month's concluding article.

The Report is published monthly, and has a subscription price of \$20 per year (\$15 per year for students, \$25 per year for institutional and library subscriptions and \$25 per year for overseas airmail). Back issues are available at \$2 each from September, 1977. Xerographic copies may be substituted as stocks are depleted. Address all correspondence to Foundation, 85 East Geranium Avenue, St. Paul, MN 55117 or call (612) 370-0990. Editorial Direction: Cary C. Hudson; Special Assistance: Resident Fellow: E. Anne Roebke and T.A. Brosz; Staff Artist: David Egge. The Commercial Space Report accepts VISA/BankAmericard and Master Charge. Please give us your full credit card number, expiration date, and the four digit Interbank number (Master Charge only). Your signature is also required on mail orders. Phone orders accepted at (612) 370-0990. No collect calls please. Foundation, Inc. was incorporated

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scientific and technology studies. Funds are provided by contract research for industry, as well as by donations, gifts and internal business profits. Capabilities include theoretical research and study, systems research and development of services and products. A high level of effort is presently being expended in astronautics, especially the commercial utilization of outer space and the need for economical space transportation. Foundation has a permanent and consulting staff of professionals to call upon including engineers, designers, scientists, communications experts, management specialists and the like. Corporate headquarters is presently in St. Paul, Minnesota. The Commercial Space Report is a concentrated effort to report all areas of private and industrial initiatives in the development of space. We hope it will stimulate ideas by raising questions and offering innovative concepts contributed by acknowledged leaders in the field. If you have any comments, ideas or requests for information or articles, we encourage you to contact us.

NEWS NOTES:

NASA TO STUDY SPACE PLATFORM...Huntsville...NASA has awarded a study contract to define a space platform for geostationary earth orbit that would permit a large number of separate payloads to be clustered on a single orbiting structure. The NASA Marshall Space Flight Center has awarded a contract for a feasibility study on the system to General Dynamics Convair, San Diego, CA.

HEARINGS PUBLISHED...Washington...Senator Howard W. Cannon (D-Nev), Chairman of the Senate Committee on Commerce, Science, and Transportation, announced the availability of a committee publication of hearings on U.S. Civilian Space Policy held before the Subcommittee on Science, Technology and Space on January 25, 31 and February 1, 1979. The hearings were conducted to aid Congress in setting goals for future U.S. space activities, and to receive testimony on space policy legislation introduced by Senator Adlai E. Stevenson (S. 244) and Senator Harrison Schmitt (S. 212). Stevenson has said that the legislation introduced by Schmitt and himself would "give direction and purpose to U.S. [space] efforts, and help guide congressional decisions authorizing and appropriating funds for the U.S. civilian space program" Persons interested in receiving a copy of the hearings should send a self-addressed mailing label to:

The Subcommittee on Science, Technology and Space
Committee on Commerce, Science and Transportation
Washington, D.C. 20510

Questions concerning the material should be directed to John Stewart, Science, Technology, and Space Counsel, (202) 224-9351.

EARTHPORT EMPHASIZING NON-SPACE ACTIVITIES...Santa Barbara...The Sabre Foundation, developer of the Earthport concept, is downplaying the launch facility aspects of the free trade zone concept. In a recent release, Sabre concentrated on the non-space benefits of a free trade zone. Space flight was mentioned along with ocean studies in one paragraph as a possible direction for the free zone industries and businesses to pursue, but the marketing of the concept is clearly moving away from space as a central theme.

SHUTTLE BOOK AVAILABLE...New York...Enterprise, by Jerry Grey, is a book which will trace the history of the Space Shuttle concept from its first conceptualization to its first flight (scheduled for next spring). Orders may be placed by sending \$10.95 per copy to William Morrow and Co. Inc. 105 Madison Ave. New York, N.Y. 10016. The book has a foreword by Isaac Asimov.

SOCIETY PUBLISHES NEWSLETTER...Philadelphia...The Space Futures Newsletter, published by the Space Futures Society, is issued periodically to review new developments in space. Free to Society members, the newsletter is \$5.00 per year to students, \$10.00 to others. Write: Space Futures Society, 1627 Spruce Street, Philadelphia, PA 19103.

FRENCH PLAN MANNED ARIANE...France...The French national space agency,

CNES, has released conceptual plans for several types of updated Ariane launch vehicles. One of these systems, called the Ariane 5/H, would, by the addition of strap-ons, engine updates, and cryogenic stages, be able to launch a 9500 kg (20950 lb) miniature shuttle type vehicle into a 200 km (124 mi) high orbit inclined 30 degrees.

SPACE SHUTTLE DELAY...In the wake of charges by a Congressional committee that the Space Shuttle program has been mismanaged by NASA, the unofficial word is that the launch of the first Shuttle flight will be delayed past second quarter 1980. Several aerospace experts have voiced private opinions that the launch cannot come off before September of next year at the earliest. Adding to Shuttle problems for NASA is the recent minor unscheduled shutdown of the test of the clustered main engines after an instrumentation failure some 50 seconds into a planned 520 second burn. In other Shuttle news, it has been reported by Aviation Week & Space Technology that NASA officials are considering launching the first manned Shuttle on a suborbital rather than an orbital mission to test the effectiveness of the thermal protective tiles which are meant to shield the craft during reentry. The TPS has had several major problems recently, and replacement materials are being investigated for subsequent orbiters. However, the suborbital flight would be a severe test for the vehicle, since it would use aerodynamic maneuvers to return to the launch center. This is considered a dangerous procedure according to some engineers and astronauts; a main reason for the concern would be the landing attempt would take place at the runway at the Cape, rather than the dry lake beds at Edwards in California, which has much more room for error.

O'NEILL TESTIMONY...Washington...Professor Gerry O'Neill of space colony fame has charged in a letter to the Subcommittee on Science, Technology and Space of the U.S. Senate dated 6 December, 1979 that the White House has created a task force, at the instigation of President Carter, "...whose purpose is to identify and [give] early warning of research that could lead to any new program of significant size, so that all such programs can be eliminated before they are started." O'Neill also stated that NASA is under orders not to even study manned missions longer than 30 days (the limit with the Shuttle), and the Office of Space Technology at NASA has been told not to fund any advanced propulsion work beyond minor modifications of existing systems. Additionally, according to O'Neill, the OMB would like to reduce the number of planned Shuttle flights to about 15-25 per year, and that it does not intend to use the funds made available by the wind-down of Shuttle R&D funding in any space-related project, but rather that it plans on cutting the NASA budget by the amount that funds are decreased.