FOUNDATION REPORT:

ADVANCES IN COMMERCIAL AND GENERAL SPACE DEVELOPMENTS

STAR PROBE STUDY EFFORT CONCLUDED BY BRITISH INTERPLANETARY SOCIETY

Project Daedalus Aims Fusion Ship at Barnard's Star

As often happens, that which started out as a simple exercise in exploring science and technology turns into an important factor in the history of technological development. The concept of Gerard O'Neill's space colonies started out as an exercise for a physics class.

Now, The British Interplanetary Society (BIS), an organization dedicated to the promotion of space research, technology and applications, has recently finished a similar design project.

Called Project Daedalus, it was initiated to see if a realistic unmanned interstellar space probe could be designed using present day technology and reasonable technological extrapolations. At this time, like many ear-

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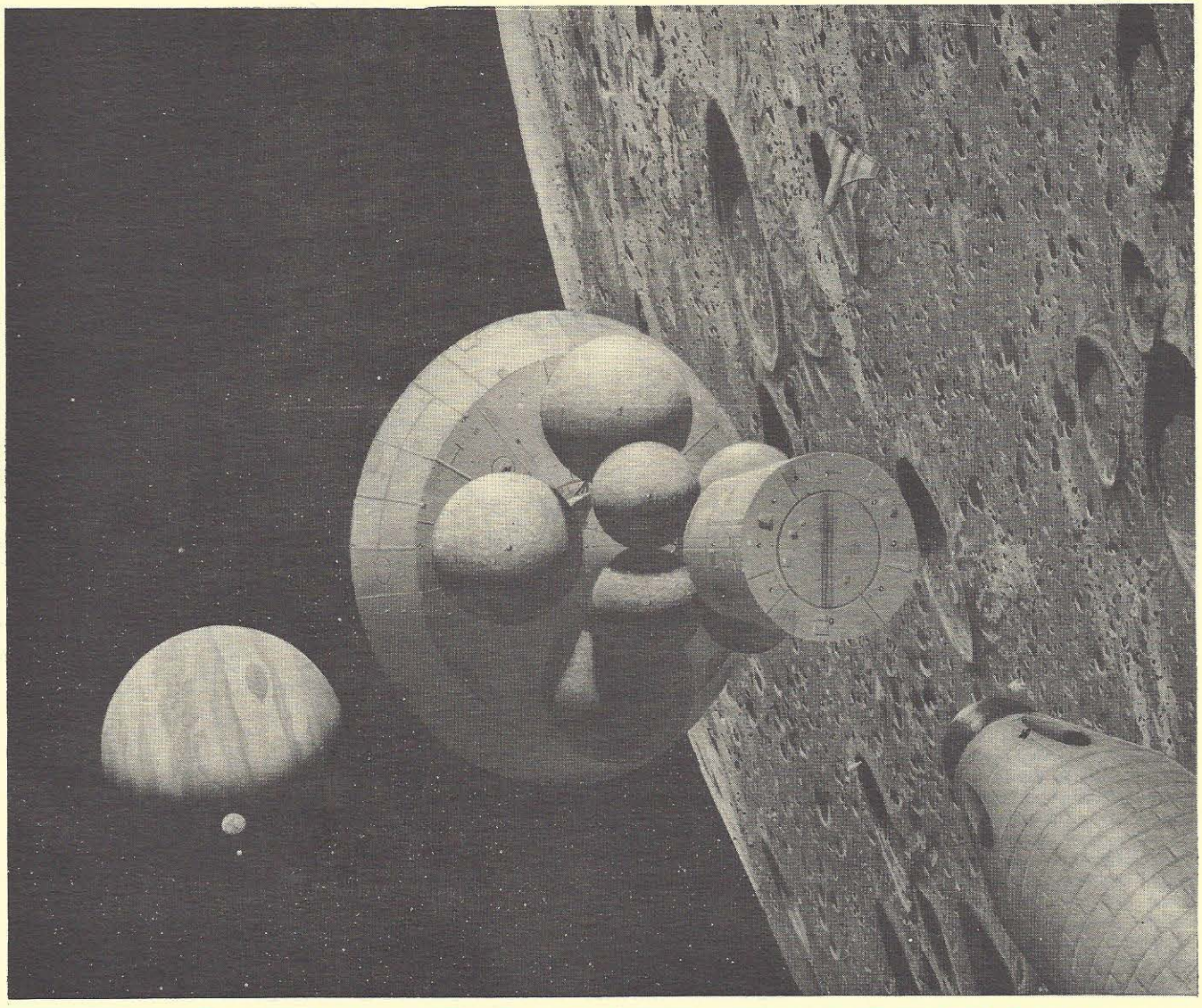

A version of the Daedalus probe being assembled in Jupiter orbit. The view is of the payload compartment looking back toward the propellant tanks of the second and first stages of the starship. The engine of the ship is directly behind the large spherical tanks. The probe will be fueled with Helium Three from the atmosphere of Jupiter. *Original artwork by David Egge, copyright 1978.*

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lier scientific studies. Project Daedalus seems an extravagant and fantastic idea. It must be remembered that from such ideas often spring future realities, realities which may bear no resemblance to the present design, but with firm roots therein.

Project Daedalus was not well funded. Directed by the British Interplanetary Society, thirteen professional scientists, designers and engineers worked for five years in their spare time to develop the concept. Additional volunteer help brought the total number involved at various times to over fifty. Between them, a concise, conceptual report was written containing nearly 200 pages of design, mathematics and engineering. The Project was not intended in any way to produce a "blueprint for a starship". Instead, it was meant as a guide to possible solutions to the staggering problem of flight between the stars.

Just how staggering is that problem? The distance between the earth and the moon is around a quarter of a million miles. An Apollo spacecraft can cover this distance in a few days. The speed of an Apollo as it leaves earth orbit for the moon is over 24,000 miles per hour.

At this speed, it would take over one hundred thousand years to reach the closest star, Proxima Centauri.

Barnards' Star, selected as an ideal target by the study because it is likely to possess planets, is nearly half again as far, 5.9 light years away compared to 4.2 for Proxima Centauri. A light year, a common method of measuring stellar distances, is the distance a beam of light can travel in one year. It is equivalent to 5,860,000,000,000 miles.

To cover these vast distances in any reasonable amount of time requires a spacecraft to develop immense speeds. Chemically powered rockets are far too feeble to attain these velocities. It was decided that the design would have to involve some type of nuclear reaction.

Nuclear fission, the power which drives all present day atomic reactors and creates the force of the atomic bomb, was still not powerful enough.

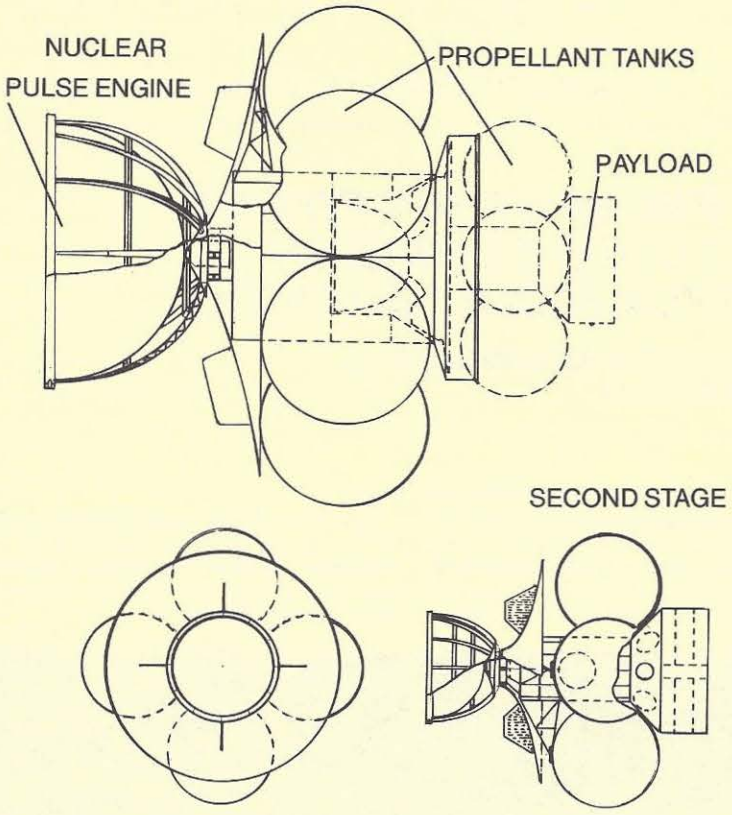
The process of nuclear fusion, the type of reaction that feeds the sun and the hydrogen bomb, was needed.

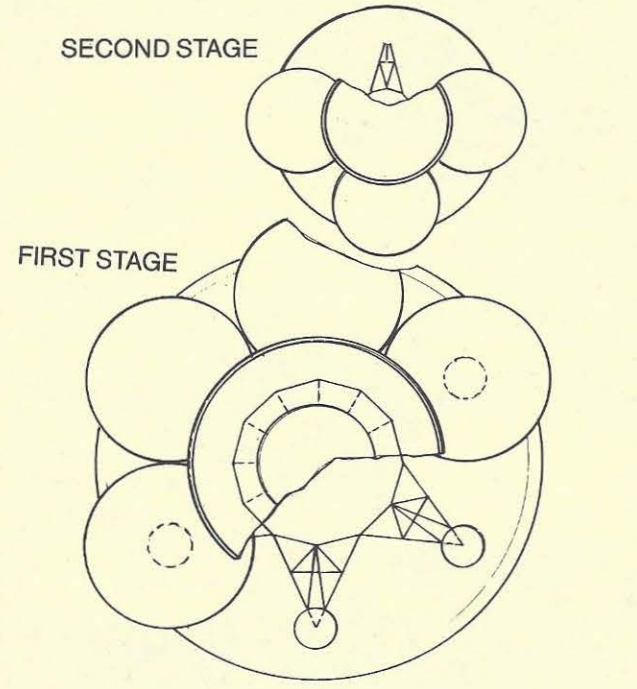
How could fusion be used most efficiently to propel spacecraft? Since no self-sustaining controlled fusion reaction has yet taken place, an extrapolation was necessary. To keep the systems as close as possible to present day technology, the study explored the research that had been done on laser or electron-beam ignited pellets of fusible materials. Hitherto, such research had been done in hopes of finding a method to use fusion energy on earth for electrical power generation. Some successes had already come about in this line of research.

Such a reactor uses tiny pellets of a material that is capable of undergoing a fusion reaction. Usually this is some form of hydrogen, in a frozen state or enclosed in a small glass sphere. The pellet is illuminated in a precise manner by either laser beams or an electron beam of great power. The pellet is heated and compressed to the point where fusion can take place, and energy is released. (Ideally, more energy than was required to fire the beam. This "breakeven" point has not yet been reached.)

The Daedalus group assumed that such a

EARLY DAEDALUS STARPROBE CONFIGURATION





TOP VIEWS

system would be operable in the forseeable future. To transmit as much of the released energy as possible into thrust, they selected a "clean" reaction, using deuterium (an isotope of hydrogen) and helium-3 (an isotope of helium). When these elements are combined in a fusion reaction, most of the energy is released in the form of charged particles. By contrast, a power plant fusion reaction will use deuterium and tritium, a reaction producing many more neutrons than charged particles. Charged particles can be controlled and directed by magnetic fields. Uncharged neutrons cannot. A rocket engine could use superconducting magnets to direct all the high-energy charged particles in one direction, producing thrust. A reaction producing neutrons, on the other hand, would simply heat up the engine and produce little thrust. (This situation, however, is useful for an earth power plant which uses the heat to produce steam).

The engine design that was arrived at was an enormous parabolic nozzle, with an opening 360 feet in diameter. Inside, the fusion pellets would be ignited by an electron beam at the rate of 250 pellets per second. A thrust of 1500 tons would be produced. A second stage was added to the vehicle, with a similar engine having a thrust of about 900 tons. The total vehicle was to weigh over 53,000 tons, including 50,000 tons of fuel. The efficiency of this type of rocket would be tremendous. Nearly one million pounds of thrust would be produced from one pound of fuel. (As a contrast, a hydrogen-oxygen chemical rocket generates 400 pounds thrust from a pound of fuel.)

In operation, the payload would be an unmanned probe. The vehicle would accelerate from orbit somewhere in the solar system. (The ship would be far too large to launch from the ground; it would be assembled in space.) The nuclear engine of the first stage would run continuously for over two years, dropping fuel tanks along the way. Then, the second stage would operate for a year and a half.

At the end of this time, the probe will have reached the awesome speed of nearly 23,000 miles *per second.* At this distance from earth to moon would be covered in ten seconds. Yet, this is still only 12% of the speed of light, and the ship would require nearly fifty years of coasting at this speed to reach Barnard's star.

To save fuel the probe would not slow down at the end of the trip, but would flash through the Barnard system at full velocity. The ship would be going so fast that the entire planetary system would be traversed in a little over a day. To gather data on the system, a complex series of telescopes, sensors, and smaller disposable probes would be used. All data would be gathered by the computers on board, and stored. The data gathering systems would concentrate on any planets which may orbit Barnard's star, but valuable data may also be collected on the environment surrounding the star, the star itself, and interstellar space.

After the probe has passed through the system, the spacecraft would then transmit its gathered information to radio telescopes back in our solar system. The probe would then continue on into interstellar space until its power ran out. Its radio silent, and control lost, it would continue to drift on at 12% light speed until it finally either strikes a sun or a planet, or flies on into the deeps between the galaxies.

It is exciting to consider the possibilities of such ideas, even though the actual realizations may be years into the future. The Barnard's Star mission as envisioned would involve two such probes. If others were built, many stars could be explored. To make such dreams reality, however, will require a society capable of working and living in space around our solar system, since such ships cannot be built or fueled on earth. Such a society would also have to be stable enough to wait the fifty or so years to hear the results of the expedition. In an era when the mere utilization of the space in earth's orbit is difficult, such dreams seem far away. Yet, they have a way of catching up with us.

In the late 1930's the same British Interplanetary Society, then quite a young organization, decided to undertake a conceptual design project. It was far-fetched and quite unrealistic at a time when the V2 rocket was still in the future, but they thought the idea would someday be an important part of humankind's future.

It was a study for a manned rocket to the moon. □

WORLD SPACE INSTITUTE PLANS TRAINING INSTITUTE FOR EARTH SENSING

Courses to be Scheduled for Third World Students

The World Space Center (USA) is currently undertaking an effort to make maximum use of the new possibilities presented by the advances in space technology for the alleviation of the principal problems facing the world. This is the Remote Sensing Data Interpretation Training Institute, to be established at Santa Barbara, California, in cooperation with the University of California at Santa Barbara and the Sabre Foundation. The project will consist of a new world training center where trainees will be instructed in the uses of remote sensing data from Landsat and similar remote sensing satellite systems. It is envisioned that groups of trainees will be brought to the Institute from developing nations to undergo a six week course in the use of such data for agricultural, environmental, and economic planning purposes. A similar course offered by the Department of the Interior at Sioux Falls, S.D., has been very successful and now requires a wait of one year for admission. Major expansion of the Sioux Falls program seems unlikely as Congress has proven reluctant to approve the necessary funding.

The faculty for this project will be brought to Santa Barbara for short terms, with a small permanent staff consisting of World Space Center personnel and University of California faculty. This will enable the project to offer some of the most capable instruction in this field without the effort of recruiting a large permanent faculty.

The facility itself is planned to include a large geodesic dome of the most current design, whose labor for assembly will be provided at substantially reduced costs by the associates of Dr. Buckminster Fuller, contingent on the project's funding. This structure is seen to be adequate for the program's needs for the foreseeable future.

The long-term goal of the World Space Center is to establish training centers for applications of space technology in developing nations in all parts of the world. These centers can be funded through revenue generated in the host nations through a free-trade zone program to be run in connection with the training centers, and thus become independent of the need for any source of outside funding. This is seen as a means of helping developing nations become less dependent on industrialized nations for modern technological resources. □

Newsletter to Change Name, Format

Since Foundation Inc. began publication of the *Foundation Report* we have received a number of letters with comments and suggestions pertaining to the contents and style of the newsletter. Some of these suggestions were well thought out, and upon consideration the editorial staff decided to incorporate those ideas that we felt would improve the newsletter.

First, the title of the publication is being changed. Beginning with the next issue, the new title will be *The Foundation Inc. Commercial Space Report,* or the *Commercial Space Report* for short. It was agreed that this title would more accurately reflect the purpose of the publication: to disseminate information on advances in the field of space, with emphasis on commercial aspects.

Second, we found that one of the best received features of the newsletter was the "News Notes" section. Again, the next issue will reflect this in a format change which will emphasize this section. Additional sources of information are constantly being pursued by our staff to ensure the timeliness of this feature.

The era of space as a commercial and profitable venture is just beginning. Our purpose is to tell you what you need to know about this rapidly developing area of new enterprises, and any suggestions our readers may have to aid in this purpose are welcomed.

—Gary C. Hudson
Editor

LARGE SPACE STRUCTURES RECEIVE RENEWED EMPHASIS BY NASA, INDUSTRY AND UNIVERSITIES

Grumman Aerospace Corporation, headquartered in Bethpage, New York, has demonstrated a beam-building machine for use in space. Built under contract to the NASA Marshall Space Flight Center, the device could manufacture beams from aluminum sheet transported into orbit by the Space Shuttle. The test model, weighing 22,000 pounds, will be used by NASA and Grumman to prove the concepts of building large structures in space.

The machine measures 14 by 8 feet and uses 0.016-inch-thick aluminum sheet producing final beams which mass 0.85 pounds per lineal foot. Three rolls of aluminum foil sheet can be loaded into the automated device, allowing the manufacture of beams one meter on a side and over 300 meters long. By reloading the roll "magazines", beams of any length could be formed.

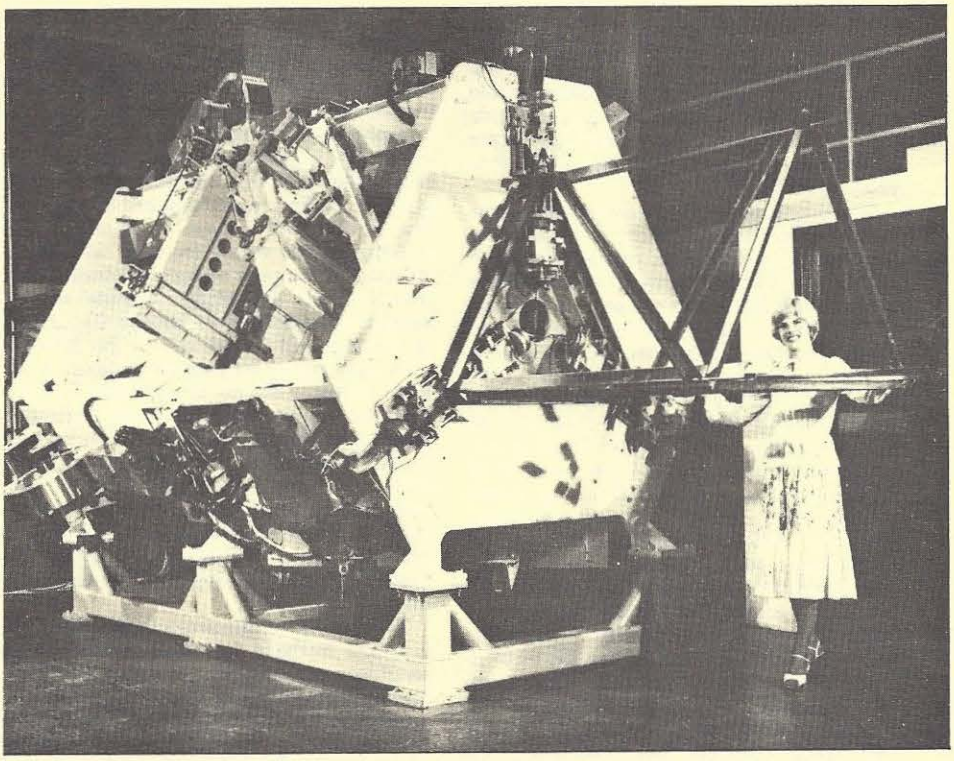
In tests recently, the machine fabricated a 40 foot beam of aluminum at the Grumman facilities on Long Island. Another version of the device will be used with composite materials like graphite-epoxy fibers which have application in large space structures because of their low weight, high strength and extremely high stiffness.

The Grumman beam-builder will be lightened by some six thousand pounds before it is tested in the cargo bay of the Shuttle Orbiter sometime in the 1980's.

In other news about large space structures, Dr. Martin Mikulas, on leave from NASA's Langley Research Center in Virginia, and Professor Charles Babcock, Jr. of the California Institute of Technology, report that they are testing several design concepts for structure which must be erected to large dimensions in space but still packed in the cargo hold of the Shuttle.

Many methods of assembling space frameworks are being analyzed by NASA. These systems include nesting columns and expandable truss frames which pop open to form rigid structural members. An example of one of the structures which Mikulas and Babcock are developing is a module which looks like a double pancake when folded in its storage configuration. Conceived with the help of Dr. John Hedgepeth of Astro Research in Santa Barbara, the module opens forming two parallel surfaces with rigid triangular trusses holding the surfaces apart, but in alignment. By assembling these modules on the ground with all wiring and electrical components, it would be necessary only to launch them and simply attach them one to another in space to develop a large structure. This simplifies the development process, according to Mikulas.

Mikulas also makes the point that aerospace designers will have to reevaluate their traditional engineering philosophy in dealing with large space structures in the future. Since it will be impossible to construct full scale development prototypes of most large structure on the ground first, the process by which the structure is first designed is critical. A highly accurate and thorough procedure of design and analysis will be needed to assure that large space structures will perform as required. NASA reports that these questions will be considered in a ten year program of Shuttle Orbiter-based space construction which could begin in 1985. □



CONTRACT AWARDED FOR POWER PRODUCTION IN SPACE EXPERIMENT

NASA's Marshall Space Flight Center, Huntsville, Ala., has awarded a $2.7 million contract to Lockheed Missiles and Space Co., Sunnyvale, Calif., for development and delivery of a flight experiment solar array wing by May 1980, for a Shuttle orbital flight test in November 1980.

This will be a significant step toward producing large amounts of power in space.

The experiment will verify the structural and dynamic characteristics of the solar array wing, its electrical performance and the readiness of solar array technology for planetary and Earth orbit Shuttle payload applications.

The solar array wing, measuring 32 meters (105 feet) long and 4 m (13½ ft.) wide, will be folded and stored in the Shuttle's cargo bay during launch. Attached to the cargo bay, it will be extended to its full length and retracted several times during the test.

When fully extended and fully populated with solar cells, the array's 82 panels convert energy from the Sun to produce 12.5 kilowatts of power. For the experiment flight test, only three of the panels will be active.

Demonstration of the experimental solar array wing will pave the way for the use of this technology for power augmentation for Space Shuttle and Spacelab to extend mission duration and later for a solar electric propulsion stage.

NASA's Office of Aeronautics and Space Technology is directing the solar array program as part of a larger program which is developing solar electric propulsion for long term missions in the mid-1980s.

The solar array technology is important for Shuttle payload applications such as a space construction base, satellite power systems, and auxiliary power modules.

news notes...

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The challenge of space is not remote: it is real. Space industrial development will mean new products, new markets and new profits for American and International business. The business of space industrialization is already a billion dollar a year activity ... in the next decade some experts predict that it could grow to twenty times that amount or more. Planning for these new opportunities must begin now.

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WRITE OR CALL Foundation, Inc., 85 East Geranium Avenue, St. Paul, MN 55117 Telephone (612) 370-0990. Offered in **Atlanta,** Sept. 7; **Newport Beach, CA,** Sept. 13; **San Francisco,** Oct. 23; **Minneapolis,** Oct. 30.

EGYPT RESERVES FOUR SMALL SPACE SHUTTLE PAYLOADS

The Egyptian government has reserved four small self-contained payloads to be flown on the Space Shuttle in the 1980s. At a NASA Headquarters ceremony, July 13, 1978, Dr. Mohamed Shaker, Minister of the Embassy of Egypt in Washington, D.C., and Dr. Farouk El-Baz, Research Director for the Center for Earth and Planetary Studies, Smithsonian Institution, presented NASA officials with a down payment to reserve Shuttle space.

The payloads, commonly called "getaway specials," can weigh no more than 90 kilograms (200 pounds) and be no larger than .5 cubic meters (5 cubic feet). They are flown on the Shuttle on a space available basis for scientific research and development purposes.

The small payloads must require no additional Space Shuttle services such as electri-

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EARTHPORT PROGRESS...Santa Barbara...The Sabre Foundation is continuing to meet with a good response in their efforts to promote international cooperation in space through the establishment of a freeport launch site, according to Earthport Project Executive Director Mark Frazier. Specific developments include:

World Space Center. As a first step for the Earthport Project, an organization is taking shape to assist in the transfer of technology relating space applications to developing nations. A number of countries are now represented on the council of the World Space Center, including: Afghanistan, Argentina, Bolivia, Columbia, Finland, Ghana, Greece, Kuwait, Liberia, Morocco, Peru, Qatar, Sierra Leone, Tunisia and Venezuela. Among the members of the decision-making council are Teofilo M. Tabanera, founder of the Latin American Committee on Space Research; Professor J. Xanthakis, of the National Committee for Space Research in Greece; and M. Id Ozone, of the Institute for Scientific Research in Kuwait. The American representative on the council is Dr. Krafft Ehricke, former chief scientist at Rockwell International. In the coming year, members of the council will oversee preparations for an international training institute dealing with uses of remote sensing for developing nations. The Remote Sensing Institute (see article this issue) is planned to open in June 1979 in cooperation with the University of California at Santa Barbara. Under the direction of Dr. Siamak Khorram, an Iranian remote sensing specialist now at the Space Sciences Laboratory at Berkeley, the Institute will offer introductory and advanced training.

Sites for a Freeport. Since June, meetings have taken place between representatives of the Earthport Project and the governments of Indonesia and Liberia, with excellent results, reports Frazier. The ambassador of Liberia to the United States, Mr. Francis A. Dennis, reiterated the willingness of his country to designate an area as a space freeport. A site near Robertsport was discussed, and participants in the meeting agreed to wait for a formal invitation from the Liberian government to visit the area. Another meeting with the head of the Indonesian space agency ended on a similar note. Air Vice Marshall J. Salatun said he has a team of researchers investigating the suitability of a site on the island of Sulawesi, which is crossed by the equator. An Earthport site visit team led by former astronaut Philip K. Chapman of Arthur D. Little, Inc. is expected to receive an invitation from the Indonesian government in the near future. Meanwhile, Kenya has become the tenth country to express an interest in being considered as a potential host country for Earthport. Other equatorial nations still under consideration include the Sudan, Sierra Leone, Panama and Rwanda.

Economic Impact of a Freeport. New computer projections prepared by an economist at the National Planning Association and a political scientist at Stanford University show that Earthport could have a dramatic effect on the economy of the host country. Exempting commercial activities at the site from taxes and tariffs for an

NEWS NOTES continued from preceding page...

extended period will apparently create thousands of jobs and generate hundreds of millions of dollars in export earnings based on the experience of existing freeports in developing nations.

RESEARCH MAGAZINE FAVORS POWERSAT EFFORT...Chicago... Industrial Research/Development magazine, a publication circulating to more than one hundred thousand subscribers, has editorially endorsed the idea of launching Solar Power Satellites to provide future electrical generating capacity for the country. According to Robert Jones, Editor of IR/D, "SUNSAT offers one of the best opportunities that has come our way in a long, long time. Steps should be started immediately to complete the planning for this project. Barring any now-unforseen difficulties, a firm commitment should be made now to build and begin operating a SUNSAT." Jones states that DOE backs the project along with NASA and the Sunsat Energy Council, an industry group. However, DOE has not yet committed to the idea and in some respects appears to be backing off from powersats in favor of coal and conservation (see Report, August, 1978). IR/D magazine was originally started as Industrial Research by space spokesman Neil Ruzic, who later was instrumental in the startup of the National Space Institute.

NOSS AIDS DEA DRUG BUSTS...Washington...In the first use of satellites for law enforcement, the Drug Enforcement Administration has employed the US Navy Ocean Surveillance Satellite (NOSS) to track ships at sea carrying marijuana from Columbia to the US. DEA claims 40 ships loaded with more than one million pounds of dope were captured. No other details concerning the operation are available, but the effort causes concern among space industry advocates. "We don't want to alienate the large number of US citizens who use marijuna and perceive this DEA action as being representative of the 'beneficial uses of space'", complained one spokesman for the industrialization effort.

TRW, NASA SPAR OVER TDRS ERROR...NASA and TRW Corporation are engaged in a 100 million dollar dispute over the Tracking and Data Relay Satellite. TRW is the prime contractor for the TDRS system which will be owned and operated by Western Union, and leased to NASA for ten years. The problem originated when it was learned that a large Soviet radar in Europe operates near the frequency range of the satellites, and will jam transmission to and from the spacecraft. Redesign of the TDRS will cost up to 100 million dollars, and NASA claims that the contractors should "eat the costs". WU and TRW charge that NASA supplied them with inaccurate data concerning the USSR's radar during the design stage.

SOVIETS TEST WINGLESS AIRPLANE...USSR...The Soviet journal Nedelya Aviatsii i Tekhnika Kosmonavitiki (NATK) reports that the USSR is testing an electroaerodynamic aircraft capable of Vertical Take Off and Landing (VTOL) flight. Using a pointed, charged nose to create a partly charged plasma, the aircraft nearly eliminates drag and employs atmospheric pressure on its tail to generate thrust. Application of the Soviet findings to spacecraft taking off or landing on earth is possible.

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cal power or deployment in space. Each payload reservation requires a $500 down payment.

To date, payments have been made to NASA for some 240 small payloads. Purchasers include private individuals, commercial firms and foreign countries.

The Egyptian purchase marks the first foreign educational use of the payloads program. Egyptian students will compete in a nationwide contest by submitting proposals for an experiment to be flown aboard Space Shuttle missions. Evaluation of the proposals will be under the direction of Dr. El-Baz, who also serves as an advisor on scientific matters to Egyptian President Anwar Sadat. □

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) 489-4466. Editorial Direction: Gary C. Hudson; Special Assistance: Resident Fellows E. Anne Roebke and T.A. Brosz; Staff Artist: David Egge. The **Foundation 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) 489-4466. No collect calls please.

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