THE CONTEXT FOR FOOD SERVICE AND NUTRITION IN THE SPACE STATION

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INTRODUCTION

Space is part of humanity's continuing evolution and an integral part of man's capabilities to fashion a better future for this and succeeding generations. There is no turning back; space is the arena where U.S. industry has the opportunity to achieve a competitive edge and restore the vitality of industrial innovation.

As in any emerging field with bright promise, skeptics can point to major obstacles to space operations, including the high cost of space transportation and space activities, the risks of new ventures and the timing of entry into the space market. Commercial activities in space represent diverse markets where international competitors will be motivated by economic, technical and political considerations. Although the technical details, costs and benefits of these activities can only be conceived in broad outline, it is time to take a constructive view of the attainable economic returns from space endeavors.

President Reagan directed NASA to develop a permanently manned Space Station within a decade to demonstrate U.S. leadership in space and to stimulate commercial exploitation of space.(1) " A Space Station," declared Dr. James M. Beggs, NASA Administrator, "provides a logical stepping stone to the exploration and exploitation of space."(2)

THE SPACE STATION PROGRAM

The Space Station opens a door for American industry. This will be crucial to the future of U.S. businesses because the successful development of commercial products and services is essential to exploiting "the enormous potential of space commerce."(1) Space commerce will be as significant in determining political and commercial relationships in the twenty-first century as developments in aviation, electronics, and computers in the twentieth century are in determining economic growth, industrial expansion, and international influence.

The Space Station will pay off because it is not just a technological challenge. It will be worthwhile because it makes many other projects in space science, telecommunications, manufacturing, and exploration possible. It clears the way to tap the inexhaustible energy and material resources of the solar system. It is the next step we are ready to take.

The Space Station will have an important role in support of a broad range of scientific and commercial activities, which may be performed either in the Space Station or in free-flying satellites tended by the Space Station.

The Station will permit extensive facilities in orbit to be built up gradually and equipment to be maintained and repaired leading to major improvements in capabilities to perform scientific investigations, to manufacture products and to reduce project costs. It could be a support base for transportation of payloads to higher Earth orbits and eventually provide routine access to the Moon and to the planets. The building of a lunar base, where materials could be processed

for use in the construction of more extensive space projects in Earth orbits and in support of scientific explorations, would provide a major mission for the Space Station. This base would give an open-ended aspect to the development and growth of an industrial infrastructure that could support an increasing variety of commercial activities designed to make the most effective use of the inexhaustible energy and materials resources of the solar system. The Space Station is "The Right Stuff" to ensure that U.S. industry will be in a position to meet the competition from other nations in exploiting the opportunities for commercial activities in space.

INDUSTRIAL PARTICIPATION

From the onset the Space Station program will involve industry to ensure that industrial organizations can make the most productive use of the unique environment of space. This is in keeping with one of the President's objectives "to encourage industry to move quickly and decisively into space." Appropriate Federal government policies and cooperation between the public and private sectors can develop the necessary industrial infrastructure. An indication of the commitment to increased participation by the private sector is the February 24, 1984 Executive Order authorizing the Department of Transportation to coordinate a program to allow private corporations to launch their own satellites into space. President Reagan said, "...and if our efforts in space are to show the same energy, imagination and daring as those which made our country great, we must involve private enterprise to the fullest."

POTENTIAL BENEFITS OF COMMERCIAL ACTIVITIES IN SPACE

The direction and scope of commercial activities in space are already being defined as a result of the wide ranging experiments being performed on the space shuttle. Unlike the Shuttle, the Space Station will be designed to accommodate experiments performed over periods of weeks and months in a nearly gravity-free environment. The strategy for near-term commercial activities must be planned and coordinated with long-term space industrialization goals, such as establishing a lunar base and obtaining energy from space for use on Earth. The Space Station program brings these industrialization goals into sharper focus. Areas of potential commercial interest with near-term benefits include:

1. A "fee-for-service" laboratory where industrial organizations could rent space to perform experiments.

2. Observations of the Earth and atmosphere.

3. A platform for a space-based communications program including the maintenance and upgrading of communications satellites.

4. New materials developed in space for use on Earth or in space-based production.

The Space Station will provide opportunities to engage in experiments and pilot plant operations in order to gain experience working in space. Participation in Space Station activities by industrial organizations could be an integral part of business planning strategies for organizations interested in space ventures.

Incentives for industry participation in commercial activities could be provided by services supplied to Space Station users. If NASA would provide long-term guarantees and service contracts, companies might be interested in providing

facilities and services charged to the users in ways analogous to similar services provided in terrestrial industrial facilities. Examples of such services are power supplies; housekeeping and life support including equipment, consumables and waste management; habitability features including crew accommodations, recreational facilities, and food preparation and service.

The return on industry investments to provide commercial facilities and services to a Space Station would be negotiated between participants in a competitive environment, with industry taking the lead to develop and provide the necessary facilities and services on a business basis. These commercial activities could be planned from a modest and embryonic start to encompass future major investment in space industrialization.

FOOD SERVICE AND NUTRITION

Habitability

The establishment of a permanently manned Space Station places the focus on habitability. Habitability could be achieved by complete food resupply from Earth, by partial recycling of air and water, and possibly by growing a few selected food resources and in the future, by a completely controlled ecological life support system. The key to achieving acceptable habitability will be providing adequate food in a form that meets the physiological and psychological needs of the crew members when exposed to the Space Station environment. The habitability goal is to maintain crew members in the physical conditions approaching those considered normal by Earth standards.

Effects on Physical Condition

There is a growing understanding of the effects of space missions on the physical conditions of crew members. For example, protein metabolism will be altered, so optimal protein levels in the diet will have to be determined. Current indications are that protein levels may have to be reduced because of effects of calcium metabolism. Carbohydrate and fat level fluctuations do not seem to have adverse effects within the limits of currently acceptable diets. Total energy requirements may increase slightly because of an increased workload and/or decreased efficiency of utilization. Calcium requirements are not known to a desirable degree; they will probably increase in an effort to reverse the loss of calcium from the bones. Even more important may be the ratio of calcium to phosphorous. Requirements for some vitamins may be altered by stress, gravitational changes and extended periods of food storage. Vitamin supplements may have to be made available to the crew members.

Dietary Goals

Dietary goals have been established to form a bridge between nutritional needs and the food service system which meets these needs. These dietary goals include the following:

- Establishing access to a variety of foods
- Determining and maintain ideal weight for the crew
- Avoiding too much sodium by eliminating highly-salted foods
- Reducing protein intake
- Reducing the calcium to phosphorous ratio

The food service system for a Space Station must meet several requirements. It must

1. Fulfill dietary goals by delivering of appropriate nutrients.

2. Deliver acceptable foods with desirable sensory attributes.

3. Maintain health and safety standards.

4. Meet unique crew needs imposed by the Space Station environment and the expected activity levels of the crew.

5. Provide potable drinking water.

Food Preparation

Techniques will have to be developed to prepare acceptable meals from foods stored in the Space Station and resupplied by the space shuttle.

Constraints on cooking devices in the Space Station environment include the absence of convection, the need to keep foods contained and the difficulty of weighing, measuring, and transferring materials. The three major forms of cooking or thermal processing are (1) fluid immersion by pressure cooking or deep fat frying, (2) roasting and baking with a combination forced convection/ microwave oven with an attached browning unit, and (3) direct contact and/or radiant heating for grilling, pan frying, and other stove-top operations.

Meal Service and Food Handling

Meal service will have to be adapted to the mission and the crew size. Individualized preplanned meals may be practical with increased crew size and some type of food service operation may be warranted. The menu may be varied and cycled, with choices offered as needed. Food monitoring systems may be used for inventory purposes and to insure adequacy of diet.

Options for meal service include solo, group or fast food "vending" with equipment to be developed for this purpose. Food packaging and handling techniques will have to meet sanitary and health requirements. It will be important to minimize waste in packaging and food processing at every step of a functioning food service system.

DEVELOPMENT TESTS

Considerable information on food service and nutrition has been obtained in past Skylab and Space Shuttle missions. The food service and nutrition requirements for a Space Station will require evolutionary advances which will have to be based on new information. Terrestrial laboratory tests can provide only part of this information because the space environment will influence food service requirements. Detailed test objectives and detailed supplementary objectives for Space Shuttle experiments must be defined to develop new concepts and approaches for food service systems and nutrition for the Space Station.

The participants in this Workshop met to exchange knowledge on the state-of-the-art of food service system and nutrition in space flight, and to explore areas where additional knowledge will have to be gained to guide the development of food service systems. There are no text books or handbooks which can be consulted to select optimized approaches. Working together, learning from each other and sharing in the creative process during the Workshop will provide the opportunity to lay the foundation for future advances of food service systems and nutrition in a Space Station.

References

1. The State of the Union Message, January 25, 1984.

2. NASA Press Conference, January 26, 1984.

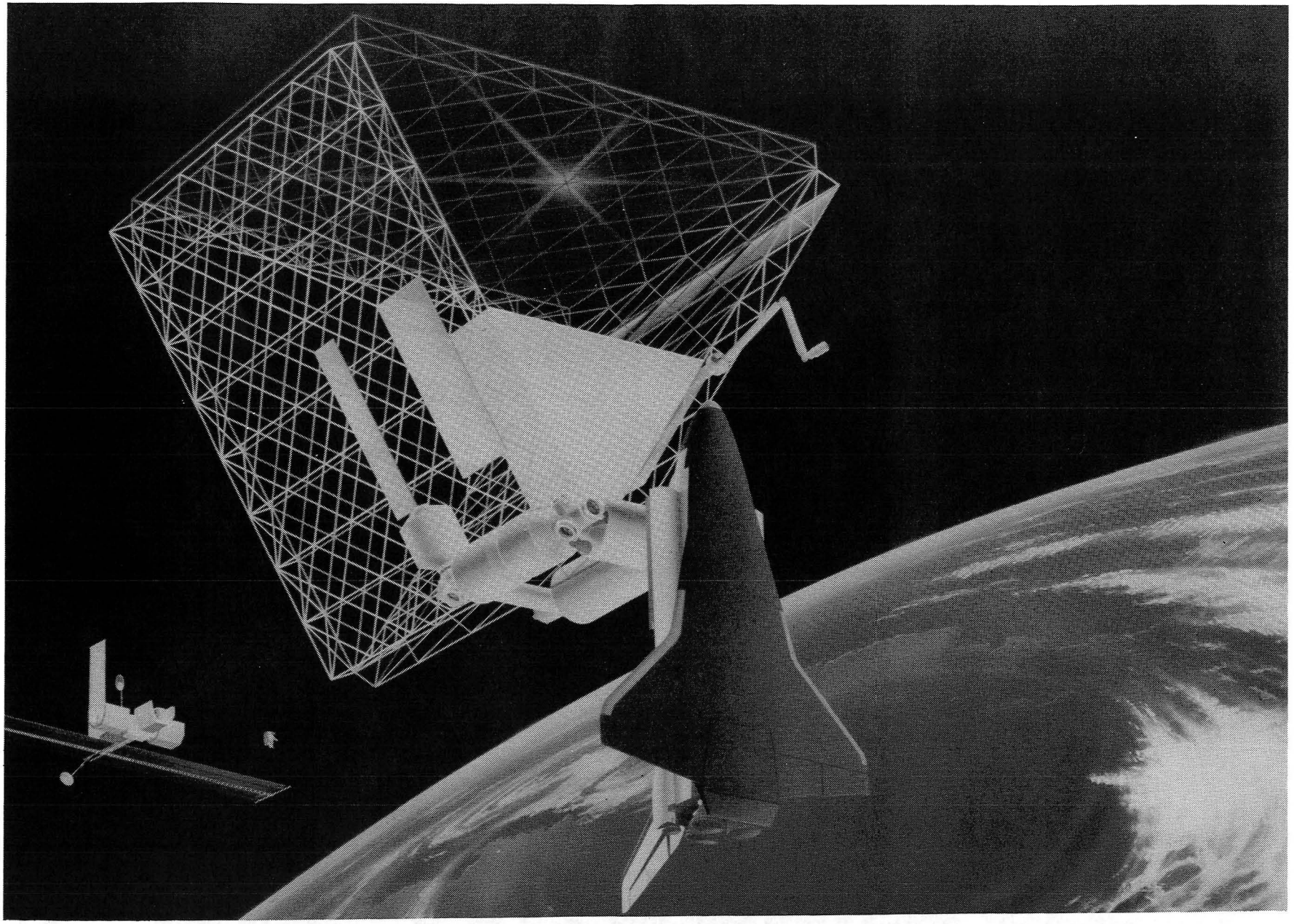
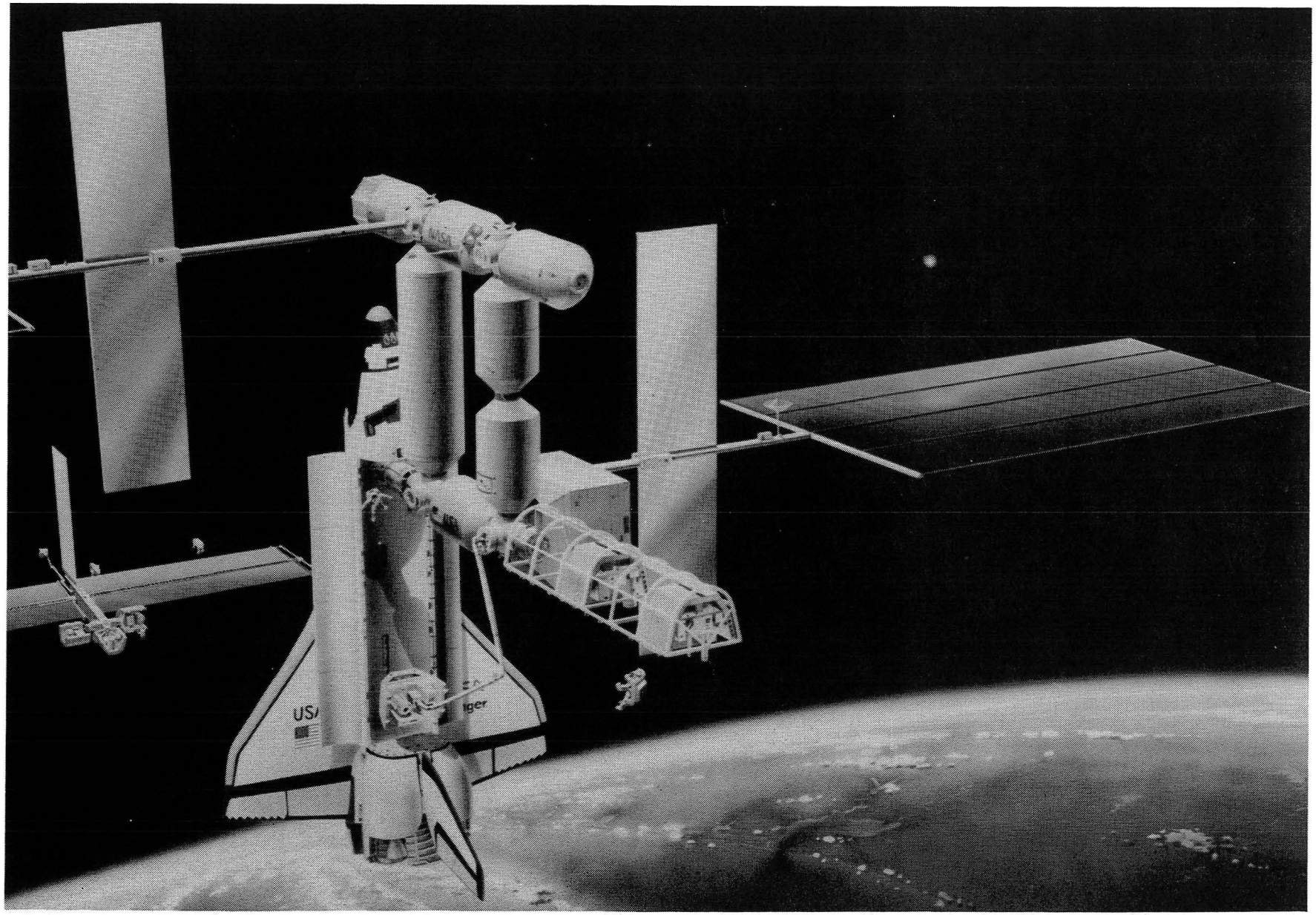


Figure 1



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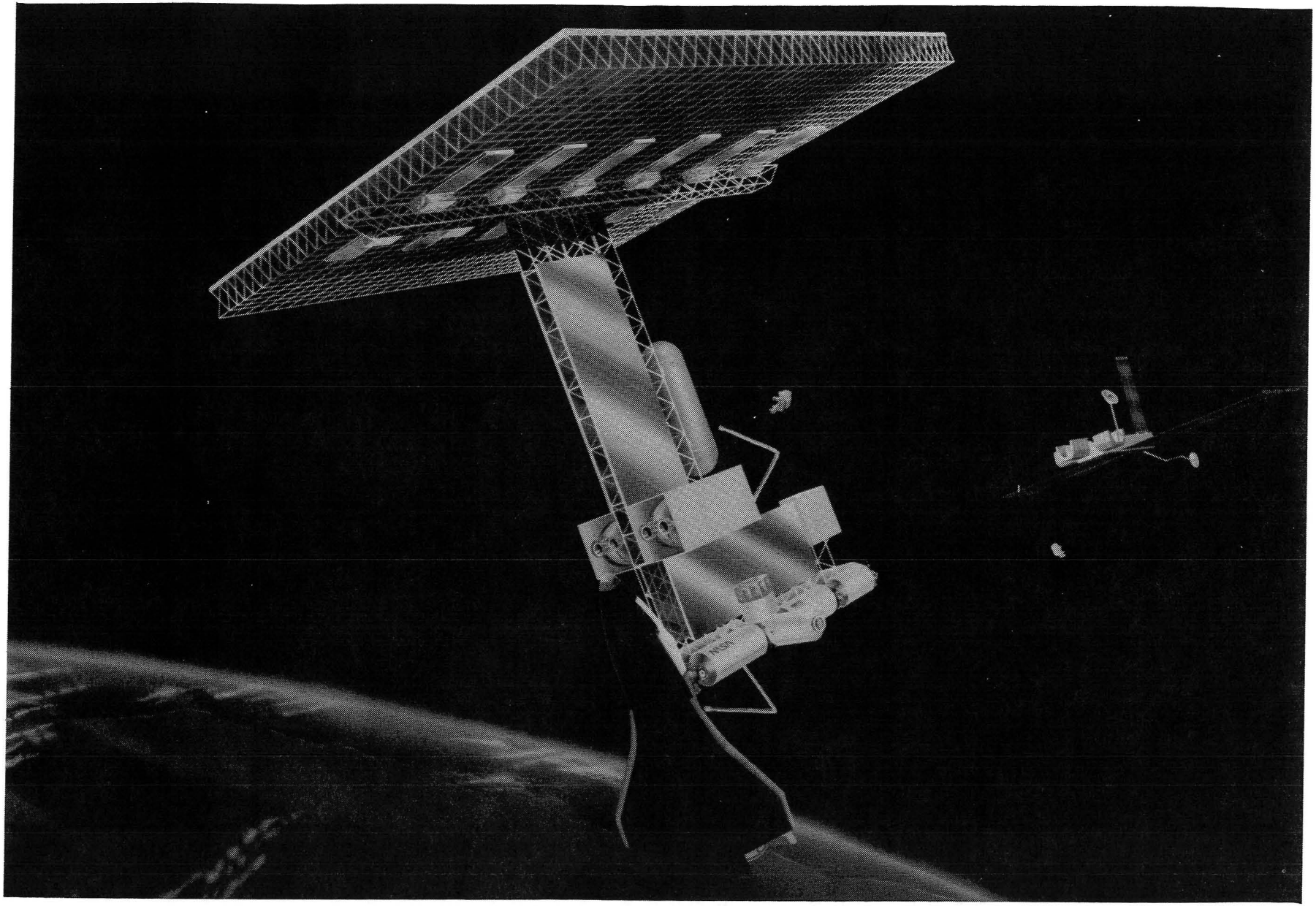

Figure 3