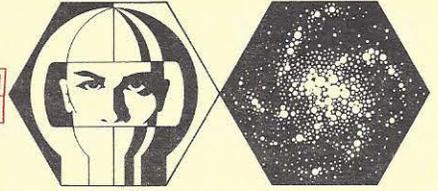


# COMMERCIAL SPACE REPORT



## RESOURCES

### Asteroids Look More Promising Than Moon

Because of advances in other technologies this past year, most notably in propulsion, the prospect of using extraterrestrial resources has increased measurably in possibility. While original schemes involved use of lunar materials, these propulsion advances (discussed in *TRANSPORTATION*) now seem to hold out hope that economically useful materials may be returned from the asteroids.

The primary motivation for early consideration of extraterrestrial materials was for space construction of colonies and solar power stations. Presently, in fact, there is a NASA sponsored study in progress with General Dynamics Corporation in San Diego which is exploring the trade-offs between use of earth or space resources to build powersats. This original consideration focused on the moon because we have an understanding of lunar geology (through the Apollo samples), and because it was thought that asteroids were too far distant (from an energy standpoint) to be practical sources of raw materials. The invention of the mass-driver engine by O'Neill and O'Leary caused experts to reevaluate the use of asteroidal resources, and the near term deployment of advanced nuclear propulsion would make

asteroid mining highly competitive with either lunar or earth based mining.

Beyond metallic and solid materials, however, there are several other resources which will become available to humans once advanced propulsion systems come into use. The foremost of these are light gases such as hydrogen and helium from the atmospheres of the giant planets. In fact, the British Interplanetary Society recently suggested in their Project Daedalus star-probe study that the atmosphere of Jupiter is a prime source for helium-3, a very rare isotope of helium which will become useful in advanced fusion reactors.

Another use of space may be as a source of agricultural land. While the idea may sound exotic, the use of advanced transportation systems will probably make feasible growing of food and other cash crops on either the moon or some of the larger asteroids. Such a possibility has been suggested in both science-fiction novels (such as Heinlein's *The Moon is a Harsh Mistress*) and by some scientists. From an energy standpoint, the idea is no more unusual than growing wheat in Kansas and shipping it to the Ukraine. □

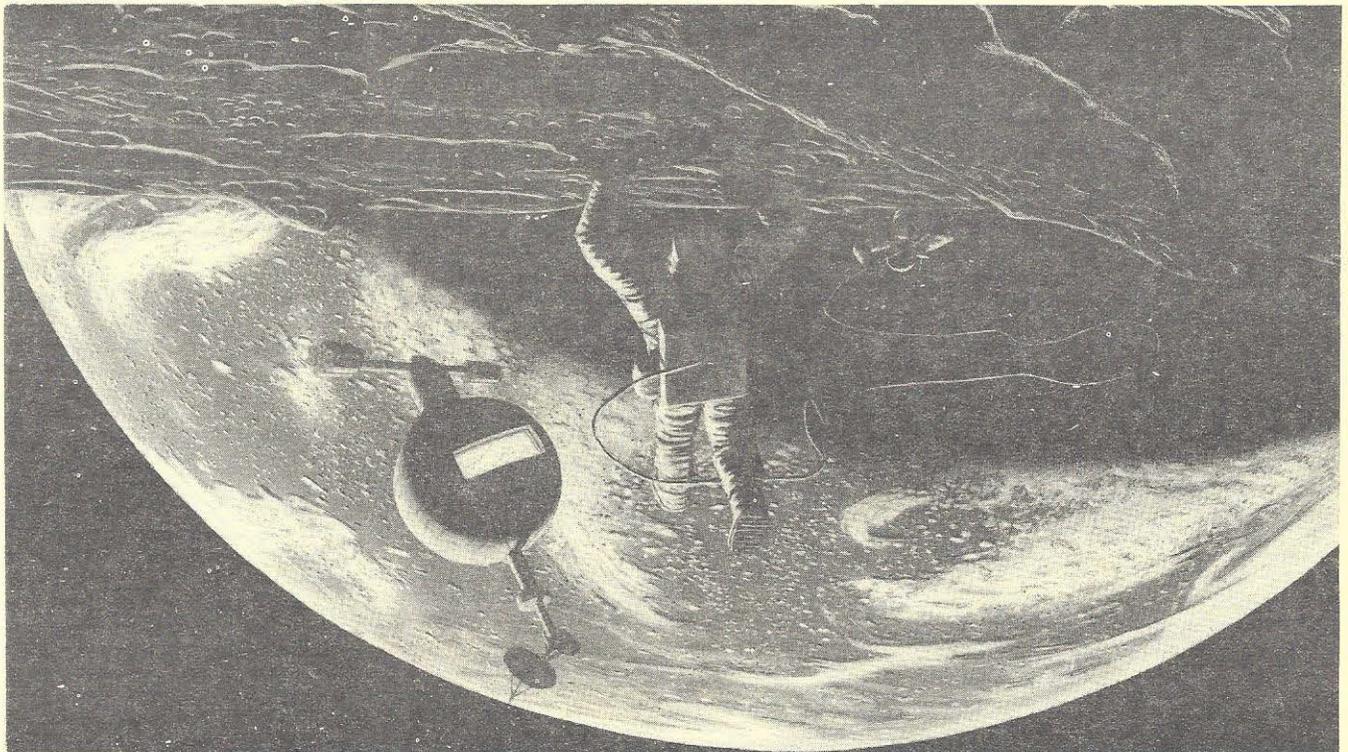
— Editorial

## YEAR END SUMMARY ISSUE

Following our first complete year of bringing you news and opinions about space industrialization activities around the world, we thought it appropriate to round up a summary of interesting and important events and ideas in this December issue.

1978 has been the year when commercial space has finally reached a level of respectability. While a long way is still to go to actually begin profitable space industry ventures, the issue seems not whether the technology is available but if the "will" is. However, it seems useful to briefly review the progress made in several important fields, namely: material resources, energy, communications and transportation. You will find these topics covered in brief in the rest of this newsletter.

... continued on page 70.



# ENERGY

## Solutions Come Hot and Heavy

1978 was the year when space offered more solutions to the "energy-crisis" than any other field of technology. From ways of using sunlight to directly pump lasers to schemes which would store electricity in the trapped particle belts around the earth, more innovative concepts have been proposed this past year than ever before.

Early in the year, NASA sponsored a conference on "Radiation Energy Conversion in Space". This seminar generated most of the new energy related concepts which were introduced this year, including the laser powersat (see *Report*, November, 1978) and the laser-powered commercial airplane (*Report*, March, 1978).

The laser powersat seems to offer the most hope for a near term industrial project in space. A primary reason why this appears to be the case is the laser powersat can, without modification, supply electricity, process heat, or direct power to airplanes. Microwave powersats would be limited in their utilization due to the very large antenna size they require, the land area necessary for the antenna, and the unknown side effects of a microwave beam on communications and biological organisms. Lasers can be precisely focused, and produced in any power level required (for example, 100 MW for aircraft and process heat requirements for industry, larger for electricity baseload service). Further, the laser powersat seems

to be an inexpensive development effort which could be funded by a single company or small group of firms in say, the construction or energy business.

In other developments related to space, progress in producing fusion reactions has been reported by both the inertial (i.e., laser or electron-beam implosion method) and magnetic confinement researchers. The

USSR has apparently achieved high yields of neutrons from e-beam fusion pellet experiments as early as 1975 (the news is just coming out now because the US Department of Energy had classified the reports of the breakthroughs). For application of this technology to spacecraft, see *TRANSPORTATION*.

Progress is also being made in the manufacture of metallic hydrogen, which would have application to a variety of energy-needing processes in space, including propulsion. Scientists report producing metallic xenon in the laboratory (see *News Notes*, this issue).

On the political front, efforts are still underway to obtain funding for a group of bills before the Congress to provide funds for the examination of the microwave SPS concept. No major progress on these measures was seen during the last session, but supporters say the proposals will be reintroduced next year. □

# COMMUNICATIONS

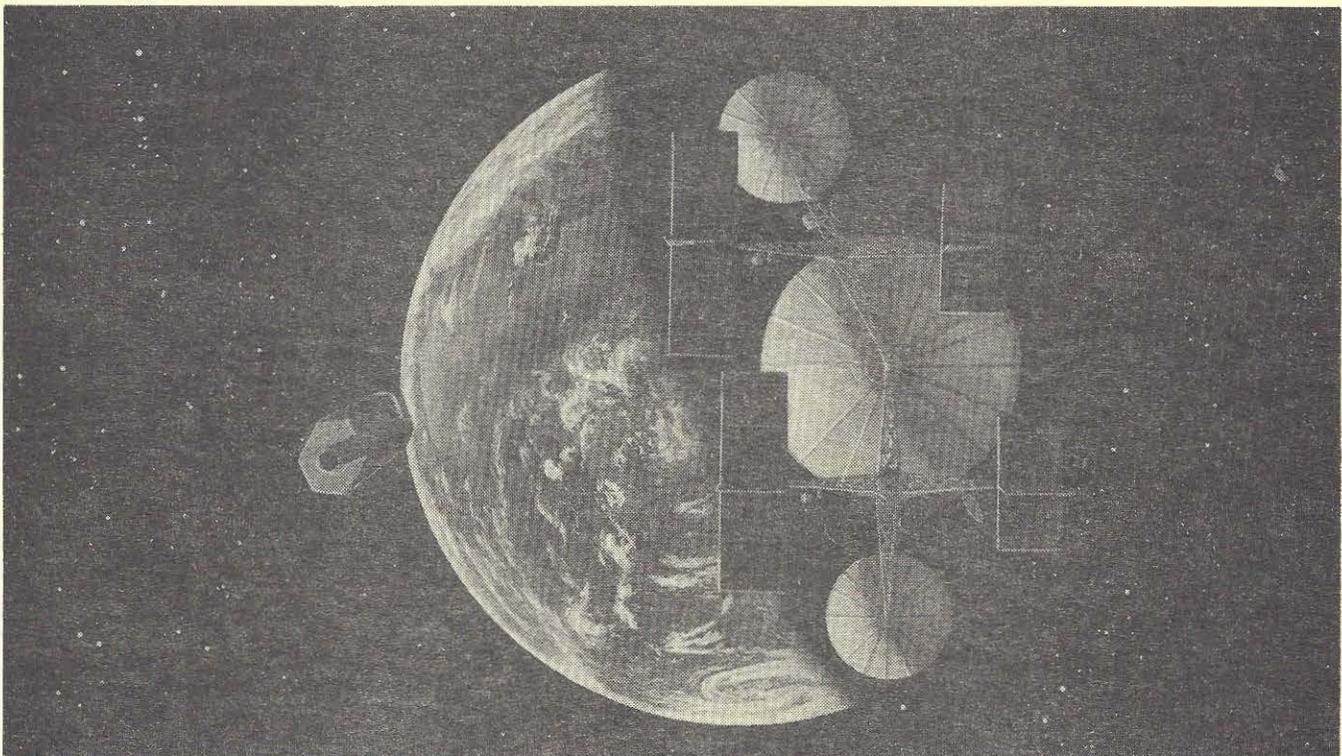
## High Power, Multiuse Satellites Foreseen

Studies on space industrialization this year by both Rockwell International and Science Applications, Inc. both indicated a strong need for high power communication and information satellites in geosynchronous orbit in the late 1980's. Such satellites, similar to the one proposed by Comsat Labs (see illustration) in 1977, would service many different users at the same time. Among the suggested uses would be handheld pocket communicators, a national information network, data communications, and electronic mail systems.

Ultimately, a large number of highly soph-

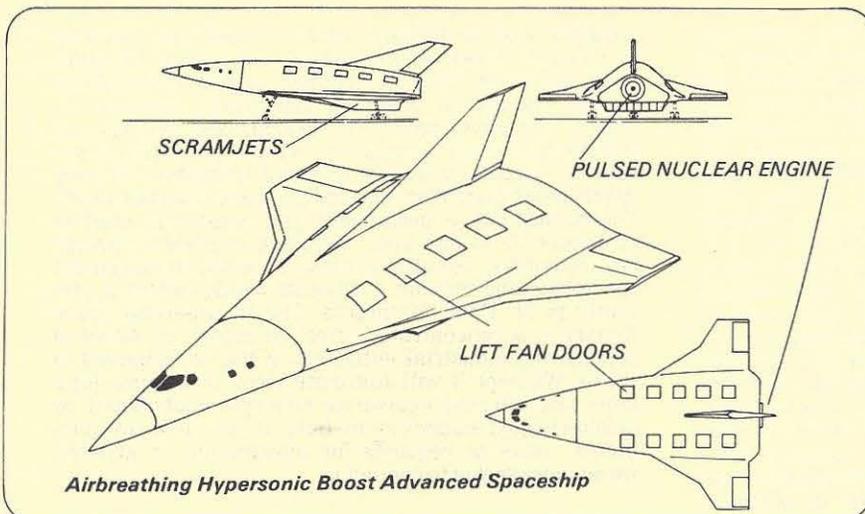
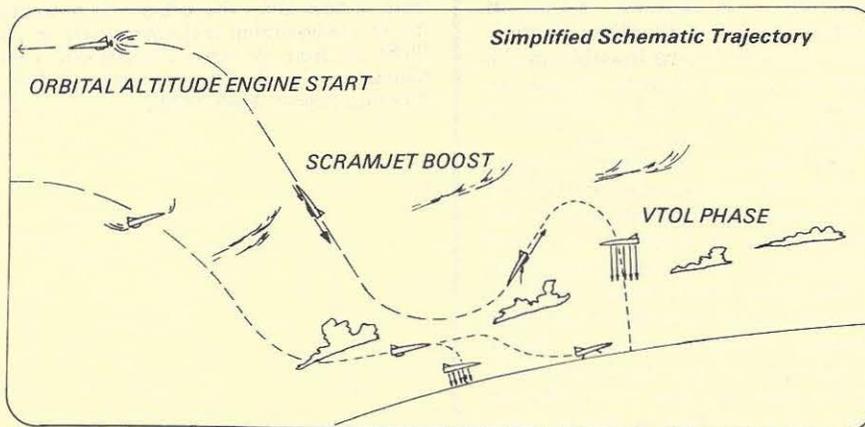
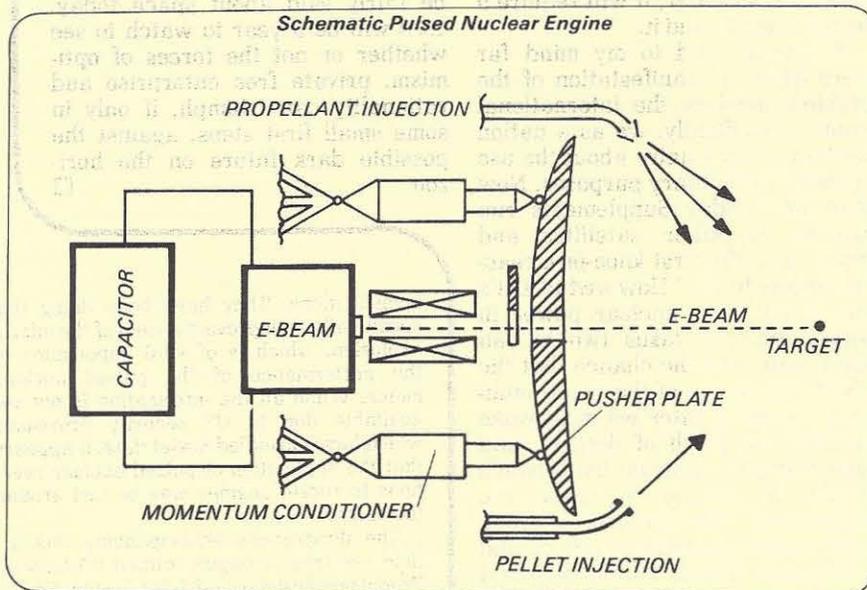
isticated orbital antenna farms would link the entire world in a voice, video and data processing network. The market size for such a service is staggering, yet the technology is nearly available at this time, and the economics of establishing this network are such that space communications platforms are the only way that it could be feasibly done in the next few decades.

On the near-term front, expansion of existing space communications facilities and services continues, as evidenced by the new trade magazine now in circulation called *Satellite Communications*. □



# TRANSPORTATION

## Energy Technologies Promise Progress



Dramatic breakthroughs in the fields of beamed energy and fusion power have raised hopes in the advanced propulsion technology community that major advances may be made in the performance of rocket engines in the near future.

One of the most important new applications of our increasing theoretical capabilities in the beamed energy field may mean the use of fuelless air-breathing single-stage orbital transports is at hand. Recently, much thought has been given to the possibility of using lasers to heat propellant in a simple rocket, and to expel the reaction mass to make a low-cost earth-to-orbit rocket possible. This concept uses ground based powerplants, probably nuclear, to provide the energy for the lasers, which are only about 20% efficient. With the advent of sun-pumped orbital lasers, the enormous capital costs of the electrically driven ground based laser can be avoided. Using a scheme developed in a paper in *Journal of Spacecraft and Rockets*, (August, 1976, L. Myrabo, "MHD Propulsion by Absorption of Laser Radiation"), orbital lasers could be used as a very effective power source for a new type of air-breathing launch vehicle which would need no fuel to carry payloads into earth orbit. In fact, such a vehicle could be built without any moving parts in its propulsion system.

The primary advantage to such a MHD booster would be the capability to operate from any site on the plant which may be illuminated directly or through relays from an orbital powersat. The ground based concept is limited by the fixed site requirement of the large, electric discharge lasers. For the orbital powersat concept, no special ground facilities of any type would be needed.

The orbital lasers could also be used for earth transportation according to a proposal made by Hertzberg and Sun (see Report, March, 1978). Combining the various functions of such a powerplant could help make its realization more feasible, since each use (i.e., power, aircraft propulsion, spacecraft propulsion) could be demonstrated with the same laser, or simple modifications of a common system.

Other energy related work is having a significant impact on advanced space transportation studies, as well. The breakthroughs made by the USSR in the last several years in inducing fusion reactions to occur in compressed pellets of fusible matter means that the Foundation, Inc. concept of the fission-fusion hybrid pulsed nuclear engine is closer to reality. It has been reported in *Aviation Week & Space Technology* magazine that the Soviets have also been experimenting with the use of uranium fuel in the highly compressed pellet

... continued

by Gary C. Hudson

## YEAR END SUMMARY ISSUE

If the technology is no longer the limiting factor in the coming development of outer space, what is? While I have said that the "will" to make a commitment is vital, a more precise definition is required. There are questions of business which need to be considered, such as markets for space services and products, return on investment, profitability and the time needed to develop a mature market. Unfortunately for most companies and entrepreneurs, the answers to these questions depend on the much more serious matters of national and international law, and politics.

Presently the businessperson exists in a vacuum with regard to space industry. Since the idea has only barely penetrated the barrier of the *status quo* which lawmakers and bureaucrats always erect and maintain about themselves, we might expect this characteristic uncertainty to persist for a few more years, at least. Clever pre-emptive actions by the space business community will be needed to overcome this problem.

One manifestation of the seriousness of this political-legal problem can be seen in the recently announced "new" Carter administration space policy. While I have no particular love for a public space program (far and away preferring a private group of programs), I am

appalled by what a shortsighted, bumbling administration envisions as a "new" national program. If there is anything new in the recent Carter speech on space at the Kennedy Space Center, it will require a semantician to find it.

A second, and to my mind far more ominous manifestation of the problem involves the international arena. Specifically, we as a nation seem to be very naive about the use of space for military purposes. Now that the Sunday Supplements run articles on killer satellites and space war, the first knee-jerk reaction seems to be: "How awful! Let's ban space war, nuclear power in space, etc.". It takes two to ban space war, and the chance that the USSR will be one of the two is minimal. Sooner or later we must wake up from the myth of detente, and face a simple strategic truth which should be obvious to those who understand the relation of fast, economical spaceships and orbital mechanics. Simply stated, the first nation or group which deploys advanced technology spacecraft armed with directed energy weapons has the military option of closing space to all other parties. Such spacecraft are feasible in the next one to two decades. Unless we accept the fact, we all will become one of the "... other parties".

The best way to offset the problems in the non-technological sphere is to move aggressively now to begin building a foothold in space commencing with the exploitation of the space environment. *De facto* solutions often turn out better than planned solutions when it comes to solving complex problems such as the ones we now face. This attempt at a solution is highly risky,

to say the least, and will be correspondingly difficult to implement.

While it is always popular to suggest that this or that issue is now at a turning point, I think that this may be fairly said about space today. 1979 will be a year to watch to see whether or not the forces of optimism, private free enterprise and rationality can triumph, if only in some small first steps, against the possible dark future on the horizon. □

investigations. They have been doing this specifically to improve the yield of the micro-explosion, which is of vital importance to the performance of the pulsed nuclear motor. While all the information is not yet available due to US security provisions which have classified Soviet data, it appears that the application of pulsed nuclear reactions to rocket engines may be just around the corner.

The illustrations accompanying this article are from a paper entitled "Advanced Propulsion Systems and Solar System Space-ships", which was presented recently in Europe. Besides showing the schematic layout of a pulsed engine, they also illustrate a new style spaceship which would fly an air-breathing trajectory early in its flight to orbit to avoid atmospheric contamination by fission fragment residues. (See also Report, April, 1978.) □

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: Gary C. Hudson; Special Assistance: Resident Fellows 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



in 1971 as a non-profit 501(c)(3) Minnesota Corporation. The company is a diversified research and development organization formed to engage in advanced

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:

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**SPACE INDUSTRY BOOKS AVAILABLE...**The American Astronautical Society has published the proceedings of the 23rd Annual Meeting of the Society which was held in October 1977 at the San Francisco Airport Hilton Hotel. Comprising two volumes of the AAS Advances in the Astronautical Sciences series, the books were edited by R. A. Van Patten, P. Siegler, and E. V. B. Stearns. Volume One comprises papers on the topics: "Technical Aspects of Large Space Structures", "Advanced Transportation Systems", "Technical Aspects - Making It Work", "Communications and Navigation", and "Technical Aspects of Space Habitation". Volume Two contains "Historical Precursors and Analogs", "Economic Realities of Space Operations", "Psycho-Social and Biological Considerations", "Space Law", and "Space Community Planning". The first volume is 590 pages (\$45.00), and the second is 530 pages (\$40.00). Copies are available from the AAS, Publication Office, Box 28130, San Diego, CA 92128.

**SPACE ENERGY REPORT...**New York...The American Institute of Aeronautics and Astronautics has published the conference proceedings of the 3rd Annual NASA Conference on Radiation Energy Conversion in Space as Volume 61 of the AIAA Progress in Astronautics and Aeronautics Series. The editor is Ken Billman of NASA's Ames Research Center, Moffett Field, California, the conference chairman. The principle theme of this volume is the analysis of potential methods for the effective utilization of solar energy for the generation and transmission of large amounts of power from satellite power stations down to the earth for terrestrial uses. This volume constitutes a progress report on the many NASA and industry studies of SPS, but also contains a number of important papers which go beyond the baseline concept of the microwave SPS. The book contains analyses of the feasibility of laser transmission of power, new electricity storage concepts for SPS, use of laser energy for propulsion, and nuclear pumped lasers for space use. This may be the most important new book on space industrialization options of the past several years. Copies may be purchased from the AIAA Publications Dept., AIAA, 1290 Avenue of the Americas, New York, New York 10019. Cost is \$24.00 (members) or \$45.00 (non-members) (690 pages). Visa and Mastercharge are accepted.

**SPACE SOCIOLOGICAL SURVEY...**Washington...Dr. T. Stephen Cheston of Georgetown University has received a \$15,000 NASA grant from the Advanced Program Office of NASA Headquarters. The grant is for the dual purpose of surveying activities and interests of social scientists who may be involved with space studies, as well as to determine the feasibility of a academic journal which might act as a forum for scholarly exchange on the topic of space and social/humanities activities. Any seriously interested individual or researcher may obtain a copy of the survey questionnaire by writing: The Institute for Social Science Studies of Space, Suite 403, 2135 Wisconsin NW, Washington, D.C. 20057. A midterm briefing has been presented by the group recently with a final briefing scheduled next April.

**SPACE PROCESSING, SOVIET STYLE...**Washington...Soviet cosmonauts conducted materials processing in space studies (MPS) aboard the USSR's Salyut 6 space station during the last weeks of their recent record-breaking flight. During one of two MPS experiments, mercury cadmium telluride semiconductor material was formed. The zero-gravity of space is ideal for the formation

of this substance, which is primarily used in military sensors because of its response in the infrared region of the spectrum. Other space processing work had been done earlier aboard the space station.

**COST OVERRUNS COMPARED...**The Space Shuttle is presently only about 9% over estimated cost, according to NASA official testimony before Congressional committees. Recently the European Space Agency has determined that the cost overrun for the Ariane booster will be about 5%. Both the Shuttle and the ESA Ariane are strong competitors for the communications satellite launch market.

**STEP TO METALLIC HYDROGEN...**Cornell...A team headed by Dr. Arthur Ruoff and funded by NASA has succeeded in manufacturing a small quantity of metallic xenon, which is normally a gas at room temperatures. The metallic xenon was made using a diamond anvil to squeeze the xenon to 300,000 atmospheres (about 4.5 million pounds per square inch); however, the material was not stable in the metallic form when pressure was removed. Along with the change to the solid state, it was determined that the xenon became a superconductor. Work on xenon is a precursor to experiments with metallic hydrogen, which is predicted to also be a superconductor, and which some scientists believe may be stable in the solid state. If it were to be stable, and a superconductor, pellets of the element might be able to replace fission-fusion hybrid pellets in a pulsed nuclear motor, leading to a virtually pollution free form of high performance engine which could be operated in the atmosphere.

**SPACESHIPS OF THE MIND...**London...The British Broadcasting Corporation has released a new book by Nigel Caulder (former editor of New Scientist) which is a generally thorough summary of the status of space industry and space civilization. Meant to accompany the BBC series "Spaceships of the Mind", which will not be shown on US television in the near future, it is a useful and interesting work with many provocative and innovative ideas discussed in interviews with leading researchers in the space field. Just available in US bookstores, it retails for about \$12.

**REGRETS...**St. Paul...This issue of the **Commercial Space Report** is about a week late due to start-up difficulties with the new Foundation, Inc. computer system. This new machine will ultimately allow us to prepare the newsletter and associated **News Notes** faster (thus containing more up-to-date information) but memory and static electricity problems have conspired to force a delay in this issue (and the deletion of the **News Notes** in the last issue). We believe that the problems have now been resolved. Thank you for your understanding.

**NEXT YEAR...**St. Paul...The next year of the **Report** will have a three part series on space war and its implications for space business, and coverage of near term prospects for space processing, space habitation and new transportation systems. Additionally, potential industrial possibilities for laser powersats will be covered in a two part series.