

FOUNDATION REPORT:

ADVANCES IN COMMERCIAL AND GENERAL SPACE DEVELOPMENTS

NATIONAL ACADEMY OF SCIENCES ATTACK NASA SPACE PROCESSING EFFORT

Committee Claims No Major Benefits from Materials Processing in Space

An *ad hoc* committee formed by the Space Applications Board of the National Academy of Science's National Research Council has released a report critical of the National Aeronautics and Space Administration's Materials Processing in Space program. The Committee on Scientific and Technological Aspects of Materials Processing in Space (STAMPS) stated that it had "... not discovered any examples of economically justifiable processes for producing materials in space and recommends that this area of materials technology not be emphasized in NASA's program."

While such a statement is clearly in error, the Committee, comprised of primarily aca-

demie scientists unfamiliar with industrial criteria for technologically oriented products, seems to be calling for more science and less applications effort in NASA's program. Throughout the 76 page report the Committee stresses the poor science which has been allegedly performed by NASA in the past, and urges that these preliminary experimental results not be considered sufficient proof that commercial applications may ultimately ensue.

Besides a shifting of emphasis from applications to science, the members of the Committee call for both peer review of experiments which may be flown in the future and a general lowering of expectations

concerning the possible findings. One significant statement from the STAMPS report claims that there may be useful findings from space experiments "... provided that the problems proposed for investigation in space have from the outset a sound base in terrestrial science or technology and that the proposed experiments address scientific or technical problems and are not motivated primarily to take advantage of flight opportunities or capabilities of space facilities." If such a policy was followed by scientists and engineers in terrestrial laboratories, the results would of course, be catastrophic. The Committee seems unwilling to allow space processing experiments on-board the Space Shuttle without careful analysis of the planned experiment to ensure that potential applications benefits are controlled or eliminated. STAMPS members argue that no experiments should be flown in space on-board Shuttle during the first five years of operation unless they are subjected to peer review. Adoption of such a policy by NASA would effectively close the door to early industrial participation in the Materials Processing in Space program.

Industry and academic scientists interviewed by the Report are in agreement that the STAMPS Committee findings are but a new round in a long standing feud between the applications oriented NASA and the scientific community. It is no secret that members of the STAMPS group have been at odds with NASA on the breakdown of government funds going to support scientific investigation of materials phenomena in space vs. applying the knowledge we already have to manufacture new or improved products. NASA will be looking hopefully to the findings of a new National Research Council study group which will be named the Commercial Aspects of Materials Processing in Space (CAMPS) Committee. CAMPS will produce a report concerning space processing and the industrial perspective sometime next year. But until then, the negative impacts from the biased STAMPS Report will be a political football in Washington. □

TRW GETS CONTRACT FOR MATERIALS PROCESSING IN SPACE

TRW Defense and Space Systems Group, Redondo Beach, Calif., has been selected by NASA for negotiations leading to the award of a contract for the Materials Processing in Space-Spacelab program. The contractor's estimated cost is approximately \$9.7 million.

TRW will serve as prime contractor for the various aspects of the Materials Processing in Space (MPS) program which will utilize Spacelab and related facilities. This contract will be for the initial phase of the MPS-Spacelab payloads project and is expected to begin in September 1978 and continue through 1981.

This contract is to develop and support the operation of specialized and general purpose payload systems that will accommodate a variety of different materials processing experiments during a series of recurring Earth orbit missions of the Space Shuttle. The first series of experiments to be performed were selected from proposals

sent to NASA by scientists from throughout the United States and numerous foreign countries.

Objectives of NASA's MPS program in which these and other related experiments will be performed are to study new or improved processes and to identify candidate products of initial commercial interest. Areas of immediate interest include electronic materials, metals, glasses and certain chemicals produced by processes such as crystal growth, solidification and containerless processing.

The MPS program is under the direction of NASA's Office of Space and Terrestrial Applications in Washington, D.C. The Marshall Space Flight Center, Huntsville, Ala., has project management responsibility for the operational aspects.

Proposals were also submitted by General Electric Co., Valley Forge, Pa. and McDonnell Douglas, St. Louis, Mo. □

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DETAILS IN
NEWS NOTES

SUPPORT BUILDS FOR SPACE SOLAR POWER

Funding Bill for Additional Study Goes to Senate

The "Sunsat" or "Powersat" concept, involving the orbiting of multithousand ton solar power satellites to supply baseload electricity for the United States in the next fifteen years, has cleared a major hurdle for proponents. The U.S. House of Representatives has approved a \$25 million funding plan which would investigate the solar power option in much greater detail than is now possible.

The measure, introduced by Rep. Ronnie Flippo (D-Alabama), recently passed the House by a wide margin. Rep. Flippo's district includes the Marshall Space Flight Center of the National Aeronautics and Space Administration. The additional funds, however, will be spent by the Department of Energy, not NASA. The primary role for NASA would be to develop the advanced heavy lift launch vehicles necessary to orbit the thousands of tons of building materials necessary to build each 10,000 Megawatt powerplant.

The driving force behind the attempt to build the mammoth satellites is the newly organized Sunsat Energy Council, a non-profit organization headquartered in Washington, D.C. and headed up by the originator of the concept, Arthur D. Little, Inc. vice-president Dr. Peter Glaser. The Council has backed the Flippo effort since there seems to be little interest in the idea among Administration officials, who are no doubt wary of any efforts to promote new energy sources at the expense of conservation. Mr. Frank Press, Science Advisor to the President, has remarked that he sees solar power from satellites as not being an option until the "middle of the Twenty-first Century".

Senate action on the bill is pending, though it is expected that it will be taken up sometime during the month of August.

During hearings before the House Science and Technology Committee last month, Klaus Heiss, President of the Princeton-

based ECON, Inc., an economic consulting firm, estimated that it would cost \$15 to orbit the first satellite and that a planned array of 50 powersats would cost \$500 billion. The Sunsat Energy Council believes that the satellites will cost about \$1700 per installed kilowatt-electric, which is less than the NASA Johnson/Marshall Space Flight Centers estimate of \$2000-\$4000. NASA has calculated that the cost of the first unit of powersat would be \$50-\$60 billion.

The Boeing Company, one of the institutional members of the Sunsat Energy Council, completed a \$1 million study of the concept last fall in which they estimate that each satellite would yield \$76.8 billion in revenues over its 30-year lifetime. A network of satellites could bring in revenues of \$3.5 trillion in 30 years, making the U.S. a net exporter of energy and improving the balance of payments.

In response to such studies and increased Congressional pressure, NASA has established a Solar Power Satellite (SPS) office under the leadership of Frederick Koomanoff. While it is clear the agency would prefer to leave the matter in DOE hands, this increased Congressional interest is getting unusual attention from Administration and NASA staffers. In testimony before the House committee, both Undersecretary for Energy Dale Myers and NASA Deputy Administrator Alan Lovelace cautioned that the powersat concept requires intensive study. At the same time, the Administration has opposed additional investigative study funds. □

LOW COST TRANSPORTATION IS THE KEY TO SPACE

Pioneering Work Done During Last Decade Now Being Duplicated by Aerospace and Government Studies

by Tom Brosz

In the area of advanced space vehicles, Foundation, Inc. has contributed to design efforts which have pointed the way to very low cost space transportation. These conceptual designs were developed with primarily state-of-the-art technology in order to show that low-cost systems need not require the development of new technologies. Starting in 1972, Foundation initiated a research project which led to a series of different vehicles, each targeted towards a specific use and payload range. The series fit together in an attempt to cover all foreseeable market opportunities and requirements for the next two decades. All of the designs reflected the philosophy that space-flight need not be prohibitively expensive; some designs were improvements on existing concepts, others were wholly original.

From the beginning of the study, reusability was a key factor. The ideal vehicle

was one which could be refueled, refurbished and ready to fly again in a period of time similar to that of commercial airliners. These designs, using chemical rather than nuclear fuels (in line with the state-of-the-art limitations), were to be single state systems whenever possible. This would prevent the difficulties associated with "throw-away" hardware and complicated staging procedures.

From the first, Foundation study team members were impressed with the concepts of Philip Bono, a McDonnell-Douglas engineer who advanced single-stage shuttle vehicle concepts in the early and middle sixties. Bono's designs employed a plug-nozzle engine known as the "aerospike". This engine consisted of a series of combustion chambers or small rocket motors arranged around the rim of a truncated (blunt) cone structure, rather than the familiar

bell-nozzle rocket engine shape. In fact, the aerospike has often been referred to as an "inside-out" bell nozzle.

The unique patented plug-nozzle concept allows the blunt base of the engine to be used as a heat shield during atmospheric reentry, eliminating the need to retract cumbersome bell-nozzles and allowing the booster designer the advantage of tail-first entry. In a typical, non-reusable rocket, the largest masses are the payload and the engines, following depletion of the fuel. These are typically at opposite ends of the vehicle. During an attempted reentry in such a configuration, the booster would tumble and exhibit other signs of instability. This makes shielding against the high temperatures of reentry difficult and expensive, besides causing complex control problems.

In a space capsule, like Apollo, without large, bulky fuel tanks to consider, the weight is concentrated toward the blunt end of the heat shield, causing the capsule to fall blunt end forward. Foundation attempted to simulate this condition in a launch vehicle with large self-contained fuel tanks. The design used liquid hydrogen and liquid oxygen propellants, the only combination available which would permit a single-stage vehicle to attain earth orbit. Liquid hydrogen is much less dense than most liquids, and nearly twenty times less dense than liquid oxygen. The Foundation team designed a vehicle with the hydrogen tank forward near the nose, above rather than below the payload compartment. The liquid oxygen tank, heavier but much smaller, went below the payload bay, nested above the aerospike engine. This arrange-

ment moved the center of gravity of the vehicle system towards the rest of the booster throughout the entire flight regime, making for stable reentries.

The first vehicle using this concept was the "OSIRIS". Designed to be man-rated, it would have weighed 640,000 pounds at liftoff and could have transferred 8,500 to 15,000 pounds to low earth orbits. Almost all of the technology was off-the-shelf, leading to costs of less than \$50/pound to orbit payloads.

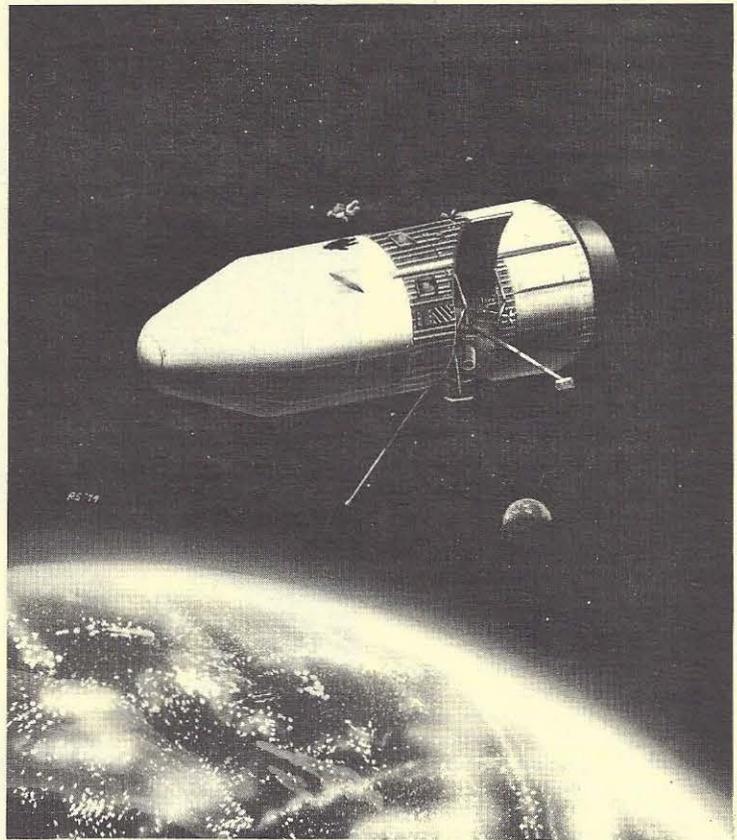
While highly useful for much of the work done by present smaller rocket boosters, the OSIRIS system could not match the large payloads which vehicles like the Space Shuttle could launch. Foundation decided to expand the OSIRIS concept and create a system to fill this niche and still keep costs low. Again, a VTOVL (Vertical Take Off and Vertical Landing) system was decided on. When using a vertical takeoff, wings are generally useless, and add weight that a single stage vehicle can not afford to carry. For freighter launch vehicles it is not necessary to use wings to moderate the effects of reentry deceleration forces.

The new vehicle was called "SEA DRAGON", and used the OSIRIS aerospike and fuel tank arrangement, with the exception that the oxygen tank was placed alongside the payload bay rather than below it. The booster would weigh more than 8,000,000 pounds at liftoff and carry more than 200,000 pounds into earth orbit. Costs per pound of delivered payload could go as low as \$5-\$8.

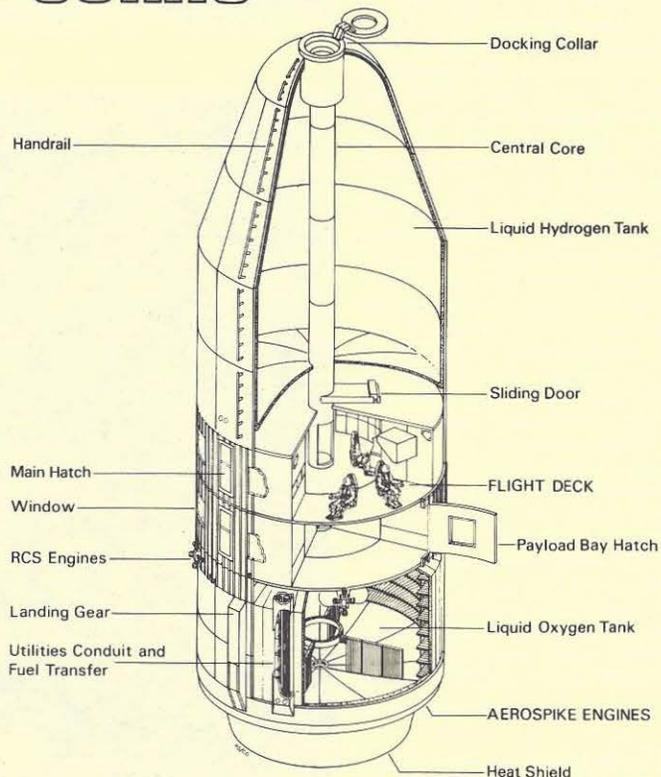
The rectangular cross-section of the payload bay was specifically designed to accept a pair of payload modules aimed at providing a nearly universal space habitat structure. Named the EYRIE module, it would have enclosed nearly 80,000 cubic feet of space. The nearly square shape was a compromise between the highly efficient cylindrical pressure containers which a weight-limited space program must use and the cubical shape of a container designed for human occupancy. The module could be used as living quarters, a space factory, a laboratory or any other function that would fit within the enclosed volume. Because a definite "up-down" orientation is useful for human beings even in a zero-gravity situation, regular floors and ceilings were added. The module could be configured to be part of a rotating space station, or could be used on the surface of a planet.

Use of the SEA DRAGON and EYRIE modules would open the space frontier to widespread commercial development. Ideally, space factories and other manned and unmanned facilities would proliferate. This would open a market for a vehicle which could transfer payloads from many sites on earth to orbit without the ground facilities which would be necessary for the OSIRIS and SEA DRAGON vehicles. A close

(Box, Above) A Rick Sternbach painting of the Osiris launch vehicle on an earth resources mission. Note the scale of the painting by locating the astronaut performing extravehicular activity. (Box, opposite) A cutaway of the Osiris vehicle, drawn by Sternbach and Charles Duelfer. The design has a unique placement of the low-weight hydrogen tank above the crew compartment. The payload bay is pressurized and located immediately below the flight deck. All illustrations in this article copyright Foundation, 1978.



OSIRIS



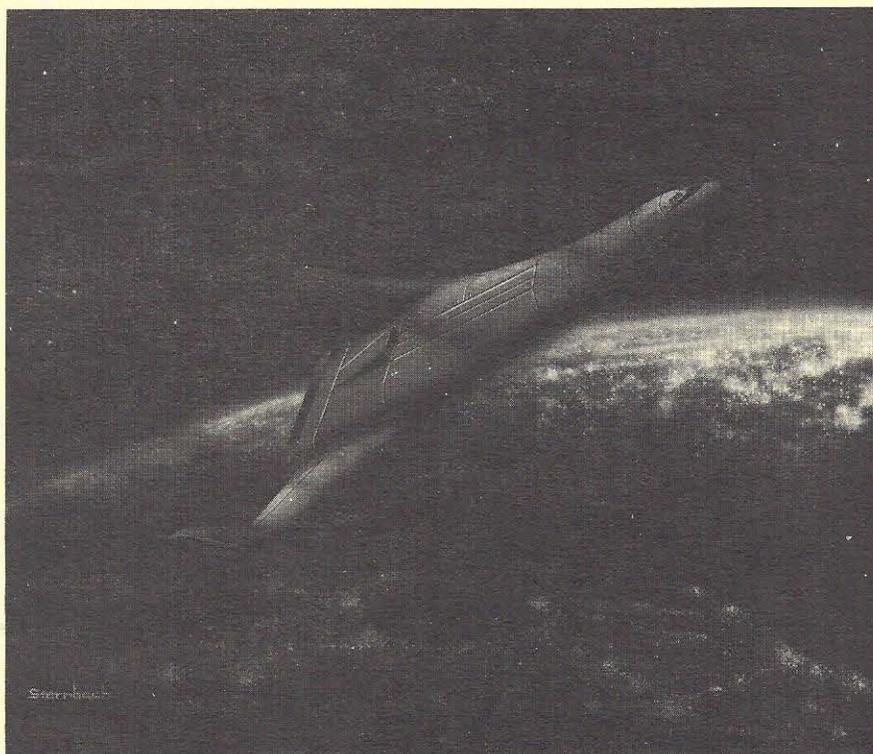
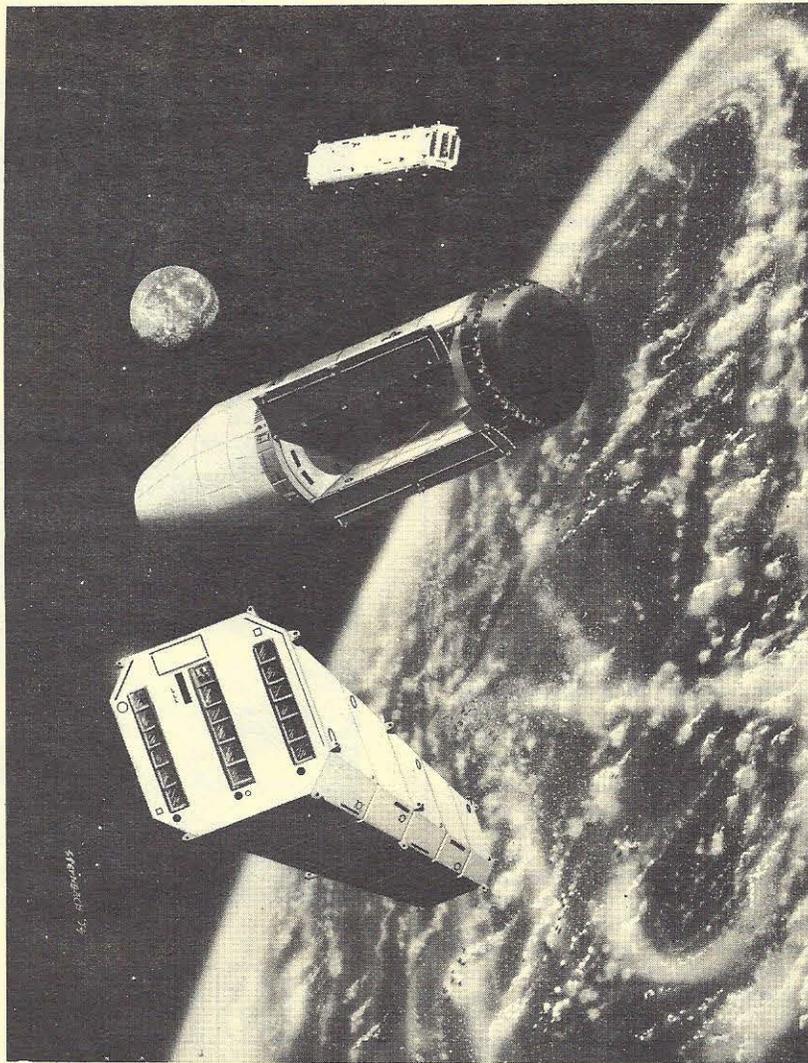
examination revealed that a vehicle which could deliver payload to and from customers and factories, for example, would be highly successful. The capabilities of winged vehicles now became more important. Unwilling to launch a large space booster from a fixed launch pad, Foundation designers researched the concept of a horizontally launched aerospaceplane. Using wings for lift during the first portion of the flight would reduce the noise associated with the launch as well as permitting the use of smaller rocket motors. The lesson learned was that a winged spacecraft which used its wings during both the flight into space as well as the flight back from orbit was the ideal commercial chemical launch vehicle.

Such a spaceplane has been designed in 1967 by Len Cormier, a Rocketdyne employee who formed his own company, Transpace Corp., to promote the concept. The aerospaceplane, more than 200 feet long and weighing more than 2,000,000 pounds, was called WINDJAMMER. The combination spacecraft/aircraft was a delta winged vehicle with propellant stored in the aircraft body as well as in the wings. It would have been mounted upon a launch sled with high-speed tires and equipped with a separate rocket motor. (The landing gear of the plane would have been unable to support the fully fueled weight of the total system.) During the launch, the combination of lift and rocket thrust would carry the vehicle into orbit. The WINDJAMMER was designed to return to earth like the Space Shuttle . . . using an unpowered glide to bring it safely home. By equipping the vehicle with advanced airbreathing jet engines which could burn the residual hydrogen gas left after the main propulsion system has shut down, the aircraft could fly between ordinary airports and a special launch site.

Foundation modified the design to include the aerospike engine and an advanced air cushion sled concept as well. Even though the aerospaceplane must be flown from special launch sites, it can still operate out of regular airports much like a jumbo jet. This enormous flexibility if paid for by incorporating new technologies into the system, however, what was advanced technology at the time of the study has now become, six years later, conventional. Far more exotic single-stage winged boosters are now being proposed regularly by NASA and its contractors (see Report, July, 1978).

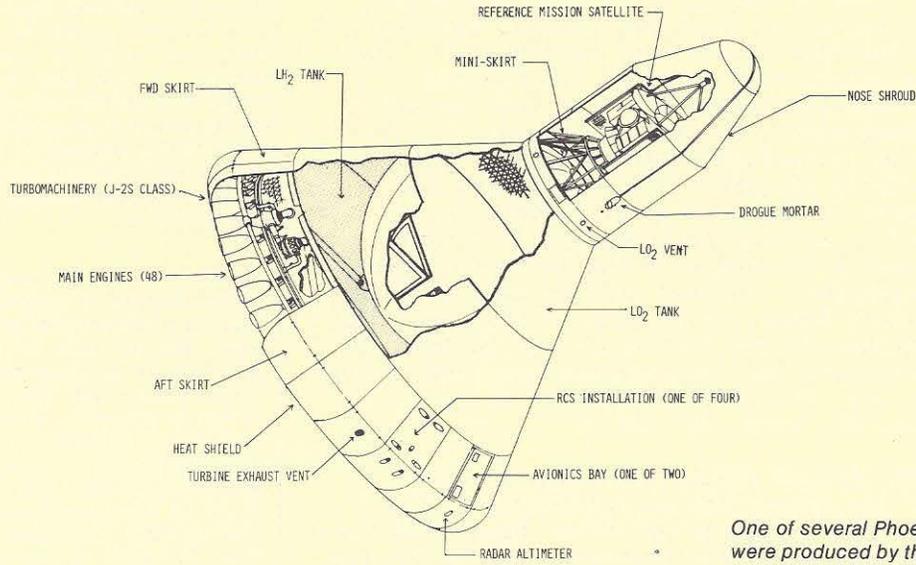
By the end of the study, Foundation had demonstrated that a whole family of low-cost transport vehicles could be built using conventional technology. One market remained unfilled however, and a small low-cost unmanned vehicle was designed to serve it. The system, known as ATV/PHOENIX, was meant to orbit payloads about the size of the present NASA 200 pound "Get-away Specials" (more than 200 have been sold thus far). Designers at Foundation maintain that this vehicle could be developed for less than half the cost of a single Space Shuttle flight, and would orbit payloads for about \$50/pound. Two major aerospace companies, when approached with joint venture plans for the vehicle develop-

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(Above) "First Components" a painting by Rick Sternbach showing the beginning of assembly of a space factory. (Opposite) Reentry of Windjammer over San Francisco.

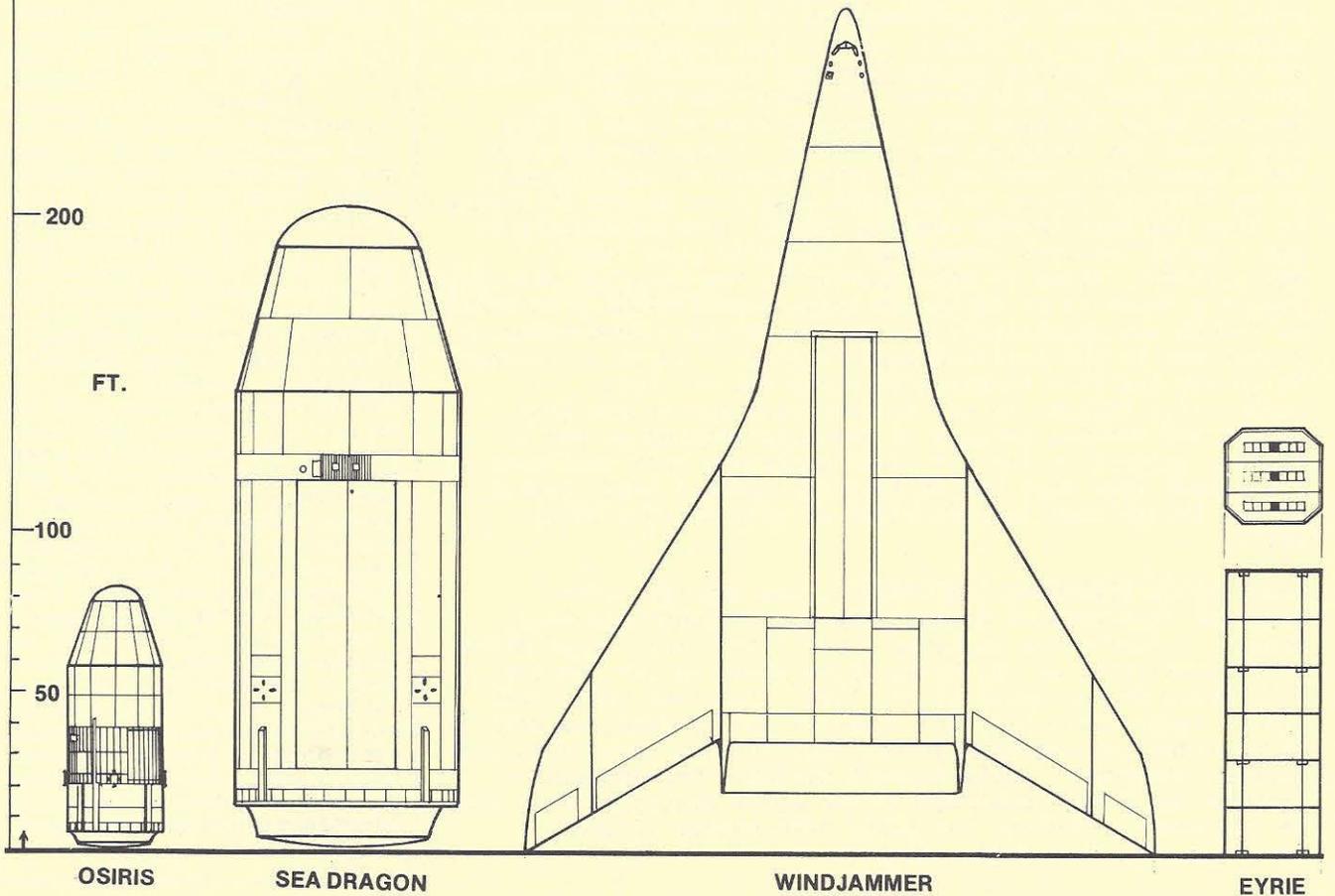
PHOENIX L'



One of several Phoenix vehicle designs which were produced by the Foundation design team in 1974 to 1976. This particular vehicle, called the Phoenix L', would have orbited 2000 pounds.

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THE FAMILY OF FOUNDATION MANNED SINGLE-STAGE LAUNCH VEHICLES



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VEHICLES

ment, refused to participate on the grounds that there was no market for small payloads.

With the project done and having published the results, the Foundation team turned to a different task. The challenge: could a launch system be made which is inexpensive enough for a group of private investors to fund that would use even simpler off-the-shelf technology? The team saw the answer given partially by the efforts of the OTRAG company in West Germany. Some of the additional information uncovered by the Foundation study will be covered in a later article. □

FOUNDATION TO HOLD SHORT COURSE...St. Paul...Foundation, Inc. will sponsor a series of four short course seminars this fall titled: "The Third Industrial Revolution". The intensive one-day meetings will focus on the business aspects of space industrialization for technical marketing and management professionals, as well as engineers and research personnel in technology oriented firms. The programs dual goal is to enlighten decision makers and executives with regard to the commercial opportunities present in space and to provide technologically-oriented attendees with a working knowledge of the business aspects of space industrialization. Courses will be held in Atlanta on September 7, Newport Beach, California on September 13, San Francisco on October 23 and Minneapolis on October 30. For a copy of the brochure and the registration form, please contact Foundation, Inc. at (612) 370-0990 or write to 85 East Geranium Avenue, St. Paul, MN 55117.

SPACE SHUTTLE COURSE OFFERED AGAIN...Los Angeles...The Extension Office of the University of California at Los Angeles (UCLA) will offer a course entitled: Space Shuttle - Shuttle Payloads for the fifth straight year on October 16-20, 1978 at UCLA. The course will focus on the Shuttle Orbiter, Payload Interfaces, Upper Stages, SpaceLab and other aspects of operating in the Shuttle era. A tour of the full-size Orbiter Mockup will highlight the first day. The course fee is \$500. For more information please contact Hap Hazard, Navy Spaceflight Coordinator, Navy Space Systems Activity, SAMSO, Los Angeles, California (213) 643-1648.

OTRAG UPDATE...Santa Barbara...Reason magazine reports that the recent invasion of Zaire's Shaba province, site of the OTRAG launch site, was masterminded by East German military advisors, and not by Cubans, as has been suggested in the world press. Quoting London Observer reporter Colin Legum, they note that an East German military team headed by General Heinz Hoffmann was in Angola from May 8th to the 12th, when the invasion was launched. Legum states: "The East German involvement in the anti-Mobutu struggle appears to be directly linked to the role they have played in trying to stop the West German company, OTRAG, from developing a new type of low-cost long-range rocket to lift 'spy' satellites." Since it was reported by the Observer that the People's Republic of China has begun negotiations with OTRAG to launch spy satellites, the motive for East German/Soviet assistance to the invasion appears clear. Legum concludes: "Although the FNLC invasion of Shaba has at least temporarily failed, it may in fact have served the East German and Russian purpose of possibly putting an end to OTRAG's project in Zaire." OTRAG spokesmen have confirmed to Foundation that they are in fact considering other launch sites, though they have no plans at this time to leave Zaire.

LARGE SPACE PLATFORMS CONFERENCE...Los Angeles...The American Institute of Aeronautics and Astronautics will sponsor a Conference on Large Space Platforms: Future Needs and Capabilities, at the Hyatt House Hotel in Los Angeles, California on September 27-29, 1978. Sessions will cover future large space platform missions and systems, as well as specialized laboratory modules, construction techniques and support equipment. Life support systems, transportation systems and power requirements for space platforms will also be discussed. Contact the AIAA, 1290 Avenue of the Americas, New York City, 10019.

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The Foundation 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. The 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 Foundation 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.