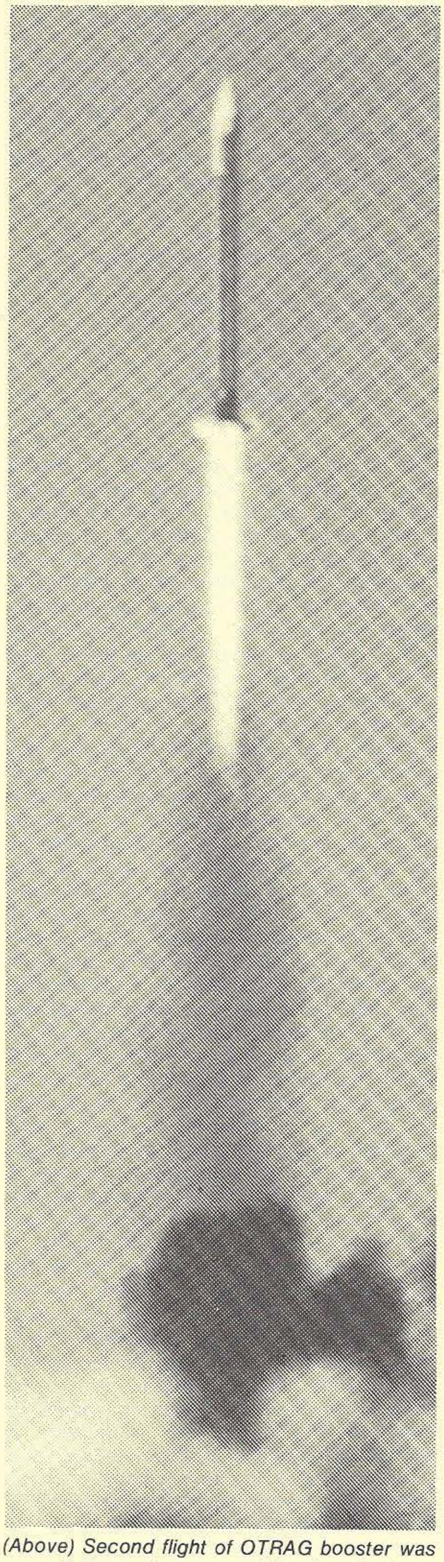
FOUNDATION REPORT:

ADVANCES IN COMMERCIAL AND GENERAL SPACE DEVELOPMENTS



(Above) Second flight of OTRAG booster was essentially a carbon-copy of first launch shown here, conducted one year ago.

OTRAG: SECOND AND THIRD FLIGHTS

Step Toward Orbital Launch Next Year

On May 20, in the midst of heavy fighting in Shaba province, Zaire, the West German firm Orbital Transport and Rockets, A.G. launched a second test vehicle to an altitude of 30 kilometers. A third launch a week later, reported to be a test of the staging principle of the OTRAG design, is believed to have failed to meet its test objectives according to an analysis of preliminary flight information. The extent of the problems with the third flight is not yet known.

According to company president Lutz Kayser, who returned to Germany on May 31, the second launch was a repeat of the four-engine single-stage configuration which had been tested just over one year ago in Zaire. Full propellant tanks on the second flight contributed to the higher altitude reached by the rocket, as compared to the 12 kilometers attained at the initial test. Kayser also revealed that the third launch was to be a 16 engine, two-stage rocket, and that OTRAG plans to launch a small orbital spacecraft sometime next year.

While the first test flight employed a makeshift wooden gantry and launch platform, the recent tests now use a metal tower designed to stabilize the vehicle during the first seconds of flight. OTRAG has not yet tested the orbital guidance system planned for their OTRAG-200 vehicle which will orbit a 440 pound payload next year.

The stated goal of the OTRAG company is to develop cheap launch vehicles for satellite payloads, especially those of developing nations. Kayser, designer of the vehicle systems, rejects the use of advanced technology in the booster wherever possible, preferring instead to use steel propellant tanks, automotive wind-shield wiper motors for propellant control, and inexpensive nitric acid and diesel fuel as propellants. The largest OTRAG configuration, known as the OTRAG-10000, will contain 600 engines, each of three tons thrust, and will weigh 1000 tons at liftoff. A payload of 22,000 pounds may be placed into low earth orbits, and more than two tons can be placed on station at geosynchronous altitudes.

The quoted costs for such a launch have not changed inlight of the second and third flights: $15 million for the largest booster. OTRAG has stated that the actual cost of the flight will be $5 million.

In related news, the *Wall Street Journal* reported on June 23 that OTRAG (which they described as the controversial builder of inexpensive missiles) has been allowed by the French government to set up a branch office in Paris. The office will be a sales

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SCIENCE APPLICATIONS STUDY HIGHLIGHTS INDUSTRY CONCERNS

Space Industrialization (SI) is the medium by which services, energy and products are returned from space to Earth to provide economic and other benefits to mankind. Although the Science Applications, Inc. (SAI) study focuses on the United States as the mechanism for benefit generation and transfer (with an appropriate payback to its industry and citizenry for investing resources and labor), it is the world that benefits. Indeed, the underdeveloped and developing countries are now, and will continue to be, prime beneficiaries from Space Industrialization. It is possible to construct credible commercial scenarios which step these nations into the twentieth century equivalent of the U.S. in less than 100 years, without significant local or global economic or environmental damage. The great power for what is considered "good" in the western world (health, safety, knowledge, creative growth, etc.) afforded by Space Industrialization has been comprehended by a very few, but there is evidence that realization is spreading. (See *Report*, June, 1978).

The SAI study concentrated on the U.S. and what we may gain from the investing of our resources, both public and private, in SI. The future was examined to characterize resource pressures, requirements and sup-

continued

ply (population, energy, materials, food); also, the backdrop of probable events, attitudes and trends against which SI will evolve were postulated. The opportunities for space industry that would bring benefits to Earth were compiled and screened against terrestrial alternatives. Most survived, and a population of the survivors were examined to determine if SI would ever be "worth the investment". A cursory market survey was conducted for the selected services and products provided by these initiatives and the results were astounding. Space Industrialization is a billion dollar a year business now; in thirty years it could grow by 100 times that amount or more. Additional factors were examined by the SAI study team, leading to the following observations:

(1) Foreign competition is becoming very strong in SI. It is no longer "our" domain and these pressures will increase. This may limit or spur U.S. increased involvement.

(2) The developing and underdeveloped nations of the world may consider the U.S. and SI a threat or a powerful tool for progress depending on how we promote it.

(3) Prospects for economic return to the government are excellent, so long term investments should be justifiable. A few billion of dollars invested in the eighties will result in hundreds of billions in tax revenues, millions of jobs created, strong economic growth and good balance of trade impacts in twenty years or less.

(4) Although some U.S. industry will resist SI, a strong support base can be built among U.S. private enterprise.

(5) In both domestic and international law there are no legal entanglements which will seriously inhibit SI development, if we develop "proper policies" and "stick to them".

(6) Although many social and political institutions will be affected by SI, the most significant are those institutions governing industry and government relations and those relating the U.S. to the rest of the world. Nothing precludes mutually beneficial arrangements in both of these arenas. Historically, such arrangements have taken several years to evolve.

(7) The most important SI initiatives would appear to have rather high initial investments, and payback periods longer than normal for private investment. A mechanism for reducing initial risk and shortening these payback times is possible and will attract substantial industry support upon initiation.

Industry Comments and Recommendations

To achieve commercial perspectives on SI, industry representatives involved in private enterprise in the three major categories (Information Services, Energy and Products) were contacted by SAI. One purpose was to obtain information on how government and industry could cooperate and complement in order to make space industrialization grow.

Each individual contacted was given both written and personal briefings on what SI consists of and what the study was about. Discussions were typically tailored to the specific industry of interest.

There is no general lack of faith in the future of space industrialization in any area, only a perception that the economic risks of involvement are very high relative to normal market risks except in the more mature communications industries. As the risks come down with new knowledge, demonstration programs, government initiatives, and so forth, it is anticipated that the level of industry involvement will increase substantially.

At present, however, a corporate leader/manager cannot justify a major investment in products (at the basic research stage and having much too high transport costs) or energy (overwhelming techno-economic risk). The more expensive communications systems (such as the Orbital Antenna Farm of Morgan and Edelson, COMSAT) are being looked at rather seriously, although there are large total capital and payback times on these systems. One simple message is certain. As techno-economic risks come down, U.S. industry will steadily increase its allocation of resources to SI if a reasonable payback can be obtained. "Reasonable payback" will vary broadly based on initial investment, near term vs. long term risk, and guarantees.

OVERALL INDUSTRY PERSPECTIVE ON SPACE INDUSTRIALIZATION

PERCEPTIONS

- Work to date is too shallow to provide data base for industry decision on interest.
  - -Products poorly defined.
  - -Markets too indefinite.
  - -Terrestrial alternatives appear cheaper.
  - -Experimental data too soft.
  - -Theoretical basis unsubstantiated.
- Risks are too large relative to capital outlay required.
- Return on investment too far down stream.
- Transportation cost too high by factor of 100 or more in most cases.

BUT

- The prospects are "interesting".
- Would like to see more data.
- Will get more involved if the competition does.
- Would like to see relevance in NASA sponsored R&D for their products.
- Want channels of communication established on a broad, up to date basis.
- An appropriate risk reducing or risk sharing policy will spur interest and involvement from practically all segments of industry.

RECOMMENDATIONS

- Establish better communications with domestic industry by means of:
  - -Interface organization.
  - -SI newsletter with background and current information.
  - -Continual feedback from domestic industry.
- Establish means of sharing costs and risks of SI R&D.
- Reduce transportation costs.
- Make research relevant to potential products.

Industry Feedback—Space-Derived Products

A substantial amount of work on previous studies related to space products has been done. Of particular interest are those by GE, TRW and McDonnell-Douglas. In the SAI study a different approach was desired. Specifically, product manufacturers were sought who were non-aerospace and had little or no previous contact with space processing or manufacturing concepts. After providing them information on SI in general and space processing in particular, extensive follow-up discussions were held.

The data gathered by SAI presents one of the best overviews on how main-stream U.S. industry thinks, works and makes decisions.

These comments came from managers in the following companies:

- Arthur D. Little, Inc.
- Ball Brothers Research Corp.
- Shell Oil Company
- Talley Industries, Inc.
- U.S. Polymeric Corp.
- Arvin Industries, Inc.
- Olin Chemicals Corp.
- Union Carbide Corp.

In almost all cases, the feedback revealed that the domestic industrial world is not aware of the real import of the NASA Space Shuttle or of NASA activities in Space Industrialization. They view extraterrestrial materials, lunar mining, space habitation, and anything much beyond earth-orbital operations as being "far-out Buck Rogers stuff". Such visionary planning turns them off to the near-term realities of Space Industrialization when the total concept is not properly presented.

Nearly every contact stressed the fact that the work to date is too shallow to provide a data base for industrial decisions. Very few proposed products or services would survive the rigors of a typical corporate planning review; several contacts provided detailed descriptions of their own firm's reiterative review schemes. Specific comments included: (a) the proposed products are too poorly defined at this time, and therefore (b) the markets are too indefinite and cannot be rigorously evaluated; (c) some terrestrial alternatives appear to be cheaper in view of perceived space costs (d) the experimental data is too soft for industrial use, meaning that it is too theoretical and too fundamental to reveal solid products and permit applied researchers and engineers to get firm grips on production processes and costs; (e) many things that are taken for granted by space advocates and those involved in Space Industrialization at this time are viewed at highly theoretical and unsubstantiated; (f) the risks involved are very large relative to the capital outlay required, even to determine product or service feasibility; (g) the return-on investment times are far too long for consideration by executives who must report to Boards of Directors who are in turn responsible to stockholders, as most ROI times range from 5 to 10 years at the very most, the longer times being acceptable only to firms with very large gross sales; (h) space transportation costs are viewed as being too high, usually by a factor of ten and even as much as a factor of 100 in some cases.

SPECIFIC FEEDBACK AND RECOMMENDATIONS FROM INDUSTRY

The following data provide some specific comments, concerns and recommendations received by SAI from industrial contacts. Additional information was gathered from less formal contacts at technical and management conferences.

INDUSTRY FEEDBACK—COMMUNICATIONS

CONCERNS

- The scope of planned and projected geosynchronous satellite activity is not generally recognized.
- Possibility of beam interference by 1981 is real and significant.
- Intelsat alone is projected to grow by a factor of 17 to 20 times (channels) by 1993; over 100 times by year 2000.
- Certain communication satellite technologies are lagging in the U.S. due to a lack of stimulation. Examples:
  - -Large deployed solar arrays
  - -Momentum wheels
- Crowding (frequencies and GEO orbit) will lead to communications "rationing" in the 1980's unless:
  - -Integrated platforms are developed.
  - -Terrestrial technologies take over.
- Some organized coordination and stimulation is necessary if general technical leadership is to be regained by USA.

RECOMMENDATIONS

- Promote government agency (FCC, etc.) acts fostering space competition to ground capabilities.
- Promote cooperative international planning on the use of GEO-SYNC in the eighties.
- Do an orderly assessment of the status of U.S. technology.
  - -Analyze pieces currently being used.
  - -Project future most probable origins of hardware.
  - -Stimulate selected developments.
- Government should serve in R&D capacity only, with industry fulfilling the requirements of pilot and operational program.

INDUSTRY FEEDBACK—ENERGY

ATTRACTED TO SPS CONCEPT BY

- SPS is a potentially open ended kind of solution but with a potential for relative near term (1995+) implementation.
- The potential for low installed power cost after the R&D is complete ($2000/KW is general threshold) looks attractive.
- It has the potentially most acceptable environmental impact of baseload alternatives if the microwave issues are settled.
- It neatly separates generation (SPS) and distribution (rectenna + wiring, etc.) issues and systems.
- It avoids future issues concerning hydrocarbon resource (coal) allocations such as national defense, fertilizers, etc.

BARRIERS

- Public perception of microwave radiation "hazards".
- Supporters of terrestrial alternatives, particularly fusion.
- The level of cost risk is much too high today.
- The Carter Administration will tend to ignore and downplay such bold new initiatives as detracting from the need to conserve.

RECOMMENDATIONS

- Stop treating the SPS like a space program and start treating it like a power program. Sell generation to the power companies and electricity to the consumer. Don't make a big deal out of the fact that it's coming from space. That is incidental.
- Develop a plan designed to specifically demonstrate acceptable risk level for investors.
- Develop a businesslike approach and get the message into *Fortune, Forbes,* etc.
- Develop a working relationship with every state and every power company in the U.S.
- Address the long term military, economic and industrial impacts of depleting hydrocarbon resources.
- Learn to understand and assess job impacts.
- Put priority on biological and environmental research but don't get bogged down.
- Go for strong information system synergy.

Perhaps the two most significant comments are the first and last. The first is a direct admonition to sell the benefits, not the program. The power companies never sold electricity by showing smokestacks, generators, dams and power lines. SPS should be presented to power companies on the basis of generation and distribution benefits to them and sold to the public as an investment in clean, cheap electrical power.

The last point reflects the observation by these reviewers that the demands for power in space in the eighties and nineties will provide a strong forcing function for an SPS prototype size program. A technology and development program should thus be possible which maximizes benefit to both SPS and future information systems.

In spite of this somewhat negative viewpoint, SAI reports it was highly encouraging that all contacts admitted that the prospects for Space Industrialization looked "interesting". They all wanted to see more data. Nearly every one of them said that they believed their companies would get involved in Space Industrialization if their competitors did. It was pointed out that at least one of these firms is already involved in a product or service which could directly benefit from one of the Space Industrialization services studied by SAI: large scale data transfer and electronic teleconferencing. Therefore, some of the negative comments should be viewed as "protective". It is to be expected that domestic industry would like to appear to be very hard-nosed and conservative with respect to space industrialization while at the same time taking very hard and continual looks at it.

All contacts felt that an appropriate risk-reducing or risk-sharing policy on the part of the federal government would greatly spur interest and involvement from practically all segments of industry. This is to be expected, too, since it is to any firm's advantage if the government will underwrite, subsidize, or otherwise bear some of the R&D costs that would otherwise have to be amortized over the production run. There is also historic precedence in our own history for this sort of government-industry cooperation in the areas of high-risk and large capital outlay requirements.

. . . contacts said they would like to see more NASA-sponsored R&D that would be relevant to products and more NASA R&D that fell into the realm of applied research on products and services.

Most contacts said they would like to see more NASA-sponsored R&D that would be relevant to products and more NASA R&D that fell into the realm of applied research on products and services. Most of them are aware of the fact tht much work remains to be done in the basic theoretical side of space processing before applications can be identified, but they felt that far too much stress was being placed on pure or theoretical research in this area with little understanding of their own earth-bound problems that could possibly be solved through applications of space processing.

Finally, all individuals stated they would like to see better communications between NASA and themselves in their own language with an awareness of their own problems evident. They were not aware of current NASA activities in this area beyond the technology utilization efforts which, according to most, were somewhat exotic and unrelated to their needs.

The industrial contacts stressed the fact that it would be up to NASA, they felt, to establish these channels of communications because it is NASA that has a service and a product to sell to them. They have trouble understanding the NASA approach and language, and they are reluctant to take the time and expend the effort to learn the language of an organization whom they view as a supplier. Most of them are very market- and sales-oriented, and therefore extremely sophisticated in these areas; as a result, most of them view most of NASA efforts as being very amateurish.

Although some of the advanced planning publicized by NASA and being carried out by some academic groups that have become advocates may be useful in creating enthusiasm among the intelligensia and young people, domestic industry views this as too visionary and believes that it may actually be hurting their chances to sell Directors and stockholders on the advanced work requirements they might like to do in Space Industrialization. This is because there is considerable confusion today between Space Industrialization—the cold, hard nuts-and-bolts of profitable space operations—and space habitation, which appears to be Elysian and Utopian . . . and therefore unworthy of consideration for risk of capital.

Recommendations arising from a study of these feedbacks from industrial managers, financial planners, and production engineers include the following:

1. Establish better communications with domestic industry through an intermediary who can filter, translate, integrate, and smooth the flow of data in both directions without loss of confidentiality. Middle-men and interface groups are well-known and widely-respected within domestic industry; most mergers and acquisitions are carried out by interface groups, to say nothing of hiring executive personnel.

2. Establish a Space Industrialization newsletter that comes out regularly, is intended to be read by managers, executives, financial planners, and operating people in domestic industry. It should be written in language understandable to these people and contain information that may be useful to them.

3. Establish a means of sharing risks and costs of initial participation in Space Industrialization, particularly over the next ten year critical period of start-up in the field.

4. Reduce space transportation costs. One contact pointed out that he could never justify making things in orbit with a transportation cost of even $100 per pound when his current product that is satisfactory in the existing market costs only $1 per pound ready-to-ship.

5. Begin efforts to make space processing research relevant to existing product and process problems in industry; this can probably be done only by people who have an intimate inside knowledge of a particular industry, since many production, product, process, and service problems are known only to those in that industry or that one particular company.

A great deal of work remains before Space Industrialization enters the main stream of government and industry planning, and a proper public understanding is achieved. A solid information base, a dedicated advocacy group and very hard work are the essential ingredients to accomplishing these objectives. The rewards will be worth the effort, and attaining these goals will turn Space Industrialization into the mechanism for achieving the next plateau of human development. ☐

ROCKWELL PREVIEWS SECOND-GENERATION SHUTTLES

Studies conducted by Rockwell International and sponsored by NASA have recently examined the launch vehicle requirements for future space systems. The major requirement for these future launch systems was found to be high payloads delivered to orbit at low costs. The studies selected the proposed Solar Power Satellite as a target for launch vehicle configurations, since the large mass required to be boosted into orbit for such a satellite was seen as a major challenge.

At present, the proposed launch costs for a single space shuttle flight are about $350 per pound. Rockwell feels this should be reduced to $10 to $15 per pound as a long-term goal. To do this will require vehicles that will be able to carry much larger payloads than the Shuttle's 65,000 lbs., that will have few or no expended parts, and will utilize improved ground operations for maximum efficiency.

Initial designs make extended use of Shuttle technology and hardware. One of the approaches requiring the lowest additional development costs is to replace the Space Shuttle's outboard rocket boosters with fully reusable liquid fuel boosters. At present, the solid boosters are dropped into the ocean. They are designed to be recovered and reused a certain number of times, but there is still some doubt about the feasibility of this approach. The reusable liquid-fuel booster would burn liquid hydrogen and liquid oxygen, and use the Space Shuttle Main Engines (SSME) already developed for the Orbiter of the shuttle system. When the boosters burn out and drop off of the Shuttle, clamshell-type doors will close over the engines to protect them from heat during re-entry. Parachutes and landing rockets would assist the booster's soft landing in the water. The initial designs for this system would increase Shuttle efficiency by replacing solid-fuel rockets with more efficient liquid-fuel rockets. So, in addition to long-term reduced costs per flight from multiple uses of the booster, the Shuttle will have its payload increased to 100,000 lbs. on a due east launch.

The next possible step is to convert the Shuttle Orbiter for heavy-lift use. In this concept, the propulsion system at the rear of the Orbiter is converted into a self-contained engine capsule. In other words, the winged fuselage forward of the engines is deleted and replaced with a blunt heat shield. This engine capsule is recovered for reuse by entering the atmosphere ballistically, like an Apollo capsule, rather than gliding down like the winged Orbiter. Like the liquid-fuel booster concept, final landings will be made using parachutes and retro-rockets, although this capsule is equipped with landing legs for touching down on land instead of water. Since the wingless capsule is much lighter than the Orbiter, a larger portion of the mass launched into orbit can be devoted to payload. In this example, the payload is an Apollo-type manned space capsule atop an auxiliary propulsion stage.

The engine capsule system shown here is capable of launching 150,000 lbs. into orbit, using regular shuttle solid-fuel boosters. Should these boosters be replaced by the previously mentioned liquid-fuel boosters, the payload would increase to 185,000 lbs. A system using not two, but four liquid fuel boosters along with the engine capsule, could orbit almost 335,000 pounds.

These systems will fill an interim need to launch heavy payloads into earth orbit. For manned payloads, those hauling large numbers of people into space like an airliner, the winged orbiter can be easily converted by adding a passenger module for 74 passengers.

Although the above concepts lower launch costs and save money, they still do not lower them enough for transporting power satellite components to orbit. To reduce cost-per-pound into orbit even further, Rockwell envisions designs that move away from Shuttle hardware to further increase payloads, efficiency, and reusability.

Some staged-rocket concepts which have already been examined by NASA and various contractors include a huge winged system with an orbiter atop a booster, both completely reusable. This system may place nearly 840,000 pounds into orbit. A ballistic-landing system capable of launching a million pounds into orbit has a liftoff weight of nearly 21 million pounds.

A combination system designed by Rockwell uses both winged and ballistic elements. Here, the boosters have folding wings, while the payload section is reused by landing it ballistically. At launch, all the engines burn at once in both boosters and central core. Propellants are pumped from opposing pairs of boosters into the main vehicle during flight, one pair at a time. As each pair is drained of fuel, it drops off, unfolds its wings, re-enters and flies back to base. Finally, the central core alone flies into orbit. Since there are six boosters (three pairs, plus the central core), this is actually a four-stage system. Air-breathing jet engines on the boosters assist at launch, and while the booster is flying down for a landing.

The major goal for launch vehicle designers is a single vehicle that could orbit payloads without dropping stages, whether or not these stages are reusable. Such a system should be reusable hundreds of times (The Space Shuttle is designed to be reused 100 times), use low-cost fuels where possible, carry useful payloads, and in general, be as easy to operate as a standard airliner.

General approaches to do this involve one or more of the following concepts:

1. Use of combinations of fuels in a single vehicle, sometimes in a single engine. An engine burning liquid hydrogen and liquid oxygen is very efficient. However, liquid hydrogen is not very dense, and requires a large tank for little fuel weight. This means that much more weight must go into the fuel tank's structure to make it large enough, and this comes off of payload weight direct-

ly in a single stage vehicle. An engine burning liquid oxygen with a fuel like kerosene is less efficient, but kerosene is denser, requiring smaller fuel tanks for the same weight in fuel.

The "mixed-mode" vehicle compromises by using both to best advantage, burning kerosene in the early portion of the flight where thrust is more important than efficiency, and a large mass of fuel is a must; and then burning liquid hydrogen later in the flight where the higher-efficiency can be best put to use.

2. Structural designs where the airframe and the fuel tank are the same structure. In airplanes this is sometimes called the "wet wing" concept. To date, winged vehicles have been generally designed with separate fuel tanks inside and airframe, increasing the amount of additional structure weight that must be launched into orbit. In a regular, cylindrical rocket, making fuel tank and structure a single unit is much easier, and has been done for some time. To make streamlined winged vehicles into fuel tanks is more difficult, particularly if large, flat wings must contain a cryogenic fuel under pressure.

3. Use of air breathing systems for initial launch phases. A rocket engine must carry its own oxidizer along with it. If, while the spacecraft is still within the atmosphere, use can be made of air as an oxidizer, then that much less oxidizer must be carried along, saving tank space and weight. Jet engines for initial boost can help. Injecting airflows into standard rocket engines can also increase thrust.

4. Exotic materials, including composites of fibers and epoxies. These can reduce a structure's weight up to 25%. Costs for such materials is now high, but dropping all the time.

5. Exotic propellants. Use of flourine as an oxidizer, or hydrogen cooled to a "slush" to take up less space are two examples. The first increases performance, while the latter reduces structure weight.

6. Nuclear power. The use of nuclear rocket engines, covered in a previous article (*Report*, March, 1978) opens a whole new area of launch vehicle types due to the vastly increased power available for very little fuel weight. Very little uranium or other nuclear fuel is required. This is used to heat a propellant, rather than burn it, so that no oxidizer at all is required. Hydrogen or even water can be used for a propellant in these designs.

An advanced space vehicle, not yet using nuclear engines, was investigated by the Rockwell researchers. It takes off horizontally like an airplane, using special launch gear to support its heavy lift-off weight. Then these take-off gear drop off, and the space-plane flies like a normal airplane with jet engines burning hydrogen and air. Upon reaching the best area for an orbital launch, usually east along the equator, the vehicle climbs to 45,000 feet, increases its speed with a transonic dive to Mach 1.2, then climbs using rockets and jets together. When the air thins out too much for the jets to operate, they are shut down and the space-plane flies into orbit on rocket power alone.

Such a system has several advantages over vertically launched systems. First, the launch and landing takes place on a regular runway. No special facilities such as launch pads, assembly buildings, or handling equipment is necessary.

Second, the launch is jet powered, resulting in less noise than a full rocket lift-off.

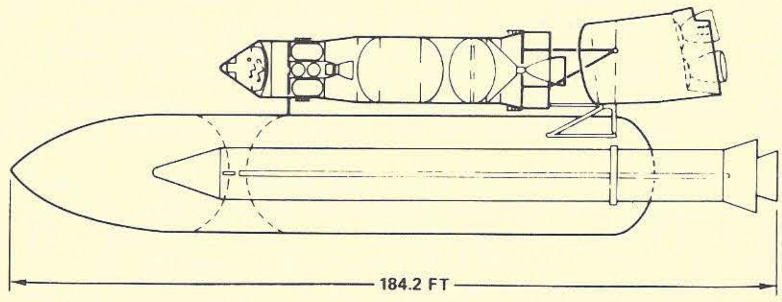
Third, the system can fly as a regular aircraft, allowing it to pick up payloads and passengers at regular jet airports before refueling and taking off for space.

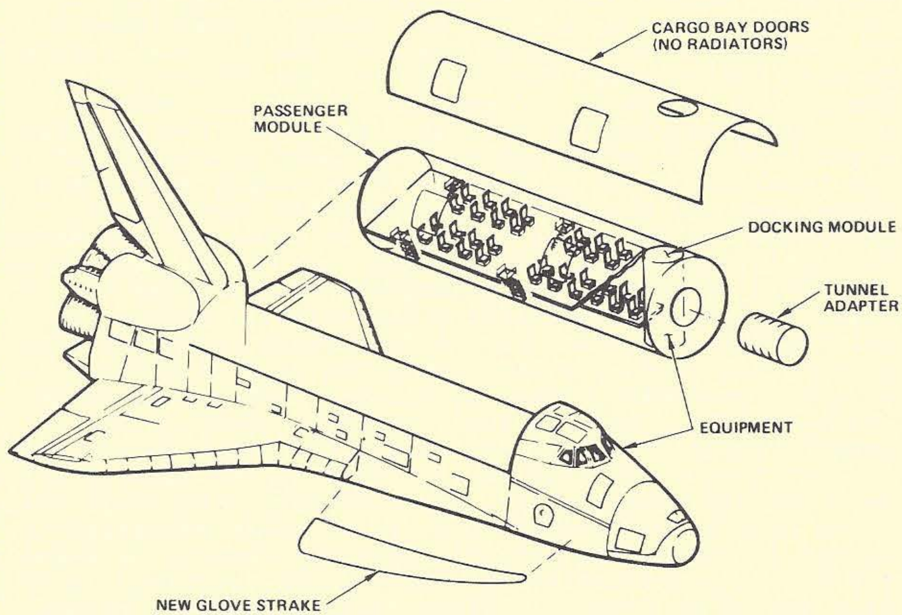
Such a system may be able to orbit a payload of 200,000 lbs.

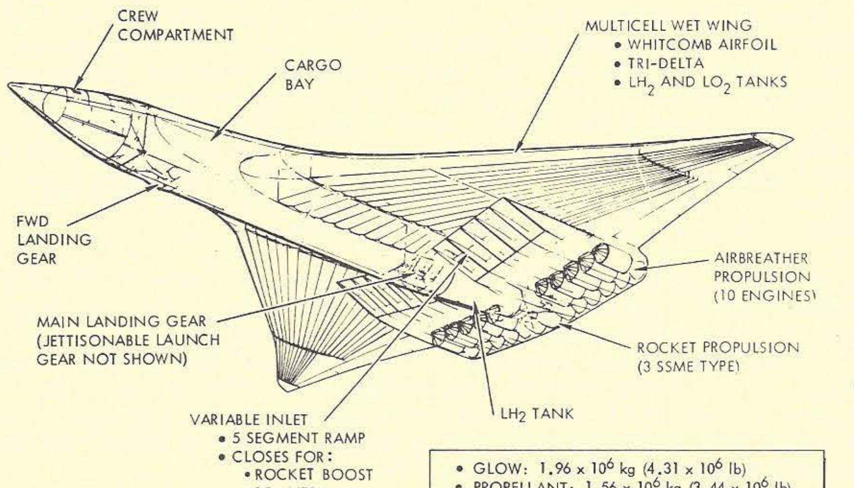
It will be interesting to see which of these concepts finds its way onto the launch pad. A slow, sequential evolution of vehicles may see all of them tried at one time or another. One certainty is that cost per pound into orbit will be the final arbiter. □

This is the first in a series of two articles on advanced chemical-powered space transportation systems. Next month Foundation Resident Fellow Tom Brosz will conclude the series with a look at Foundation launch vehicle of the past five years.

(Below) Rockwell investigators considered vehicle types ranging from simple modifications of the Shuttle to perform heavy lift functions and passenger transport, to exotic fully reusable aerospaceplanes.







- GLOW: 1.96×10^6 kg (4.31×10^6 lb)
- PROPELLANT: 1.56×10^6 kg (3.44×10^6 lb)
- PAYLOAD: 91,000 kg (200,000 lb)
- OVERALL LENGTH: 94.5 m (310 ft)
- OVERALL WIDTH: 114.3 m (375 ft)

news notes...

SPACE BEAM-MAKING MACHINE...Grumman Aerospace Corp. is initiating a company funded project which will lead to a version of a space beam-making machine, according to a recent note in Aviation Week and Space Technology magazine. The machine will be able to fabricate either aluminum or composite/plastic structural elements. The company is presently building a beam-maker which uses aluminum as feedstock. According to Grumman, the company forsees half of its future space business being devoted to the fabrication of large structures in space.

SOVIETS RETURN TO SALYUT 6... Two manned Soyuz spacecraft, launched within two weeks of each other, have docked with the orbiting Salyut 6 space station. In the second launch of an international crew by the Soviets, one of the cosmonauts is a Polish Air Force officer.

COMMITTEE BLASTS SPACE PROCESSING, NASA...Washington... The Committee on Scientific and Technological Aspects of Materials Processing in Space of the National Research Council has released its report titled: "Materials Processing in Space". Comprised of several members with negative views of the topic and NASA, the results might have been predictable. A primary conclusion of the panel was stunning however: "The committee has 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." The scientists who comprise the committee (who are primaril y academics), believe that only experiments which have a firm basis in terrestrial science and that have been subjected to peer review by other academics should be allowed on-board the NASA Space Shuttle. Besides their negative views on the general topic of space processing, the panel also claimed that they could find no advantage to any space attribute besides microgravity. Specifically, they feel that there will be no benefit from use of solar radiation or vacuum in space. The National Research Council released the report prematurely (in part) during testimony early this spring by Council officer Phillip Handler, before a committee of the Senate chaired by Senator William Proxmire (D-Wisconsin). A Foundation staff member has been informed that the Senator's office staff then made inquires of NASA why the materials processing in space program was being continued. Following release of the report to the news media last week, CBS morning news carried the negative conclusions of the committee on its nationwide broadcast Monday, June 26th. Science News also carried a report, quoting heavily from the final panel report, in the June 24th issue.

NEW STUDY GROUP TO FORM...Washington...A study committee named "The Commercial Aspects of Materials Processing in Space Committee (CAMPS)" is being established by the National Research Council. The task of the CAMPS panel will be to investigate the commercial potentials of space processing and to determine the best strategy to foster its development and growth. Nominations to the panel are now being considered.

OTRAG

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focus for the OTRAG Third World marketing effort. The action brought an immediate protest from the Soviet Union.

Moscow charged the French approval helped the Bonn government bypass a World War II ban on the development of advanced rocketry. The Soviets news agency Tass stated that the "military-industrialist circles of the imperialist powers" in NATO are cooperating closely with "neo-colonial regimes" such as Zaire to "coordinate their activities in Africa and create a military-industrial complex" there. Additional charges against OTRAG, familiar to readers of the *Report*, were repeated by the Tass propaganda attacks. □

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