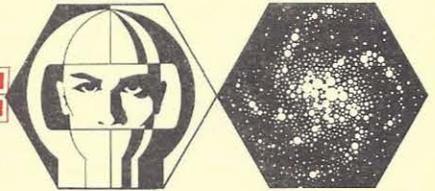


# COMMERCIAL SPACE REPORT



## WHERE ARE WE GOING WITH SPACE SYSTEMS?

### General Electric Executive Reviews Thrust of Current Space Technology Efforts

Mr. Lee L. Farnham, Vice President and General Manager of the General Electric Company Space Division has suggested that future space missions will be driven by more specific needs and wants than the past first steps into space. Speaking at the AIAA/NASA Conference on Technology for Future Space Systems in Hampton, Virginia recently, Farnham presented a thematic keynote speech entitled: "Overview of Space Systems Technology". His prime point was that applications needs will drive the development of near and medium term technology for space systems. Such an observation is fairly unique in the aerospace/NASA perspective, since it actually begins to take into account market forces which will act to force the development of the advanced technology that commercial space systems will require.

General Electric Company has been in the forefront of analysis concerning the future of a broad class of space

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## PRINCETON CONFERENCE POINTS WAY TO NEW OPTIONS

### Focus is on Satellite Power and Extraterrestrial Resources

The Fourth Princeton Conference on Space Manufacturing Facilities was held on May 14 through 17 at Princeton University, and attracted more than 200 participants who were willing to pay the \$100 registration fee imposed by the University. Generally the Princeton Conferences have focused on the specific question of the development of space colonies based on the concepts of organizer Gerry O'Neill, but this meeting was more directed at the dual question of the how and why of space power satellites (SPS) and the resources available once we make a move into space.

The conference participants exhibited both enthusiasm for novel concepts and frustration or despair at the lack of progress towards actual realization of any of the concepts or opportunities. Aerospace companies were poorly represented, though several aerospace staffers were present at the meeting "under cover". One, from the Seattle area (and obviously from Boeing) went to great pains to comment that he was at this conference not as a representative of

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## NEEDS & WANTS CREATE FUTURE MISSIONS

BUSINESS COMM  
PERSONAL COMM  
DATA EXCHANGE  
NAVIGATION  
ENTERTAINMENT  
EXTENDED SERV.

CROP SURVEY  
LAND USE SURVEY  
GEOLOGIC STUDY  
WEATHER F'CAST  
DISASTER WARNING  
ENERGY EXPL.  
SURVEILLANCE

MATERIALS RES  
PRODUCT RES  
MEDICAL RES  
PREMIUM MAT'LS  
PRODUCTION

PLANETARY EXPL.  
ASTRONOMY  
EARTH SCIENCE  
LIFE SUPPORT



COMMUNICATIONS  
MISSIONS



EARTH  
OBSERVATION  
MISSIONS



MATERIALS  
PROCESSING  
IN-SPACE



SCIENTIFIC  
MISSIONS

systems, including a study of manufacturing in space called the "Beneficial Uses of Space Study" in 1975, and the recent PLACE (Post Landsat Advanced Concept Evaluation) Study. Additionally, GE was the contractor to the NASA Goddard Space Flight Center for a study on "Global Services" which satellites might provide in the 1990's. Thus Farnham was well equipped to look at the problem of technology and space from the "market" perspective.

Drawing on these resources, as well as the background of technology experience available, Farnham first described some of the missions which are foreseen prior to the end of the century. They are in four general areas: Communications, Earth Observation, Materials Processing and Scientific. Noticeably absent from this portion of the discussion were reference to energy and military application, two important technology drivers. No mention was made of extraterrestrial resources.

Farnham then went on to discuss the technology needs created by the most demanding of the four mission types. Emphasis was on the use of electronics and computers to handle difficult problems in operation and control of advanced spacecraft. Two persistent problem areas are also power and large structures technology. However, in all cases efforts are underway to find solutions to these problems based on the existing group of missions which are under design or presently in space operation.

The technology needed for communications advances has both the highest payoff and most difficult requirements. Future comsat platforms will require large amounts of electrical power and very high data processing rate capabilities. In fact, with the growth of satellite telephony, whole "switchboards" will have to be placed in space. The idea here is to minimize the complexity of the ground station or terminal (which may be a mobile, fixed or hand held com-

municator). The level of difficulty can be understood better when one realizes the total assets of the present Bell system (80+ Billion dollars) may someday have to be recreated in space. While Farnham did not suggest anything close to this extreme step, the study GE conducted concerning global services supplied by satellite did point out the size of the potential world market for satellite communications, which may exceed the world market for electric power.

While electrical and computational power are two vital areas for future development, the cost of large areas of space structure is also a matter for attention. One square kilometer of orbital real estate is very expensive according to present Space Shuttle cost models. For example, one square kilometer of antenna support needs 1000 miles of tubing, 20000 joints, and fifty Shuttle flights to transport the material to low earth orbit. The cost if the structure was metal would be \$5 million for materials, and about \$1.5 billion for transport. If made of advanced composites, the material cost would be \$25 million, but transport costs could be reduced to \$.75 billion. (By way of comparison, transport for the metal on the Foundation, Inc. Large Launch Vehicle [Report, April, 1979] would be about \$20 million [Saturn V type engine], while the cost for the composite material would be about \$10 million).

When one considers the totality of the effort necessary to produce commercially feasible space systems in light of Farnham's overview, the picture is very encouraging. Most of the necessary advances are either under study at the present time or are even operating in prototype versions. In fact, elsewhere at the conference were several demonstrations and papers relating to advanced space structures, power systems and communication/computational hardware. It would appear that the time for major commercial interest and investment is fast approaching. □

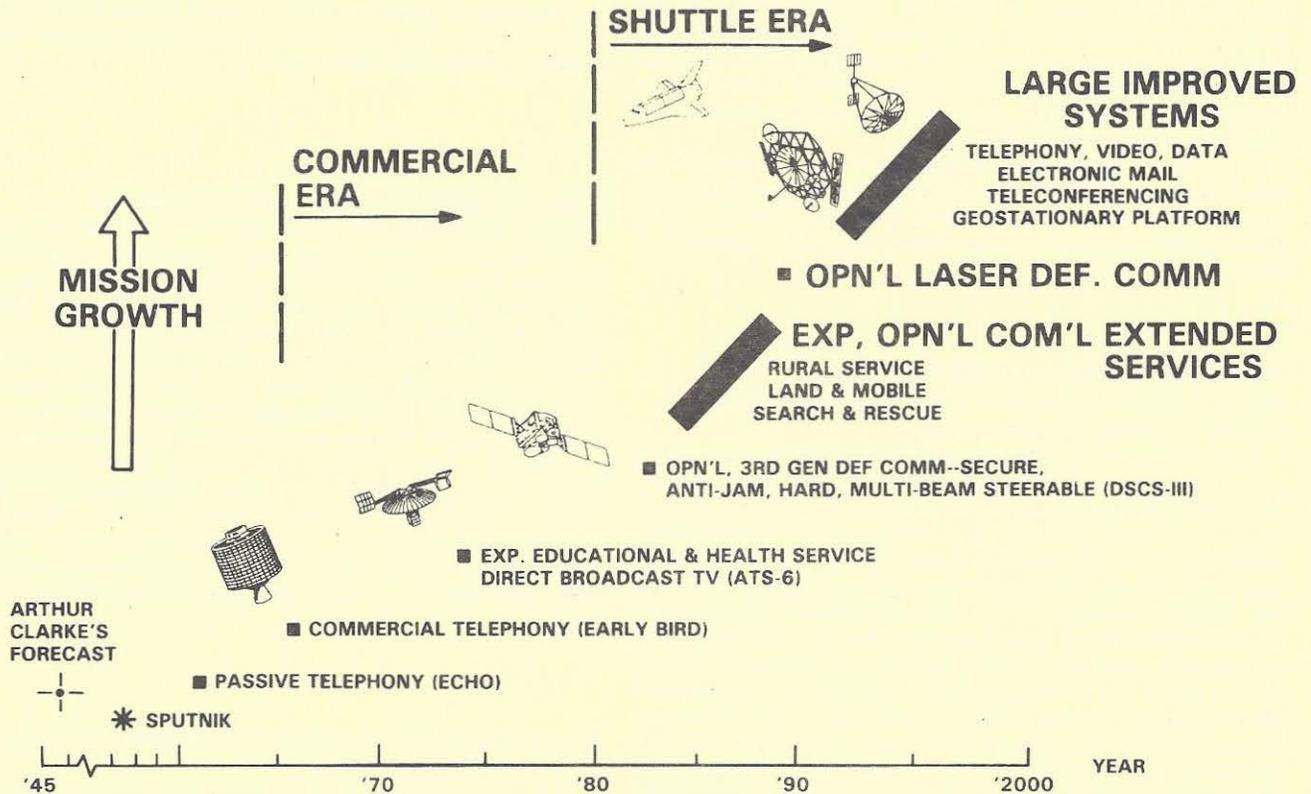


## MISSIONS & SYSTEMS CREATE FRONTIERS FOR TECHNOLOGY

COMMUNICATIONS MISSIONS	EARTH OBSERVATION MISSIONS	MATERIALS PROCESSING IN SPACE MISSIONS	SCIENTIFIC MISSIONS
<ul style="list-style-type: none"> <li>● SPECTRUM               <ul style="list-style-type: none"> <li>- HIGHER FREQ</li> <li>- FREQ RE-USE</li> <li>- SPOT-BEAMING</li> </ul> </li> <li>● POWER</li> <li>● LARGE STRUCTURES               <ul style="list-style-type: none"> <li>- SWITCHING</li> <li>- CONTROLS</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● DATA HANDLING</li> <li>● INFORMATION EXTRACT               <ul style="list-style-type: none"> <li>- SIGNATURE RESEARCH</li> <li>- INTERPRETATION</li> <li>- SENSOR DEVELOPMENT</li> </ul> </li> <li>● AUTONOMY               <ul style="list-style-type: none"> <li>- PROCESSING</li> <li>- CONTROLS</li> </ul> </li> <li>● LARGE STRUCTURES</li> </ul>	<ul style="list-style-type: none"> <li>● POWER</li> <li>● AUTONOMY</li> <li>● LARGE STRUCTURES</li> </ul>	<ul style="list-style-type: none"> <li>● SENSORS</li> <li>● PROPULSION</li> <li>● AUTONOMY</li> </ul>



# COMMUNICATION MISSIONS A NEW ERA

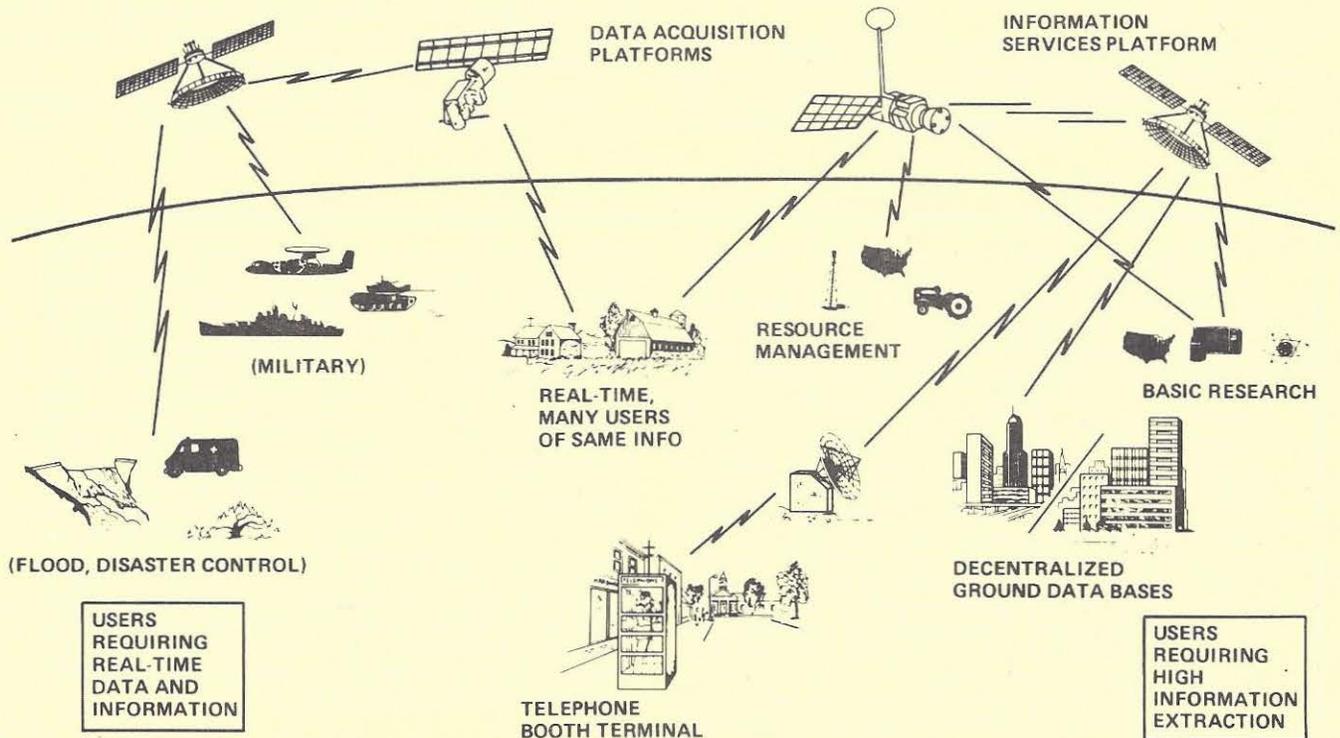


(Above) The New Era in commercial communications missions is illustrated by the chart. The volume and weight capabilities of the Shuttle and similar vehicles will permit large antennas and power supplies for direct user access. (Below) The progress of electronics will permit the advances in commercial space systems. Specifically, higher power

transmitters will allow smaller user sets on the ground, while computational advances will allow the complex switching functions to be handled in space rather than on earth. (All illustrations in this article courtesy General Electric Co.)



## ELECTRONIC DEVELOPMENTS WILL ENABLE USER DIRECT ACCESS



Boeing but rather just as a private observer. However, he also took great pains to tape the entire meeting. NASA people were also not in abundance, but representatives from other government agencies, including DOE and the Government Accounting Office were. Most of the attendees were from universities, nonprofit research organizations and non-aerospace industry.

It would be impossible for the Report to cover all of the papers presented at the conference, but we have selected several interesting presentations for short review. They fall into the categories of resources and space transportation.

**Near Earth Extraterrestrial Resources,**  
David L. Kuck, Geological & Mining Consultant,  
Oracle, Arizona (Paper 79-1377)

Kuck is one of the first persons to suggest in a scientific paper that the resources of the moon and the asteroids be used to fill market needs on earth rather than in space. Up to now, most analysis of extraterrestrial resources always assumed the product would be used to build large space structures like powersats and settlements. (Though see Report, January, 1978, "Extraterrestrial Resources", C. Alexander.) Kuck calculates that the precious metals of an asteroid only one hundred meters in diameter (Ni-Fe) can be worth 2 to 3 billion dollars. According to the author this represents stored energy as well, since the extraction of this material on earth is very energy intensive. He also calculated the possibility of producing lunar titanium for sale on earth, and determined that a facility processing 10,000 tons per day could cost up to 2 billion dollars to establish, since it would return the same value of Ti to earth annually.

**Overview of Methods for Extraterrestrial Materials Processing,** R. Waldron and D. Criswell, Lunar and Planetary Institute, and T. Erstfeld, Lockheed  
(Paper 79-1379)

The authors give a brief survey of the various chemical based methods to extract metals and other materials from the lunar soil. Primarily interested in beginning a bootstrap operation in which the amount of material which has

to be lifted from earth is minimal, they conclude that the processing of lunar materials should be done in space, not on the moon. The plant should be able to process its own weight in materials every week.

**High Performance Solar Sails and Related Reflecting Devices,** K. Drexler, MIT, (Paper 79-1418)

In one of the most interesting papers of the conference, Drexler discussed in detail a modification of the solar sailing concept. Drexler proposes the use of ultrathin films of metal foil used in a lightweight framework for a super-lightweight sail. The thickness of the foils which might be used is about 1000 angstroms, or a few hundred times the thickness of the DNA molecule. However, there are ways such films might be manufactured on a fast production line, leading to a cost of about 1 to 3 cents per square meter. Using a sail with about six square kilometers of surface, which would weigh a few thousand pounds, three tons can be transported out to geosynchronous orbit in fifty days. Ultimately the cost of recovery of asteroidal materials may be lowered to a few cents per pound with sail transport.

**Electromagnetic Propulsion Alternative,** H. Kolm, et al., MIT (Paper 79-1400)

Kolm, one of the designers of the mass driver under study by O'Neill and NASA, proposes in this paper a variety of other electromagnetic launchers for several purposes. He concentrated on the railgun, a device which does not use superconductivity, but has a higher acceleration capacity than the mass driver. The most interesting application of the railgun would be to use a 2 kilometer, 10,000 gee version to launch 1.5 ton "telephone poles" of nuclear waste jacketed with carbon composite heat shields to solar escape velocity from the surface of the earth. The projectile, eight inches in diameter and twenty feet long, would lose up to 60% of its mass due to ablation as it traversed the atmosphere, but only about one third of its velocity. The cost of the launch could be a few dollars per pound.

Copies of the papers may be obtained by writing the AIAA, 1290 Avenue of the Americas, New York, NY 10019.

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 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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**TENTH LUNAR LANDING CONFERENCE...**San Francisco...Ten years after the first manned landing on earth's moon, the Bay Area Chapters of the American Astronautical Society and the American Institute for Aeronautics and Astronautics will cosponsor a two-day meeting (July 20 and 21) entitled "Remember the Future - The Apollo Story". The meeting emphasis will be on future programs such as orbital civilizations, solar power satellites, space factories and interstellar travel. Both the technical and political aspects of space activities will be covered. (A special program called "First Trip Between Two Planets" will be presented at Foothill College, near San Francisco, the night of July 19th.) Papers on a broad range of future space topics will be presented by individuals including Peter Vajk (financing space industrialization), Robert Edelson (JPL/SETI), Mark Frazier (Earthport), B. J. Bluth (astronaut stress in SpaceLab/Shuttle), Gary Hudson (advanced space transportation), Poul Anderson and many others. Papers are still invited from qualified individuals and organizations. The conference will be held at the San Francisco Airport Hilton. For more information contact the AAS, P.O. Box 7205, Menlo Park, CA 94025, or the AIAA, P.O. Box 1548, Mountain View, CA 94040; or call Space Age Review, at (408) 737-1394.

**SPACE WAR...**Business Week magazine, which has pioneered the discussion of commercial space ventures in the past, has recently published a cover article on space warfare in the June 4 issue. The article discusses US and Soviet activity in ASAT (antisatellite) technology, laser and particle beam directed energy weapons and military communications. One important quote: "The Kremlin...has denounced the shuttle as a military "weapon"... What apparently bothers the Soviet leaders...is that the shuttle would have the capability to maneuver close to Russian satellites and inspect them in orbit, or even retrieve a Soviet platform for dissection back on the ground."

**SOVIET SPACE AIRLINE?...**Aviation Week & Space Technology (May 28) reports that the USSR is planning to ultimately use airline style operations in its manned space effort. The Soviet space planners anticipate a large traffic level necessitating the use of pilots for flying space craft and crews who perform the mission. Presently, the pilots are also the mission specialists, however the Shuttle operations will be based on this new concept.

**NASA INTEGRATION OF COMMERCIAL PAYLOADS ENDING...**Washington...The National Aeronautics and Space Administration has decided to end its role in the integration of commercial private space payloads by contracting the functions to an outside contractor. Primary reason for the NASA move is cost savings, but the act could mean that commercial operation of the Shuttle and related facilities may be getting closer.

**SKYLAB IS NOT THE ONLY WORRY...**Princeton...Princeton Professor Ted Taylor (one of former the "ORION" project team members) has cautioned that the hazard of large object collisions with the earth is a real threat, and due

to the damage which could be caused, merits our investigation and concern. Taylor, who is presently one of the members of the President's Commission on Three Mile Island, has calculated that the probability of impact of a large asteroid or comet head is one chance in 100,000 per year. If the damage caused was as much as a trillion dollars (probably a conservative estimate) it would be worth our while to spend up to 10,000,000 dollars per year to detect and track bodies which might impact the earth at a future time. Besides giving us warning, it is possible that such a search could aid in the location of valuable extraterrestrial resources.

**IAF PAPERS...**Minneapolis...Two papers on advanced propulsion systems and solar system spaceships have been accepted by the International Astronautical Federation for the 30th Congress (September) in Munich. Both papers are authored by Foundation, Inc. President Gary C. Hudson. One will be given in a session chaired by Gerry O'Neill on Extraterrestrial Resources and Advanced Concepts (paper title: "Advanced Space Transportation Systems: Economic Effects on Space Industrialization; Asteroid Mining as a Case in Point"). The second is on "Pulsed Fission/Fusion Hybrid Rocket Engines".

**MORE ENGINE PROBLEMS...**Washington...The SSME Shuttle rocket engine has encountered new problems. One major worry is now the life of the combustion chamber, which was originally planned for 7.5 hours lifetime, but which may only be reused five times due to erosion and metal fatigue. The second problem occurs in the hydrogen coolant tubes of the engine, a few of which have broken in recent tests, causing the engine to overheat and shutdown. The latter problem has forced a delay in testing the "flight article" which contains the three main engines all firing at the same time. Such a test is of course necessary before the system can be accepted for flight.