DEPARTMENT OF THE AIR FORCE
11TH WING

28 February 2001

11 CS/SCS (FOIA)
1000 Air Force Pentagon
Washington DC 20330-1000

Mr. John Greenewald Jr.

Dear Mr. Greenewald

This is our final response to your 14 August 2000, Freedom of Information Act requests for AD B133551 "NASA Space Station Update and Potential Military Uses" (Case #01-0022) and AD 363074 "Project SCAR-Satellite Capture and Retrieval" (Case #01-0027).

The Acquisition and Management Directorate has reviewed the attached documents and determined that certain information be withheld under Case #01-0022. The authority for this exemption may be found in Title 5, United States Code, Section 552 (b)(6). Exemption (b)(6) applies to the withholding of information that could reasonably be expected to constitute a clearly unwarranted invasion of personal privacy. The document for Case #01-0027 is also attached and released in its entirety.

The denial authority in this instance is Ms. Darleen A. Druyun, Principal Deputy, Assistant Secretary (Acquisition & Management).

Should you decide that an appeal to this decision or "no records" response is necessary, you must write to the Secretary of the Air Force within 60 calendar days from the date of this letter. Include in the appeal, your reasons for reconsideration, and attach a copy of this letter. Address your letter as follows:

Secretary of the Air Force
Thru: 11 CS/SCS (FOIA)
1000 Air Force Pentagon
Washington DC 20330-1000

Our action officers are Mr. John Espinal (#01-0022) and Ms. Penny Jenkins (#01-0027) at (703) 696-7269 and 7270 respectively. When inquiring, please reference the appropriate case number.

Sincerely

Rhonda

RHONDA M. JENKINS
Chief, Documentation Information
& Services Branch

Attachments:
1. Document AD B133551
2. Document AD 363074

SPACE TECHNOLOGY DIVISION NOTE
STDN 89-9

NASA SPACE STATION UPDATE
AND
POTENTIAL MILITARY USES

June 1989

By

[redacted]

(b)(6)

Approved by

[redacted]

Division Manager

DISTRIBUTION AUTHORIZED

~~to U.S. Government agencies only; test and evaluation; June 1989 Other requests for this document shall be referred to SAF/AQQX.~~

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ATCH 1

PREFACE

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This division note is the result of a study that ANSER conducted for SAF/AQSS, [redacted] It is a complete revision of an earlier study dated September 1986 (STDN 86-8). This note, in the form of an annotated briefing, portrays the current status of the NASA Space Station program as well as the potential military uses of the Space Station. The material herein is current as of October 1988. It will be further revised as changes in the Space Station program warrant.

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CONTENTS--Continued

I. INTRODUCTION

This is ANSER's second report on the International Space Station being developed by the National Aeronautics and Space Administration (NASA). The first report was issued in September 1986 as the Space Station program was being organized and when the Nation's attention was on the U.S. space launch capability, which had been essentially incapacitated by the loss of the Space Shuttle Challenger and the failures of several expendable launch vehicle (ELV) missions. Since then, the Space Shuttle Discovery has successfully flown and a new fleet of ELVs is being developed. This report comes at a time when the national space launch capability is being revitalized, and the Space Station program, recently named "Freedom," has achieved a degree of stability.

The fiscal year 1989 Space Station budget is the first nearly billion dollar budget for this program. About half is being withheld by the Congress pending program ratification by the next administration, but present indications are that a rejustification will not be required.

All of the Space Station development contractors have been selected and fully integrated into the program structure, and a major program milestone has been met with the completion of the Preliminary Requirements Review this year.

Of the many important events in the life of the Space Station, probably the most significant one since ANSER's first report was the program rebaseline. In the wake of the Space Shuttle accident, NASA acquired new leadership that challenged the original Space Station cost estimates. NASA asked the National Research Council (NRC) to validate the new estimates, and the Congress heard reports from both NASA and the NRC that projected a budget double that of the original commitment. At the same time, NASA was reevaluating its baseline assembly plan in light of accident-related Space Shuttle performance reductions. The combined budget and operations reassessments resulted in a rebaselined Space Station program consisting of two phases, only the first of which has been authorized. The design and capabilities of this first phase (Phase I) Space Station is the subject of this report.

As was pointed out in ANSER's original report, the Department of Defense (DOD) needs to be sufficiently familiar with the capabilities and limitations of the Space Station to make informed judgments regarding the use of the station for meeting national security program objectives. While not detailed and all-inclusive, this document is intended to familiarize the reader with the NASA Space Station program. (If further information is desired, please refer to Appendix A or contact the appropriate NASA offices.)

The report contains an overall description of the NASA Space Station program and an assessment of its military utility. Sections II.A through C address the status of the program, including a description of the major components, a summary of the NASA management approach, and a breakdown of the overall program schedule and the near-term definition and design phases. Section II.D reviews the potential military utility of the Space Station, emphasizing the research and development opportunities. Section II.E presents some observations and recommendations for the military.

II. NASA SPACE STATION UPDATE

OVERVIEW

- DESCRIPTION
- NASA MANAGEMENT
- SCHEDULE
- MILITARY USE
- OBSERVATIONS AND RECOMMENDATIONS

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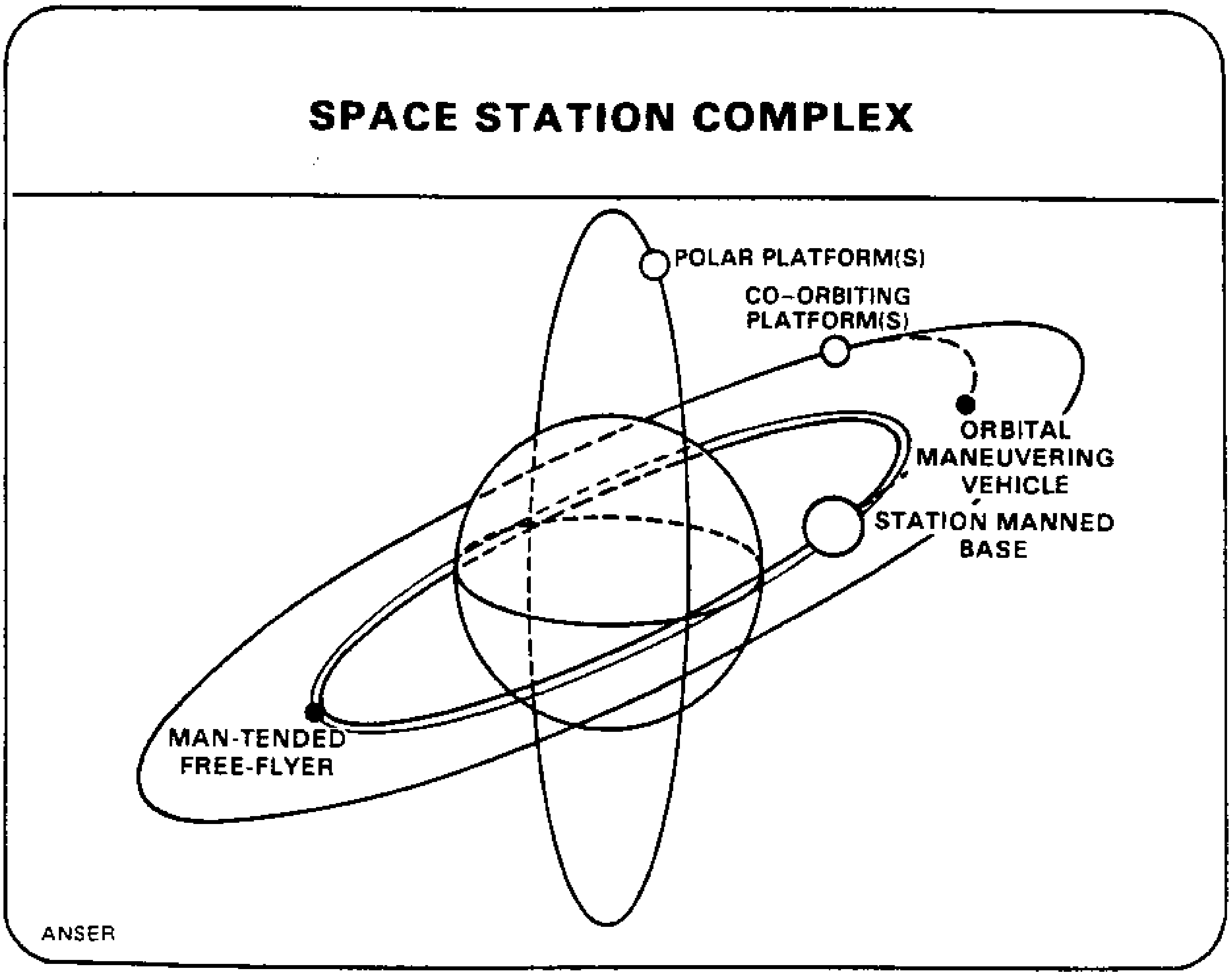
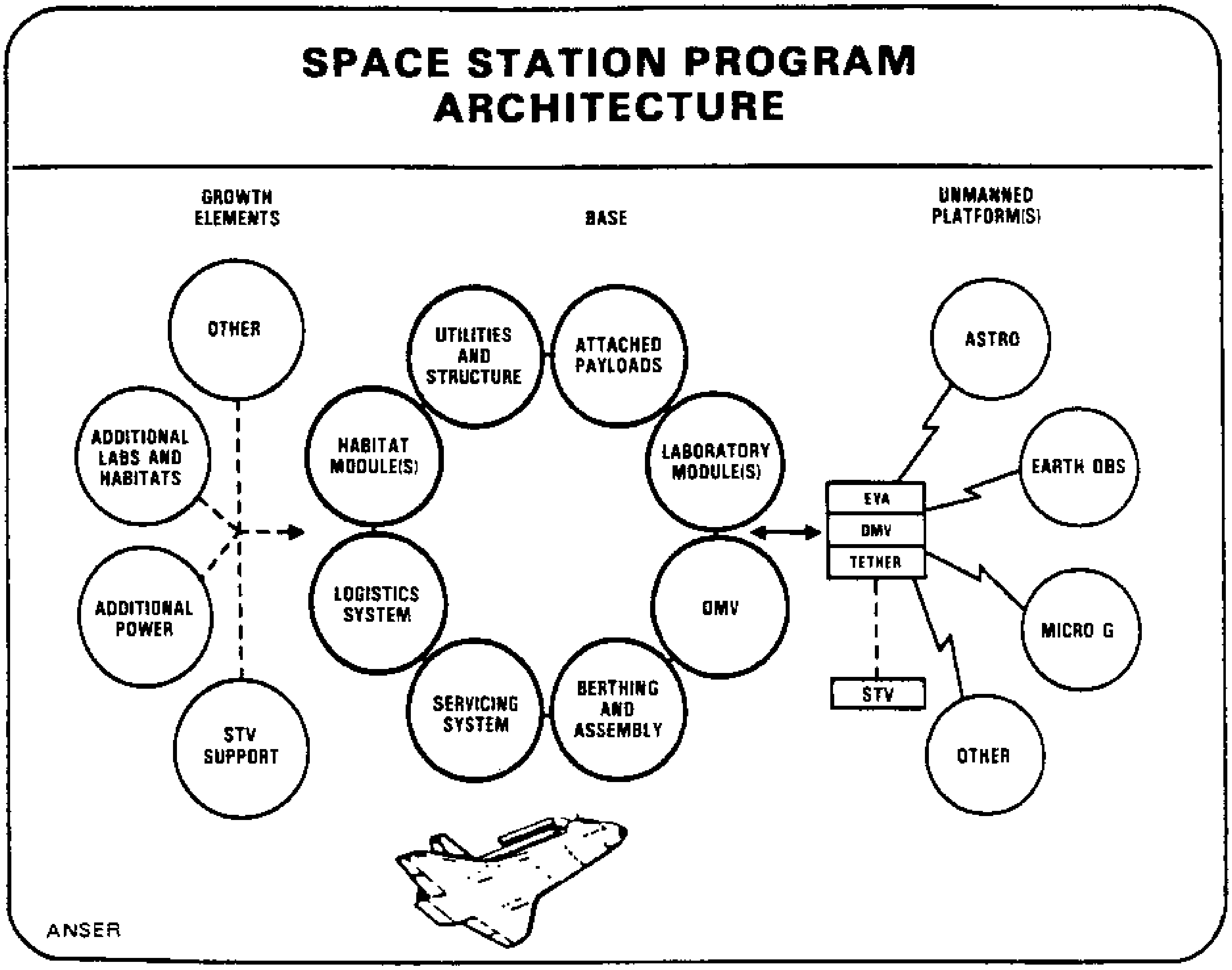
This report provides a description of the Space Station program in order to assist the DOD in addressing the issues of Space Station use and program participation. It includes a discussion of NASA's program management and schedule, it identifies military interests in the Space Station, and it provides some observations and recommendations for potential military use.

A. Description



The NASA Space Station program consists of the Space Station Manned Base (SSMB), a co-orbiting Man-Tended Free-Flyer (MTFF), two polar platforms, and Orbital Maneuvering Vehicles (OMVs). Co-orbiting platforms are planned for the future evolutionary growth of the Space Station Complex but are not part of the initial operational capability (IOC). The SSMB, MTFF, and co-orbiting platforms will operate in low earth orbit (LEO) at an inclination of 28.5° from the Equator. Current plans are for the IOC MTFF orbit to practically coincide with that of the SSMB. The polar platforms will be placed in near-polar, sun-synchronous orbits. The OMVs will be used for servicing the Space Station Complex and will be capable of operating from the SSMB, the Space Transportation System (STS or Space Shuttle), and ELVs.



SPACE STATION PROGRAM ARCHITECTURE

The manned base consists of common modules used for habitation, laboratory, logistics, and servicing functions; utilities to power the modules; the structure to support all of the elements; and provisions for berthing operations, assembly operations, and attaching payloads. Provisions for servicing the OMV have not yet been baselined by the program office.

Co-orbital unmanned platforms and the MTFF may be serviced from the Space Station, the Space Shuttle, or the Hermes spaceplane, and the polar platforms may be serviced from the Shuttle or by ELVs. With Shuttle and ELV servicing, either an OMV or a Space Transfer Vehicle (STV) will reposition the platforms if they are not equipped with a propulsion module to accomplish this task themselves. Platforms will provide a microgravity environment isolated from the manned base, allowing them to be used for astronomy and earth observations as well as for manufacturing.

Planned evolutionary growth is envisioned for the entire Space Station program, which can grow by making provisions for the OMV and by adding more modules, power, polar platforms, co-orbital platforms, etc. To prevent obsolescence, new technologies will also be incorporated throughout the 30-year expected lifetime, especially in the area of advanced automation and robotics technologies. Other advanced technologies include solar-dynamic power and launch servicing capabilities. Evolution will improve performance, increase capabilities, accommodate all users, increase lifetime, enhance productivity, and reduce costs. Its scope reflects the flexibility of the system.

Two items should be kept in mind while the Station's components are being developed. First, the design is evolving to accommodate future requirements. The "scarring" of the basic hardware to avoid large future structural and cost impacts on the system will be held to a minimum and could be relatively inflexible when the design is finalized. Second, since the system is expected to operate for approximately 30 years, changes are inevitable and must be planned for as much as possible. The effectiveness of the planning done now to accommodate change will depend largely on the quality of the requirements submitted by users today.

SPACE STATION COMPONENTS

- MANNED BASE (MODULES: HAB, LAB, etc., ATTACHED PAYLOADS, POWER SUPPLY, STRUCTURE)
- OMV
- STV
- PLATFORMS (DERIVED FROM COMPONENTS OF SPACE STATION)
  - —CO-ORBITING PLATFORMS (UNMANNED)
  - —POLAR PLATFORMS (UNMANNED)
  - —MAN-TENDED FREE-FLYERS

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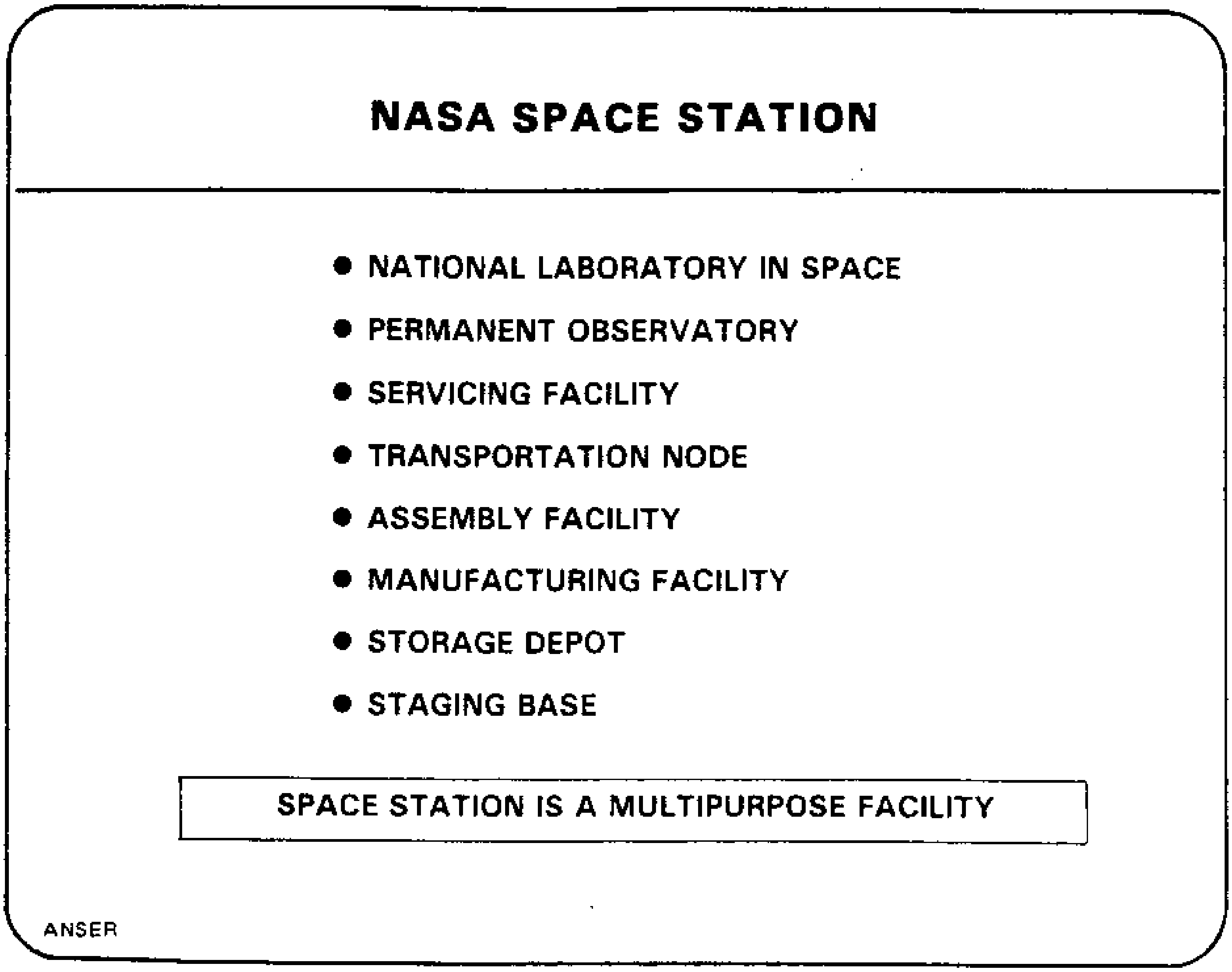
The above chart lists the major components of the Space Station Program. All the major IOC capabilities are presented in this report. The co-orbiting platform is the only element ignored, since it is planned for the future evolutionary growth of the Space Station program but is not part of the IOC. Although the OMV and STV are treated as independent of the Space Station program, they are included for completeness, since their mission scenarios are significantly associated with this program. The OMV element of the Space Station will be available at the time the Space Station achieves IOC, while the STV will be developed later. A "smart front end" for the OMV for servicing missions may also be available after the Space Station IOC. It will likely form the basis of a system for the STV that will extend servicing mission capability beyond that planned for the OMV.



NASA SPACE STATION

- NATIONAL LABORATORY IN SPACE
- PERMANENT OBSERVATORY
- SERVICING FACILITY
- TRANSPORTATION NODE
- ASSEMBLY FACILITY
- MANUFACTURING FACILITY
- STORAGE DEPOT
- STAGING BASE

SPACE STATION IS A MULTIPURPOSE FACILITY

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The NASA Space Station is being designed as a multipurpose facility, capable of performing many functions that cover a wide range of activities. The multiplicity of capabilities include:

- Research laboratory(ies) for a variety of scientific, applications, and engineering experiments, including manufacturing processes, vacuum-environment processes, man-in-space investigations, life sciences, materials sciences, and technology development
- Permanent observatory free from the earth's atmospheric distortion to look outward at the universe and inward at the earth

- On-orbit manufacturing facility to produce microgravity metallurgical crystals (compounds) and selected pharmaceuticals
- Servicing facility designed to repair, refurbish, and service U.S. space-based assets
- Transportation node from LEO to geosynchronous orbit and an assembly facility to construct and check out large structures in orbit before placement in operational orbits
- Storage depot for satellite spares and replacement parts
- Staging base for deep-space and planetary exploration, lunar missions, etc. (Before a manned mission to Mars takes place, precursor research will be conducted onboard the Space Station, i.e., life science studies, technology development, subsystem extended life, verification of space vehicle design concepts, and space vehicle assembly and test.)

Although currently the Space Station is predominantly a laboratory in space, it is also an enabling capability. The Station provides options for the future, i.e., it of itself does not inevitably lead to lunar and planetary missions, but it does enable such expeditions to occur.

CHARACTERIZING THE USER COMMUNITY

DEMOGRAPHIC SPACE STATION USER GROUPS	DISCIPLINE SPACE STATION-USER GROUPS								
	MATERIALS SCIENCE RESEARCH	LIFE SCIENCE RESEARCH	SERVICING AND ASSEMBLY	TECHNOLOGY DEVELOPMENT	EARTH OBSERVATION	ASTRO/SOLAR/ PLANETARY OBSERVATIONS	ASTRO/SOLAR/ PLANETARY PHYSICS	COMMERCIAL PRODUCTION	COMMUNICATIONS
NASA	X	X	X	X	X	X	X		X
DOD	X	X	X	X	X				X
NOAA				X	X				
OTHER U.S. GOVERNMENT AGENCIES	X	X		X	X				
ACADEMIC AND SCIENCE	X	X		X	X	X	X		
COMMERCIAL	X		X	X	X			X	X
INTERNATIONAL	X	X	X	X	X	X	X	X	X

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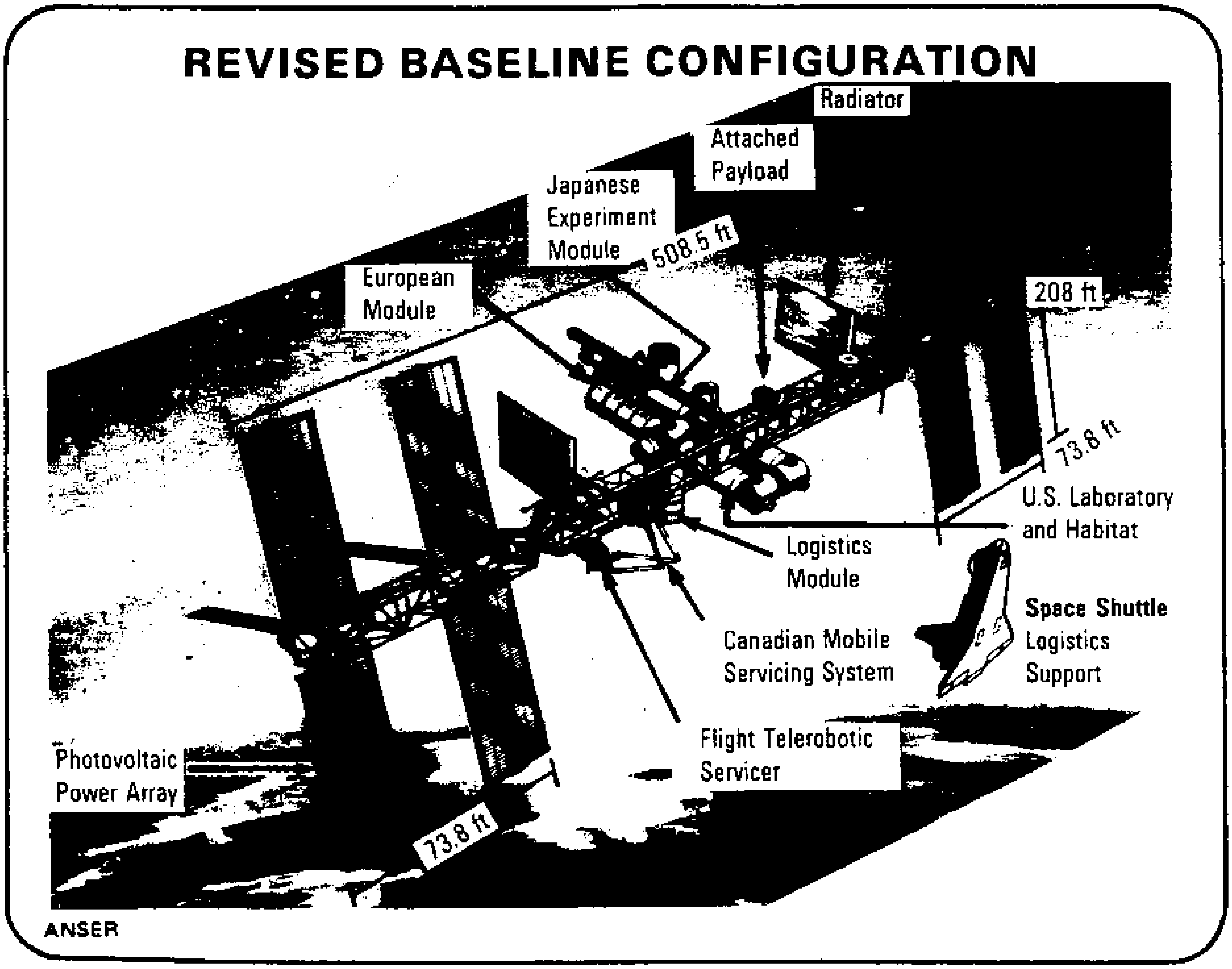
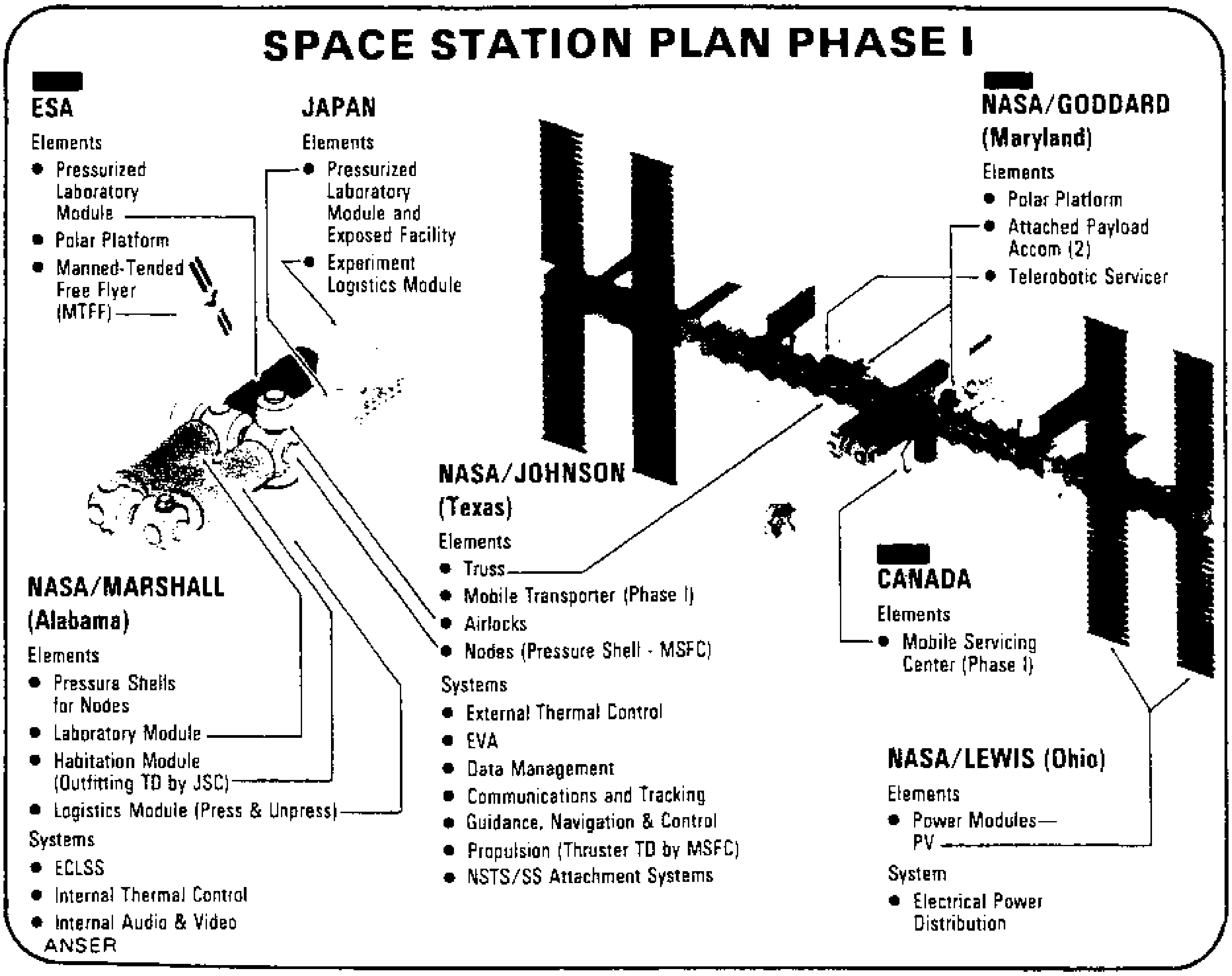
The user community will greatly influence Space Station operations. In the above chart, the users are listed along with their main interests in the capabilities provided by the Space Station. The user community will comprise various U.S. Government agencies, private industries, and international users.



As a result of the budget constraints imposed by the Gramm-Rudman-Hollings Deficit Reduction Act, NASA adopted a phased approach to the development of the Space Station. In April 1987, the Phase I Space Station, also known as the Revised Baseline Configuration, became the current Space Station, replacing a "dual-keel" configuration originally baselined in 1985. The new baseline consists of a 145-m horizontal boom with four pressurized modules attached in the middle. Four photovoltaic arrays, located at each end of the horizontal boom, generate a total of 75 kW of electric power. The four pressurized modules consist of the United States Laboratory Module and Habitation Module, the European Space Agency (ESA) Columbus Laboratory Module, and the Japanese Experiment Module (JEM) Laboratory and Exposed Facility. Canada will be providing part of the Mobile Servicing System. In addition to the manned-base Space Station, two polar orbiting platforms will be included; one will be provided by the United States and the other by the ESA. Also, the ESA will provide an MTFF. A U.S. co-orbiting platform will not be provided as a part of the Phase I Configuration.

The Enhanced Space Station, Phase II Configuration, can go in any of several directions. Its evolutionary growth will depend on user requirements, operations concepts, and budgetary constraints as they develop. Several proposed future capabilities include adding payloads, increasing power, constructing large space structures, providing accommodations for a servicing facility, and staging manned missions to the planets or to the moon. The Nation's long-term space program goals will first need to be clarified before a Phase II Configuration and funding requests are approved.

Space Station--Detailed Description


SPACE STATION PLAN PHASE I

The Space Station, named Freedom, has a number of international participants; the United States, the ESA, Canada, and Japan will contribute to the Space Station. The above figure indicates the major components of the Station and who is responsible for developing these components.

Overall, the manned-base Space Station design measures approximately 508.5 ft (155 m) in length and is approximately 208 ft across at the solar panels. The Space Station will be approximately four times longer overall and approximately five times larger in total pressurized volume than the current Soviet Mir. (When comparing the NASA Space Station with the projected mid-90s Soviet Mir, which is the same timeframe in which the NASA Space Station will become operational, these ratios are significantly reduced. The total pressurized volume of the mid-90s Mir will practically equal that of the U.S. Skylab and, as a result, the NASA Station will be approximately two times larger in this respect.) Its total weight with outfitting will be 485,000 lb. The SSMB will operate at a 28.5° inclination orbit and an altitude of 190 to 250 NM (352 to

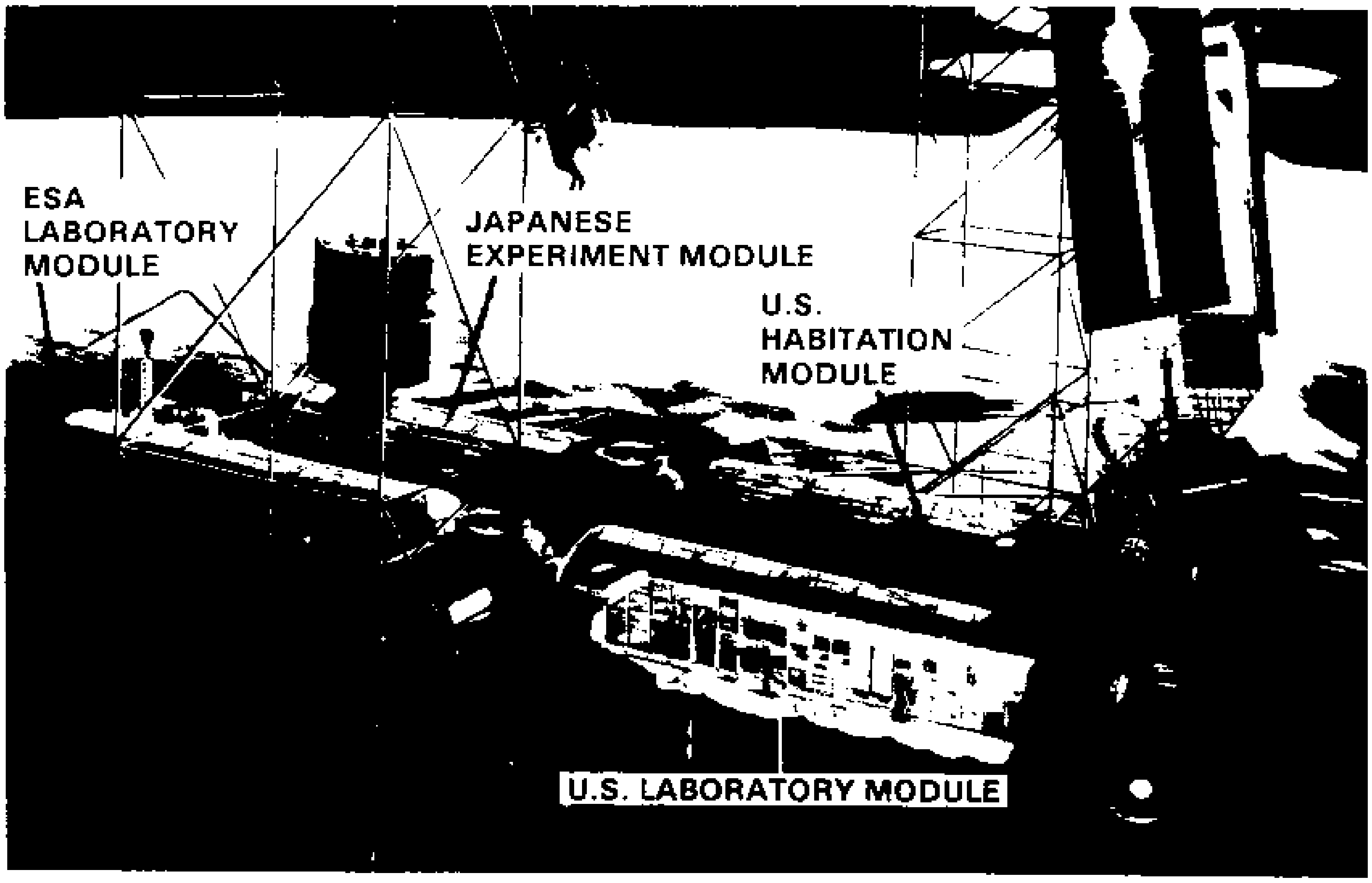
463 km). Its nominal operating altitude is between 220 and 250 NM. It will orbit the earth once every 90 minutes.

The manned base will consist of four pressurized modules with a total pressurized volume of 32,140 cu ft. Three of these will be laboratory modules, one each provided by the United States, the ESA, and Japan. The fourth, a habitation module provided by the United States, will be the living quarters for the crew of eight. Crew times on the Space Station are projected to extend to 180 days and beyond.

A logistics module and logistics system will be among the other features of the Space Station. An average of 75 kW of electric power will be supplied by the photovoltaic arrays. The peak photovoltaic output will be 200 kW. (The NASA Space Station will provide approximately 9 to 15 times more average and peak power than the current Soviet Mir or approximately 5 to 8 times more average and peak power than the projected mid-90s Mir.) Attached Payload Accommodations Equipment (APAE) will be located on the truss structure to accommodate external scientific payloads and observing instruments. A Mobile Servicing System (MSS), comprised primarily of Canadian components, will be present to assist in Space Station assembly and servicing. And finally, a Flight Telerobotic Servicer (FTS), provided by the NASA Goddard Space Flight Center, will be present to service payloads and to assist in Space Station assembly.

In summary, the ESA contribution to the Space Station is the Columbus Polar Platform, the Columbus Laboratory Module, and the Man-Tended Free-Flyer (MTFF). Canada will be contributing the Mobile Remote Servicer (MRS) element of the Mobile Servicing Center (MSC) and the MSC Maintenance Depot (MMD) as the major components of the MSS. Japan will be contributing the Japanese Experiment Module (JEM) Laboratory, Exposed Facility, and at least two JEM Experiment Logistics Modules (ELMs). The remaining components will be provided by the United States. They include the U.S. Polar Orbiting Platform (POP), the U.S. Laboratory Module, the Habitation Module, the Mobile Transporter (MT) element of the MSC, APAE, FTS, the Pressurized Logistics Carriers (PLCs), the Unpressurized Logistics Carriers (ULCs), the airlock, the hyperbaric airlock, the solar power modules, the truss assembly, the propulsion assembly, and the four resource nodes.

SPACE STATION MANNED BASE



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The main horizontal truss assembly will be the backbone of the SSMB. Overall, it is 145 m (475.75 ft) in length. Upon it, other elements will be attached, i.e., 11 pressurized elements (3 laboratory modules, 1 habitation module, 2 airlocks, 4 resource nodes, and the pressurized logistics carrier), 4 solar array modules, various externally attached scientific payloads, and other SSMB equipment (FTS, Canadian MSS, propulsion modules, antennas, radiators, etc.).

In flight, the horizontal truss assembly will be perpendicular to the SSMB orbit plane. The pressurized module configuration will have a negative 4° pitch angle down from the flight direction. This orientation is essentially an aerodynamic/gravity-gradient torque equilibrium position.

The truss assembly will comprise 5-m (16.4-ft) tubes having a 2-in diameter. The truss structure will be assembled in 5-m cubes with additional diagonal tubes for stiffness and strength. In total, the truss assembly will be made up of 366 graphite-epoxy, aluminum foil covered tubes.

There will be two sets of APAE located on the truss structure to accommodate external scientific payloads and observing instruments. They will provide 21.0 m^2 of surface area for users.

At each end of the truss assembly, two solar array modules will be attached for a total of four solar array modules generating 75 kW of electric power. The solar array subsystem has an efficiency of from 12 to 14 percent for converting sunlight into electric power. The arrays will comprise 131,200 solar cells whose area is more than one-half acre.

The photovoltaic array system will consist of beta joints (55^o rotation capability) for seasonal sun tracking and of alpha joints (360^o rotation capability) for enabling sun-facing orientation.

The electrical power system will also store energy to be able to operate during its eclipsed portion of the orbit. There will be 20 nickel-hydrogen batteries to supply electric power during this eclipsed period, which represents approximately 30 minutes (one-third) of each 90-minute orbit.

In addition to this, the SSMB will be equipped with a propulsion system which will serve four main purposes. The first will be a reboost function to counteract the atmospheric drag forces present in LEO. The second will be an attitude control function; the third will be a collision avoidance function to prevent impacts with space debris which may threaten SSMB safety; and the fourth will be a waste disposal function, which will enable the SSMB to dispose of some waste products in a somewhat controlled fashion.

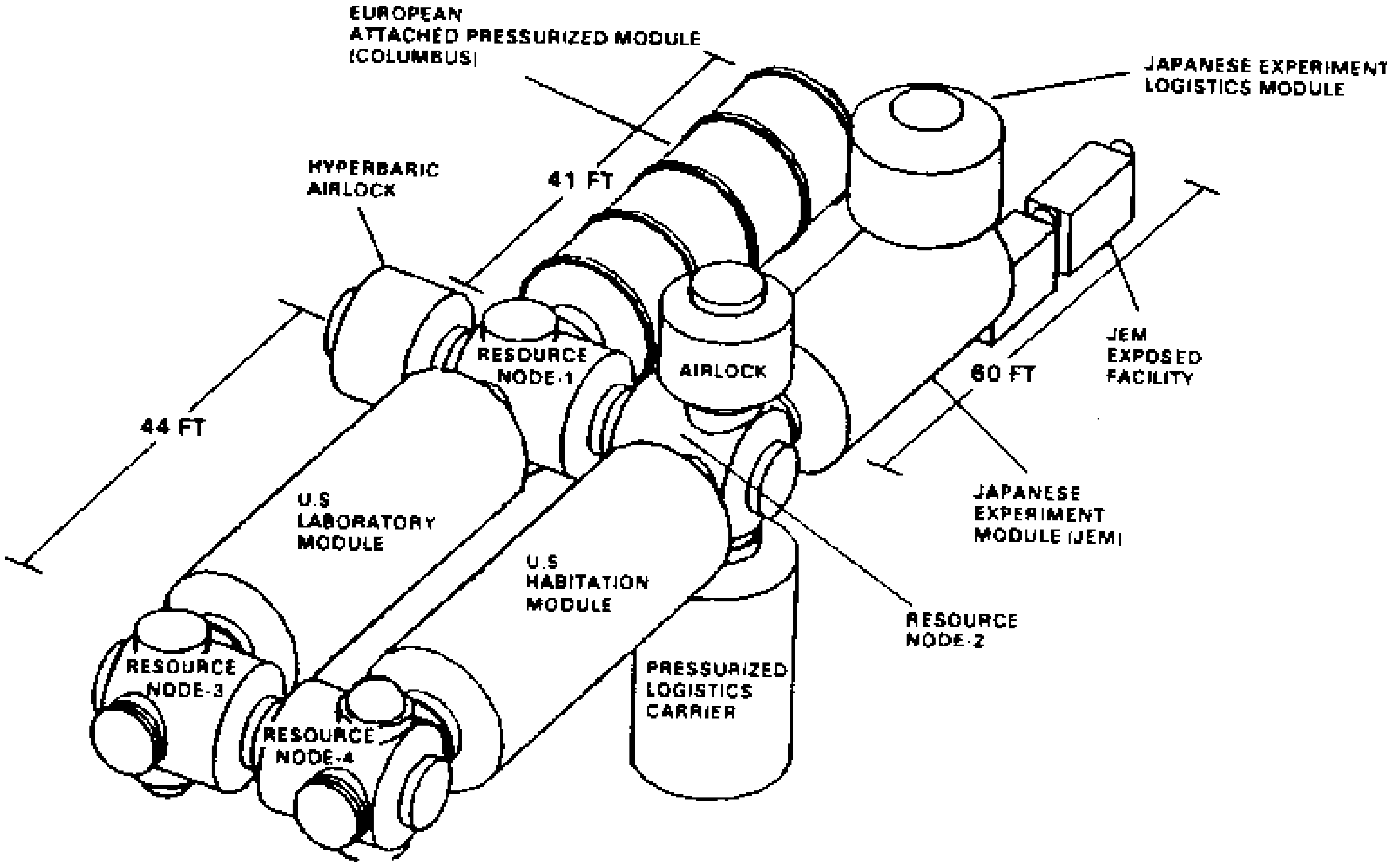
Finally, the space-to-ground communications system for the SSMB will be via the Tracking and Data Relay Satellite System (TDRSS). The link will provide up to the maximum data rate capability of 300 Mbps for the Ku-band link. Much lower data rates of several kbps will also be available through the S-band link.

For user support, the SSMB will provide at least 3,000 cu ft of internal pressurized rack space. In addition, at

least 300 cu ft of internal pressurized rack space and at least 6,000 cu ft of unpressurized space will also be provided for equipment storage.

Elements of the Space Station Manned Base

PRESSURIZED MODULE CONFIGURATION



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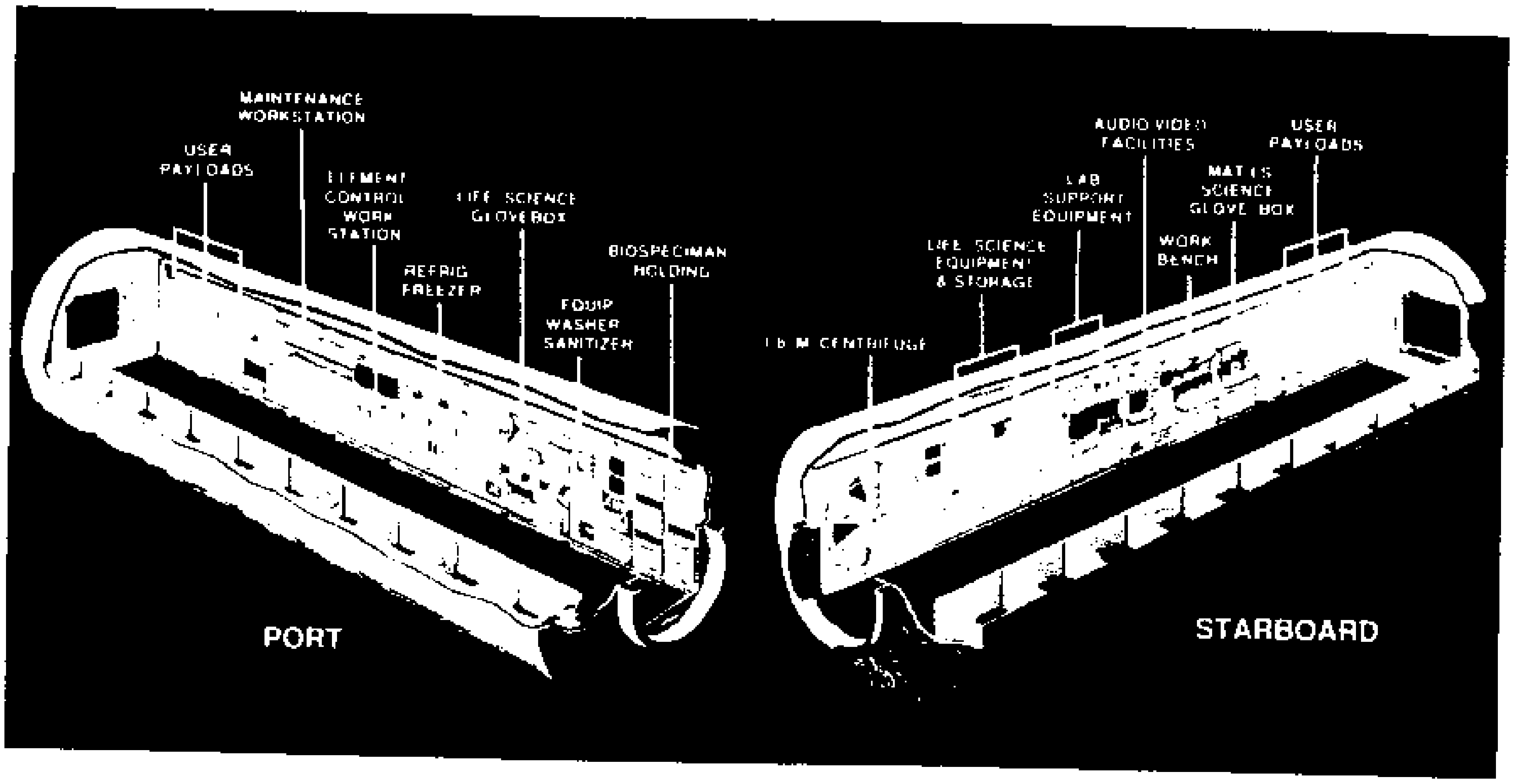
Four environmentally controlled pressurized modules are located on the Space Station as illustrated in the above figure. They consist of the U.S. Laboratory Module, the U.S. Habitation Module, the ESA Columbus Laboratory Module, and the Japanese Experiment Module (JEM) with its attached exposed facility. These modules will provide the main working and living quarters for a crew of up to eight persons. The U.S. Laboratory Module will have a 1 micro-g environment while the remaining pressurized laboratory modules will have a 10 micro-g environment. The modules are connected to four resource nodes which provide additional working areas (minimum of four workstations each) and which house the manned-base station's control systems. All four modules will share a distributed systems network, also housed at the nodes, which consists of guidance, navigation, and control; structures and mechanisms; thermal management; fluids; power; propulsion; environmental control and life support system (ECLSS); communications and tracking; and data management. The nodes and modules will be connected to the large truss structure.

Also attached to one of the nodes is an airlock which will enable transfer of equipment and Extravehicular Activity (EVA)-suited crew between pressurized and unpressurized environments. The airlock will be maintained at standard air pressure and composition and will be designed with a two-chamber configuration. The design of the first chamber will constitute a 12-ft-diameter sphere which will provide servicing and storage of EVA equipment. The second chamber will be cylindrical, measuring 80 inches in diameter and 96 inches in length. It will be the crewlock for EVA crew ingress and egress.

Attached to another node is a hyperbaric airlock which will be structurally identical to the first airlock. It is capable of maintaining pressure even when items are passed to and from the Space Station during hyperbaric operations. It can also function at higher pressures (up to six atmospheres) should a medical emergency, e.g., decompression sickness, arise.

U.S. LAB MODULE



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The U.S. Laboratory Module is shown in the above figure. It is 14 ft in diameter and approximately 44 ft in length. The ports at the ends of the module are 7 ft in diameter. The laboratory interior will be maintained at 14.7 psia (+/-0.5 psia) of pressure with an air composition of 20 percent oxygen and 80 percent nitrogen. Its temperature will be maintained at 20 to 25^{o}C (68 to 77^{o}F). The relative humidity will range from 40 to 70 percent.

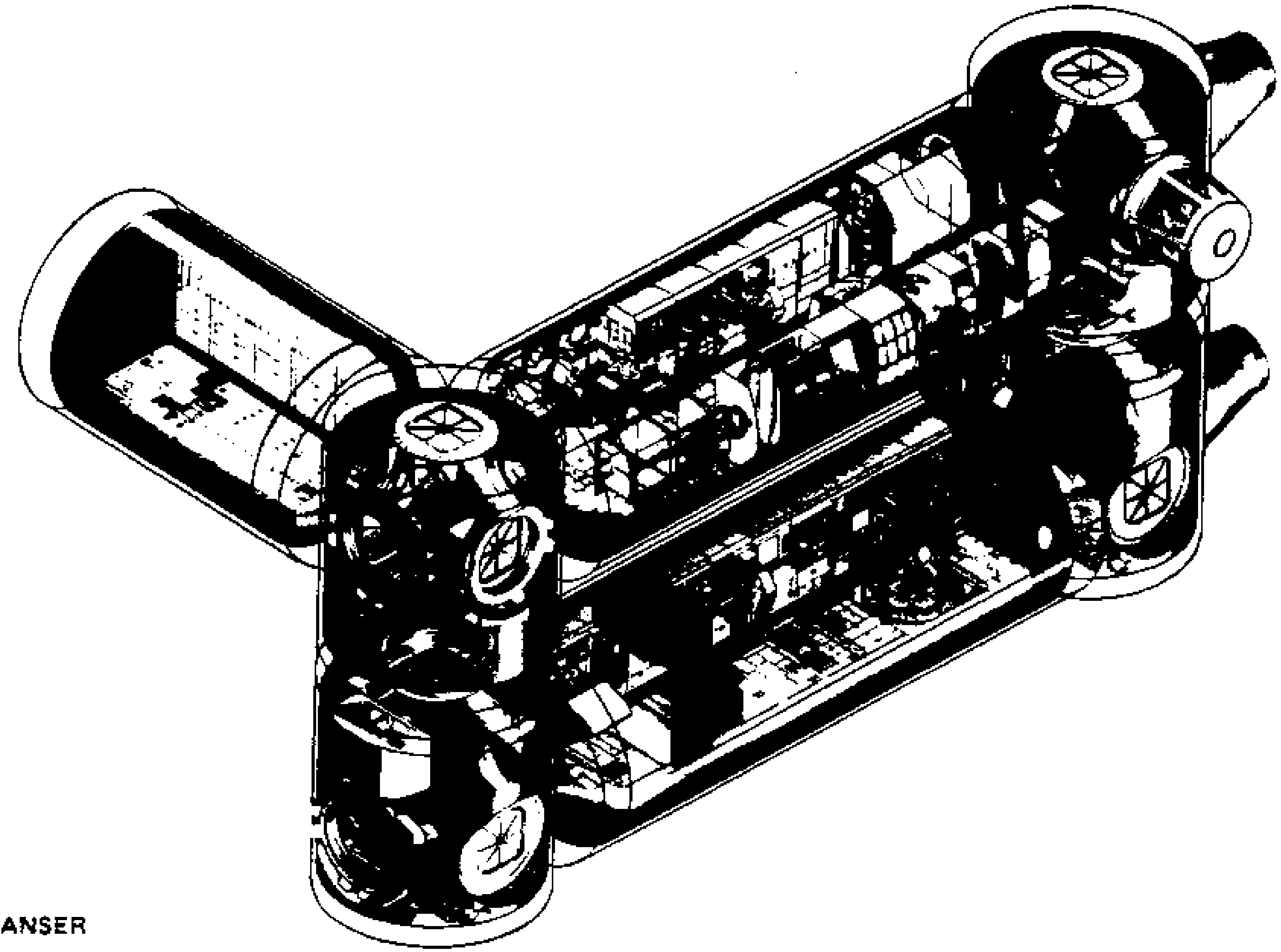
The laboratory module will be built as a double-wall, multilayer insulation structure to protect it against meteroid and debris impacts and to shield it from radiation. For scientific viewing, it will be equipped with three windows measuring 20 inches in diameter.

Basic microgravity materials and life science research, technology development, and astrophysics will be conducted in the laboratory module as well as other research experiments which require long-duration, low-acceleration levels of exposure and appreciable human monitoring and control.

The commercial potential of microgravity material processes will also be investigated.

The laboratory module will be equipped with three laboratory subsystems to support certain unique requirements dictated by materials and life science research. They are the accelerometer subsystem for measuring the microgravity environment, the vacuum vent subsystem for providing access to the space vacuum, and the process materials management system for the treatment and safe storage of raw materials and selected by-products.

All four sides of the module (floor, ceiling, and port and starboard walls) will be used for the distribution of experiment racks and related support equipment. The laboratory module can accommodate 44 double-sized racks evenly distributed so that there are 11 racks on each side. (A double rack is equivalent to one m^3 of usable volume.) Approximately 24 of these racks will be available for user payloads.



U.S. SPACE STATION
PRESSURIZED MODULES

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In addition to the U.S. Laboratory Module, the United States will also be providing the following pressurized modules: U.S. Habitation Module, Pressurized Logistics Carrier (PLC), and four resource nodes. An Unpressurized Logistics Carrier (ULC) will also be provided by the United States (not illustrated).

The U.S. Habitation Module is identical in structure and size to the U.S. Laboratory Module and will be located next to it. It will be the crew's living quarters and thus the place where the crew will be eating, sleeping, relaxing, engaging in recreation, and receiving any necessary medical care. It will also contain supplies for emergency situations. The possible unavailability of a rescue vehicle at the time of an on-orbit emergency has prompted NASA to design the Space Station with a safe haven philosophy to ensure crew survivability. This concept provides habitable conditions, communications, command and control, and fire detection and suppression capabilities for up to 45 days. The safe haven is not restricted to just the habitation module, but encompasses the other pressurized modules as well.

The PLC will be 14 ft in diameter and will be able to accommodate five double-size racks. It will have a total capacity of 3 subsystem racks and 17 cargo racks. An additional 320 cu ft of cargo space will be provided by aisle storage containers. The PLC will transport equipment between the Space Station and earth as it is carried in the Shuttle payload bay. The PLC and ULC will both be used for transporting fluids, supplies, experiments, and equipment to the Space Station and for returning equipment, waste products, and experiment results back to earth. The ULC will be 14 ft in diameter and have a variable length which can accommodate 58 different configurations for cargo support. When a pressurized environment is required, the PLC will be used; otherwise, the ULC will be the transporting carrier. The United States will be providing at least three PLCs, two ULCs, and two animal/specimen transport facilities (ASTFs).

The four resource nodes will connect all the pressurized modules. The following functions will be performed within these nodes: command and control, data management and communications, power utility distribution, water storage for thrusters, and Space Station and extravehicular activity. These nodes will be pressurized cylinders measuring approximately 14 ft in diameter and 17 ft in length.

Resource Node 1 is located between the U.S. and ESA Columbus Laboratory Modules and is attached to the hyperbaric airlock. It will function as the unmanned spacecraft control center and will be equipped with a berthing mechanism for attachment of the logistics module.

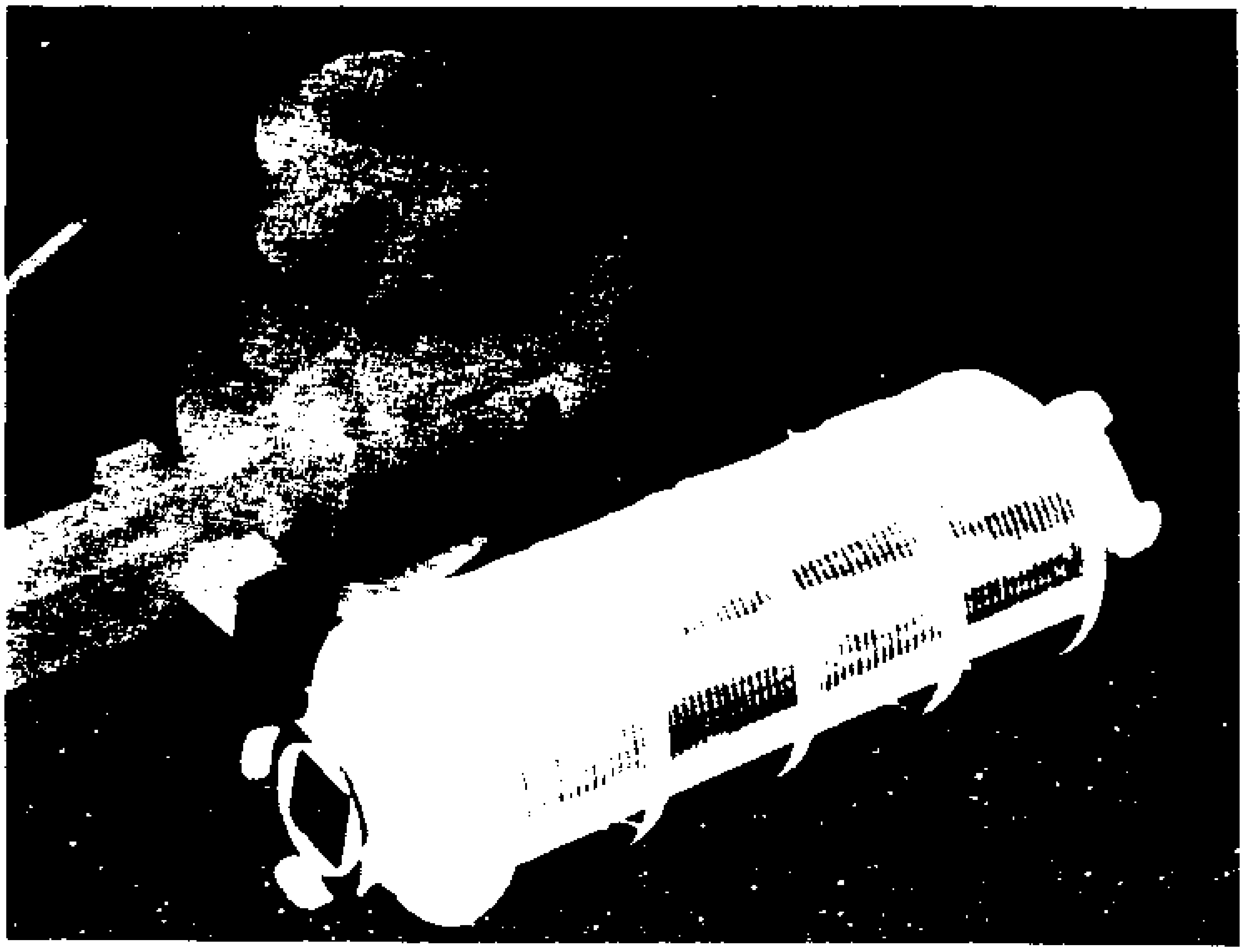
Resource Node 2 is located between the U.S. Habitation Module and the JEM and is attached to Node 1. It will function as the man-tended command and control station. Like Node 1, Node 2 will be equipped with a berthing mechanism for attachment of the logistics module.

Resource Node 3 is attached to the forward end of the U.S. Laboratory Module. It will function as the primary SSMB command and control station. Node 3 will be equipped with berthing mechanisms for attachment of the Space Shuttle and will also be provided with a cupola that enables spaceward viewing.

Resource Node 4 is located at the forward end of the U.S. Habitation Module and is attached to Node 3. It will function as the Mobile Servicing System (discussed later) control station, proximity operations station, and reserve volume. Like Node 3, Node 4 will be equipped with berthing mechanisms for Space Shuttle attachment and will be provided with a cupola, but this cupola will be oriented to enable earthward viewing.

The cupolas will be approximately 6 ft in diameter and over 3 ft in length. In addition to providing full spherical-viewing coverage, they will also be equipped with workstations for two crew members. At the cupolas, certain external SSMB support operations will be performed, i.e., support of EVAs, STS loading operations, and Flight Telerobotic Servicer (discussed later) control.

ESA COLUMBUS LABORATORY MODULE



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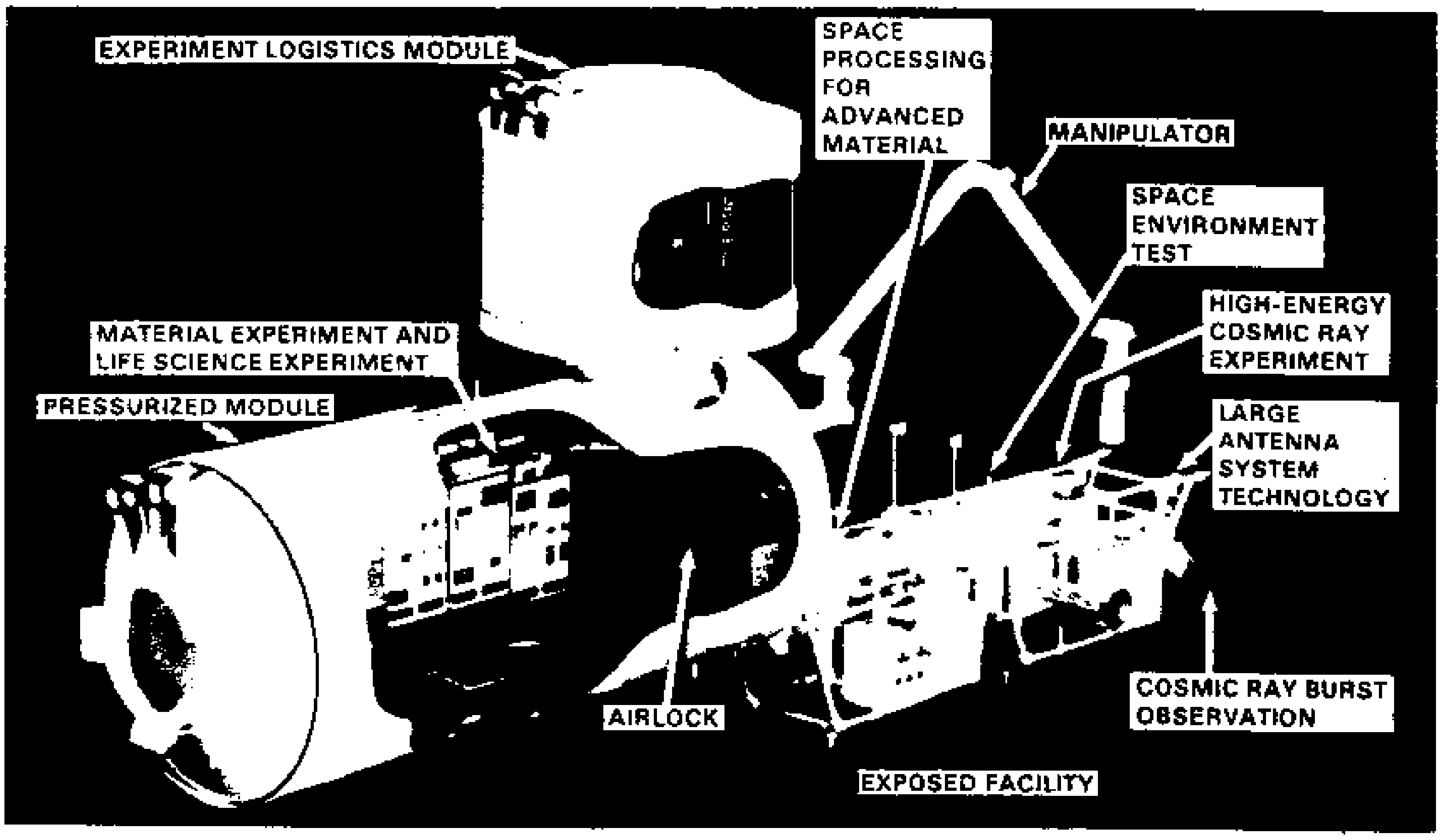
The ESA will build the Columbus Laboratory Module, which is 13 ft in diameter and 41 ft in length. It will be equipped with a docking and berthing mechanism and also windows and viewports. The module will contain a scientific airlock for experiments needing temporary exposure to vacuum.

The laboratory module can accommodate up to approximately 80 equivalent single racks for payloads, distribution system equipment, and storage. Approximately 40 single racks will be allocated exclusively for experiment use.

The Columbus Laboratory Module will be used primarily for basic life and materials sciences research and for fluid physics. The module will contain a fluid physics laboratory (four racks), a gravitational biology facility, biotechnology research facility (three racks), a biochemical and biological analysis facility, a metallurgy laboratory (three racks), a crystallization laboratory (three racks), a containerless processing laboratory (three racks), and a thermophysical properties measurement facility (one rack).

JAPANESE EXPERIMENT MODULE (JEM) WITH PAYLOAD ACCOMMODATION



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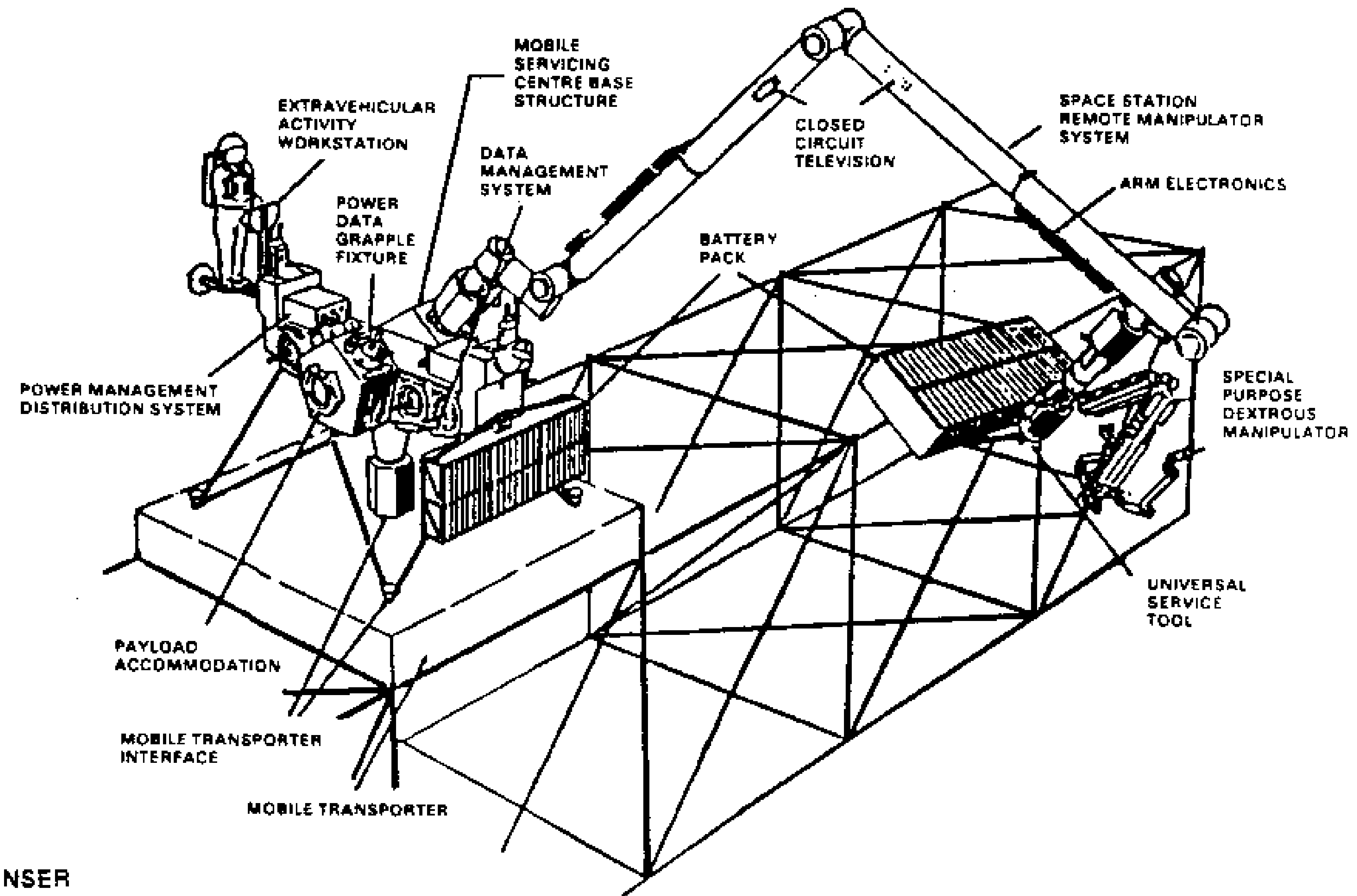
Japan's National Space Development Agency (NASDA) will provide the JEM, the Exposed Facility, and the ELM. The pressurized experiment module is 13 ft in diameter and 35 ft in length, while the exposed facility is 25 ft in length. An airlock connects the JEM and the exposed facility. The pressurized module will be equipped with windows and can accommodate 11 double racks to users for payloads and laboratory support equipment. Basic microgravity life and materials sciences experiments will be conducted in the pressurized experiment module.

The unpressurized exposed facility will be used for materials processing, earth observation, scientific observations, advanced technology development, and communications. Eight square meters of attached payload surface area will be available for users.

The ELM will transport and store supplies between earth and the Space Station as it is carried in the Shuttle payload bay. In the event of an on-orbit emergency, it can serve as a safe haven for up to two members of the crew.

CANADIAN MOBILE SERVICING CENTER



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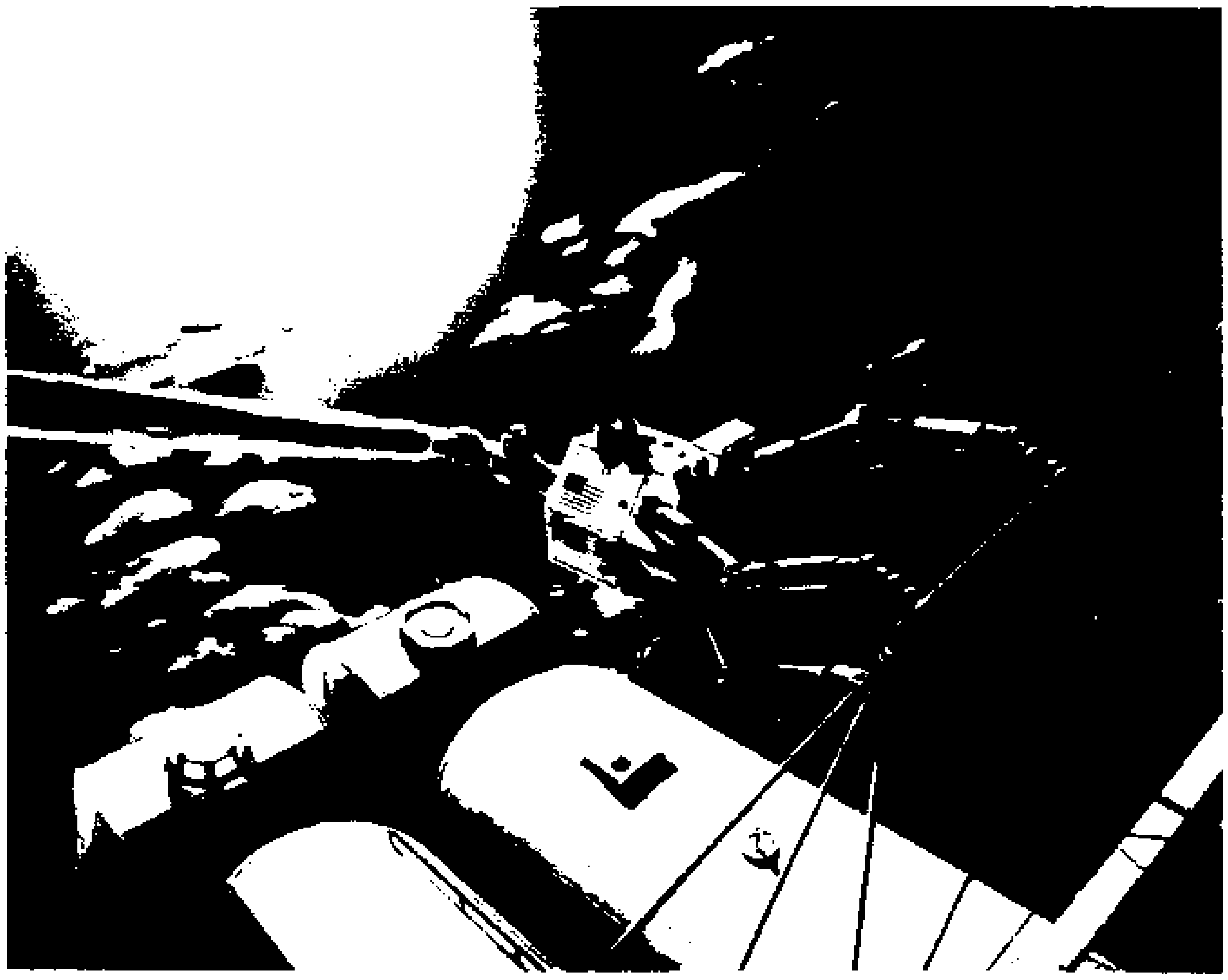
The Mobile Servicing System (MSS) is a highly automated tool for assembly, maintenance, and routine servicing of the Space Station and payloads. The MSS will support various major SSMB functions, i.e., SSMB assembly, SSMB maintenance, SSMB operations, and attached payload servicing. It will also mate all the logistics modules to the Space Station pressurized modules as they are removed from the Shuttle payload bay.

The MSS will be a teleoperated manipulator arm with the ability to move about the exterior of the Space Station. The primary element of the MSS is the Mobile Servicing Center (MSC), which comprises the Canadian Mobile Remote Servicer (MRS) and the U.S.-provided Mobile Transporter (MT). The MT will measure 16 ft x 20 ft in base and will provide mobility for the MRS. The MT will be capable of transporting the MRS along the main truss assembly and changing planes on the SSMB truss.

The MRS will consist of a 55 ft (17 m) Space Station Remote Manipulator System (SSRMS) and a Special Purpose Dextrous Manipulator (SPDM) for providing deployment and retrieval capabilities and also assembly, maintenance, and servicing capabilities. In addition, there will also be an EVA Work Station (EVA-WS) where an EVA astronaut will have limited control over the MSC. The SSRMS will be capable of carrying the EVA-WS when it is not attached to the MRS structure, and thus the SSRMS can provide an astronaut positioning capability. And finally, the MRS will consist of a Power Management and Distribution System (PMDS), Data Management System (DMS), and Communications System (CS).

In addition to the MSC, the MSS includes the MSC Maintenance Depot (MMD), a stationary facility (garage) providing maintenance and servicing of the MSC. The MMD serves as a storage facility for MSC Orbital Replacement Units (ORUs) and for off-loaded MSC systems and equipment.

FLIGHT TELEROBOTIC SERVICER (FTS)



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The Flight Telerobotic Servicer (FTS) is a highly automated telerobotic system which will be capable of performing hazardous and routine tasks, thereby increasing crew safety and reducing EVA time. An artist's concept is displayed in the above chart. It will be operated by both supervisory and autonomous control. Its capability of precise manipulations in space will aid in payload servicing and Space Station assembly by installing and removing truss members, installing truss fixtures, mating thermal utility connectors, changing out ORUs, etc. The FTS is part of an automation and robotics technologies development program directed by Congress.

Current plans are for FTS development to be completed in time for First Element Launch (FEL) of the Space Station assembly sequence to assist in and support SSMB assembly. Launch of the FTS is to occur no later than the second assembly flight.

Platforms

SPACE STATION PROGRAM POLAR PLATFORMS AND MAN-TENDED FREE-FLYER

- SPACE STATION INCLUDES TWO UNMANNED POLAR PLATFORMS AND A MAN-TENDED FREE-FLYER
- PLATFORMS WILL BE USED FOR RESEARCH, EARTH AND ASTRONOMICAL OBSERVATIONS, AND COMMERCIAL ENDEAVORS
- CANADA, ESA, AND JAPAN ARE INTERESTED IN PLATFORMS FOR EARTH OBSERVATIONS, ASTRONOMY, AND MATERIALS PROCESSING
- NOAA HAS EXPRESSED INTEREST IN A DEDICATED PLATFORM OR SHARING WITH NASA
- GODDARD WORK PACKAGE INCLUDES DEFINITION, DEVELOPMENT, UTILIZATION, AND SERVICING OF PLATFORMS

NASA HAS MADE A COMMITMENT TO CONGRESS THAT
PLATFORMS WILL BE
"PART AND PARCEL OF THE SPACE STATION"

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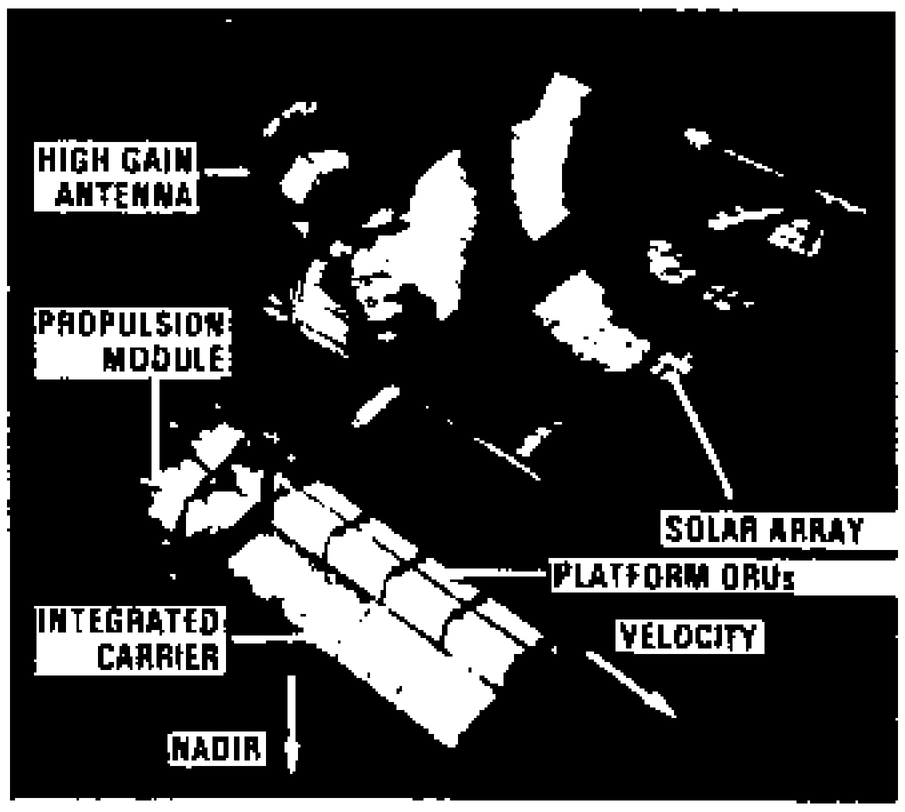
The Space Station Program includes two unmanned polar orbiting platforms. The United States and the ESA will each build one. These platforms will be used for long-duration autonomous scientific, technological, and commercial ventures. The ESA will also provide a Man-Tended Free-Flyer (MTFF).

The inclusion of platforms as part of the Space Station complex has generated domestic and foreign user interest. The NASA Goddard Space Flight Center is the focus of platform activity in the United States, and the ESA is the focus in Europe.

U.S. SPACE STATION POLAR ORBITING PLATFORM

- DESIGNED FOR EARTH OBSERVATIONS
- ORBIT ALTITUDE: 500 TO 900 KM (OPERATIONAL)
  - —INCLINATION 98° (APPROXIMATELY)
  - —SUN SYNCHRONOUS
- DEPLOYMENT ALTITUDE: 240 KM
- SERVICING ALTITUDE: HIGHER THAN 240 KM
- LAUNCH SEQUENCE: 4TH QUARTER 1995
- LAUNCH VEHICLE: STS AND PLATFORM PROPULSION
  OPTION: ELV AND PLATFORM PROPULSION (INITIAL DEPLOYMENT)
- PEAK DATA RATE: 300 MBPS
- SERVICING: AFTER 1-2 YEARS TO ADD PAYLOAD AND EXCHANGE PROPULSION MODULE IF STS LAUNCHED
- LONG MISSION LIFE: UP TO 15 YEARS WITH SERVICING
- USER REQUIREMENTS: MISSION REQUIREMENTS DATA BASE



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The U.S. Polar Orbiting Platform (POP), depicted above, is a self-contained free-flyer. It will operate in a sun-synchronous circular orbit at a 98.8° inclination. Its operational orbit will be 500 to 900 km (270 to 486 NM), with a nominal orbit of 445 NM (824 km). This orbit will allow complete and repetitive coverage. Every day, at the same time, the platform will fly over the same location on the earth's surface. Overall, it will be approximately 14.3 ft (4.4 m) in diameter and 39.4 ft (12 m) in length. It is powered by a single-wing solar array. The U.S. POP comprises a propulsion module, primary carrier, and supplemental carriers to support users' needs. Accommodations for payloads and resource ORUs will be on the primary and supplemental carriers. The POP's distributed system will include the electrical power system; the thermal system; the data management system; the communications and tracking system; and the guidance, navigation, and control system.

The U.S. POP was conceived to support a variety of missions. Some of these include earth lower- and upper-atmospheric monitoring; earth biological, oceanographic, and geological observations; solar observations; ice activity studies; and research and plasma physics measurements.

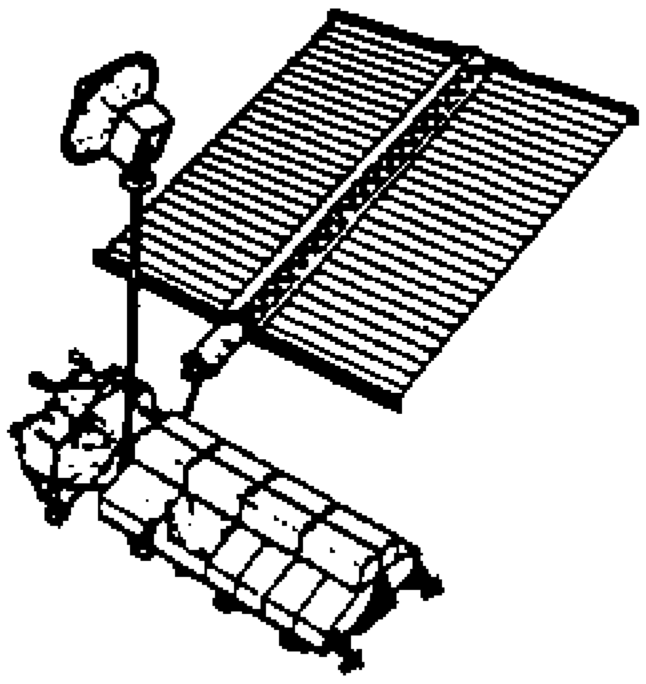
U.S. SPACE STATION POLAR PLATFORM SYSTEM DEFINITION

PLATFORM SYSTEM

- SPACECRAFT WEIGHT
  - —DRY WEIGHT (WITHOUT PAYLOAD) 6,626 KG (14,608 LB)
  - —PROPELLANT WEIGHT 2,266 KG (4,995 LB)
- POWER—SOLAR PANEL—5kW
- STABILIZATION—MOMENTUM WHEELS AND MAGNETIC TORQUERS
- DATA MANAGEMENT—REAL TIME (TDRSS) AND STORAGE
- THERMAL CONTROL —ACTIVE 2-PHASE FLUID
- EXPERIMENT INTERFACE—STANDARD PAYLOAD MOUNTING PLATE (28.5 IN X 58 IN)
- THE PLATFORM WILL BE SERVICED BY AN ELV OR THE STS WITH RENDEZVOUS OCCURRING BY AN OMV OR A PROPULSION MODULE ON THE PLATFORM

EXPERIMENT SUPPORT CAPABILITY

- PAYLOAD WEIGHT—3,500 KG (7,716 LB)
- ELECTRICAL POWER—3.2 kW
- ATTITUDE CONTROL (PAYLOAD PLATE)
  - —POINTING CONTROL—108 ARC-SEC
  - —POINTING KNOWLEDGE—36 ARC-SEC
  - —POINTING STABILITY—1 ARC-SEC (FOR 1 SEC)
- DATA MANAGEMENT—REAL TIME (TDRSS)—300 MBPS MAX LIMIT
  - —AGGREGATE PAYLOAD—20 MBPS (ENTIRE ORBIT)
  - —HIGH-RATE CAPABILITY—300 MBPS PEAK (PART ORBIT)
  - —DATA VOLUME—5×10^{11} BITS
- THERMAL CONTROL—20-25°C TO PAYLOAD INTERFACE
- ORBIT- 98.8° INCL—445 NM (824 KM) ALT



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The U.S. POP configuration and selected capabilities are depicted in the above chart. The total weight of the platform (including propellant and payload) is approximately 27,000 lb (12,000 kg). The U.S. POP is equipped with standard payload mounting plates that can each accommodate up to 204 kg of payload. The aggregate payload mass available to the user is 3,500 kg. An average of 2 kW of electric power and 2.5 kW of peak power can be provided to the individual plates, but the total payload power cannot be more than 3.2 kW of continuous average electric power or 4.2 kW of peak power. A planar, photovoltaic cell array generates the power.

The polar platform has a data and information subsystem (DIS) which can accommodate data rates ranging from several kbps to 300 Mbps. The TDRSS will handle all space-to-ground communications. Should a TDRSS downlink be missed, the DIS provides a total mass storage of 5×10^{11} bits to reduce the probability of losing data.

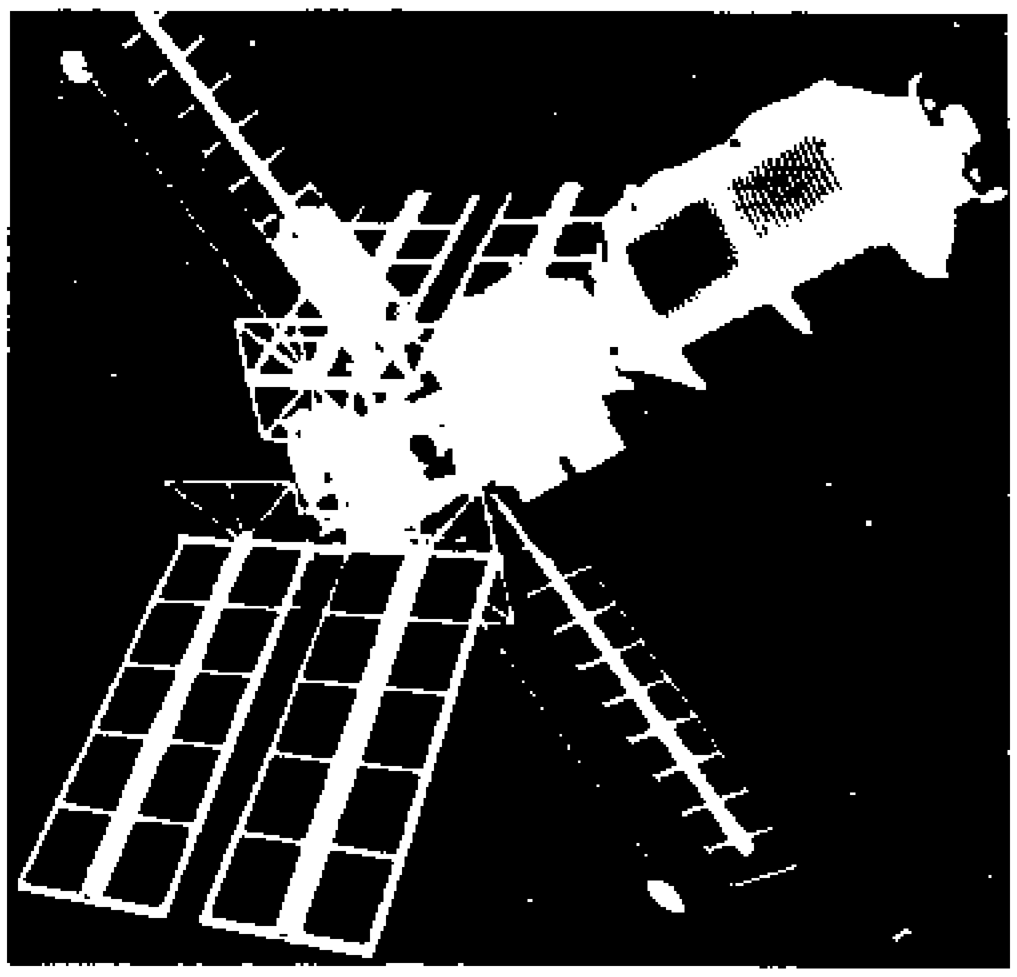
The platform also has a thermal subsystem which provides both passive and active thermal control. A two-phase fluid (ammonia) subsystem provides the active thermal control to the payloads. It rejects up to 75 percent of the total payload heat because these payloads are mounted on cold plates. The remaining 25 percent is passive heat rejection. A temperature of 20 to 25°C is maintained at the payload interface.

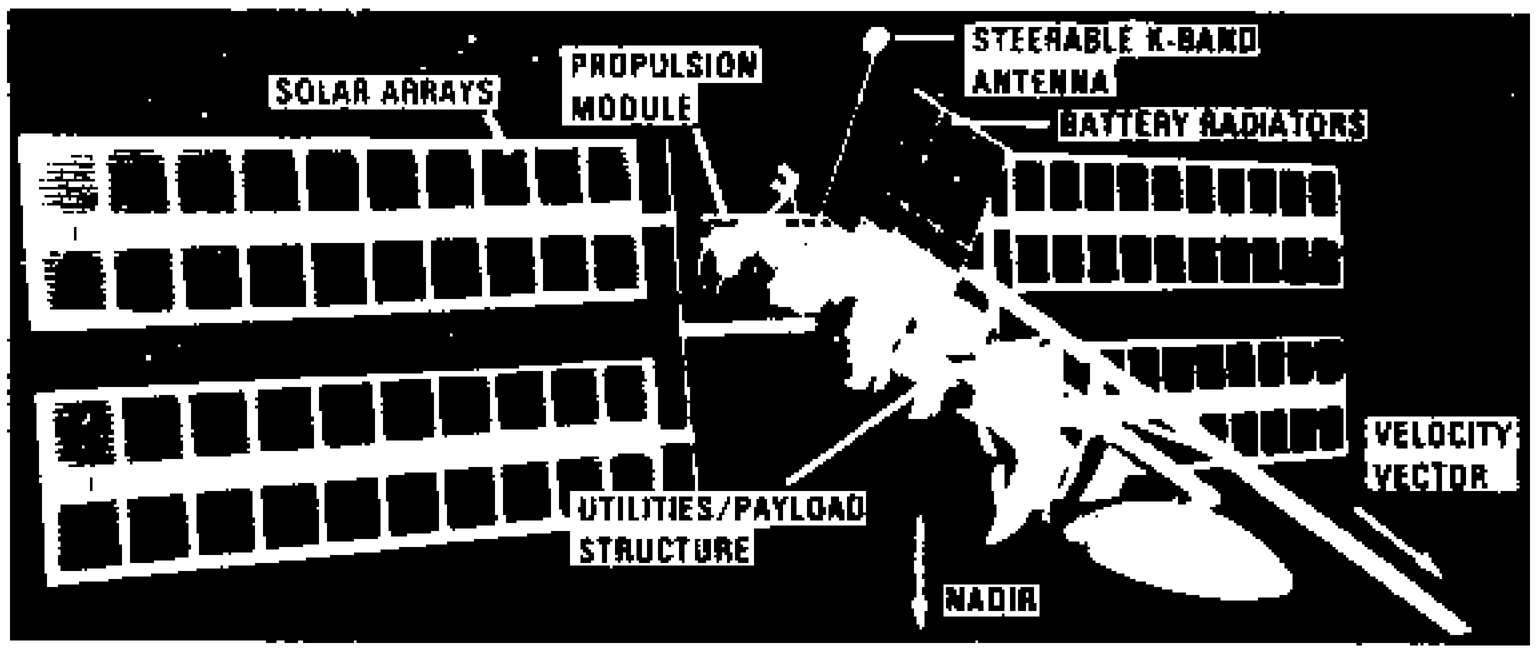
As a result of the mothballing of the Space Shuttle launch facilities at Vandenberg Air Force Base (VAFB), the Space Station program is carrying two deployment scenarios for the U.S. POP. The baseline deployment is with the Space Shuttle, while the alternate deployment scenario uses a Titan IV. Because of this, the platform is being designed with a dual-launch capability.

The platform is to be revisited periodically to change out those instruments having completed their mission. Servicing missions also include replenishing the POP's fuel and replacing failed payloads or ORUs. To facilitate servicing, instruments are packaged in ORUs. Engineers at the NASA Goddard Space Flight Center envision a servicing and change-out mission every 2 years. However, tradeoff studies between servicing and reliability are under way to examine the possibility of servicing missions every 3 to 5 years.

The baseline revisit scenario uses the OMV to deboost the platform from the mission orbit to LEO for servicing by the Space Shuttle. An alternate scenario being considered requires the platform to contain a propulsion module to deboost it for servicing and reboost it to the mission orbit. Also, a study under way addresses servicing of the platform with an ELV (e.g., a Delta rocket) as opposed to the baseline Shuttle. The final selection of the platform deployment and servicing methods is still to be made.

ESA MAN-TENDED FREE-FLYER AND POLAR PLATFORM





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The ESA Polar Platform (PPF) is an unmanned, free-flying spacecraft operating at low-earth, sun-synchronous orbit with an operational altitude of 850 km. This platform will have the same orbit as that of the U.S. POP but will operate independently of it. It will support primarily earth observation payloads. Its reference configuration is illustrated above. Unlike the U.S. platform, it has a two-wing solar array. It is 67 ft (20 m) long, 210 ft (64 m) wide (from tip to tip of the two solar arrays), and 50 ft (15 m) high (to the top of the antenna mast). Two design concepts are being considered. One major difference is whether the utility and payload modules should be separate or part of an integral structure. The mass of the separate modules concept, estimated at 1,020 kg, is the preferred and reference design. The mass of the integral structure concept is estimated to be 800 kg. The ESA is also considering redesigning this 14-year operational, serviceable platform to a 4-year operational, non-serviceable platform. A final decision as to the actual configuration will be made at a later date.

The ESA platform will be launched by an Ariane 5. (Ariane 5s are scheduled to become available in 1995.) If serviceable, it will be serviced like the U.S. POP. ESA's Data Relay Satellite (DRS) system and NASA's TDRSS will be the platform's baseline communications systems.

The ESA Man-Tended Free-Flyer (MTFF) is a pressurized laboratory capable of operating separate from or attached to the SSMB. Its missions include long-duration microgravity research in materials, life sciences, and fluid physics. It will be unmanned while operating in a Space Station compatible orbit. Its reference configuration is depicted above. The MTFF is 23 ft (7 m) long and consists of a two-segment pressurized module [13 ft (4 m) in diameter], an externally attached unpressurized resource module, two end cones, solar arrays, and a deployable antenna. The pressurized module will carry the payloads. Also, it is equipped with single and double racks (maximum of 40 single-equivalent racks) and a work bench for the crew during its servicing period. The forward cone will contain an SSMB/Hermes spaceplane-compatible docking port, whereas the aft cone will be closed with a bulkhead. The unpressurized resource module will provide communications, control, and power to the MTFF.

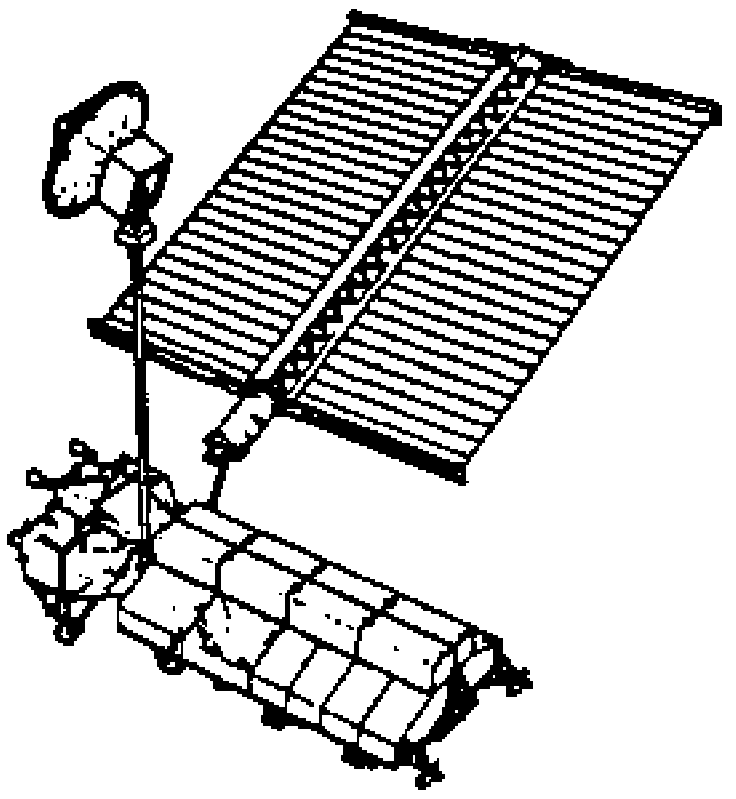
Likely research areas for the MTFF will include material processing crystal growth, protein crystal growth, plant growth, cell growth, and small animal behavior and reproduction studies.

Like the ESA platform, the MTFF will also be launched by an Ariane 5 and will utilize the ESA's DRS system and NASA's TDRSS as its baseline communications systems. Unlike the ESA platform, the MTFF will be serviced periodically at the SSMB or by the European Hermes Spaceplane. (The first unmanned French Hermes flight is scheduled for 1996, whereas the first manned flight with a crew of three is scheduled for 1997.) The Hermes is expected to visit the MTFF once every 6 months. The MTFF will have its first Space Station servicing not earlier than 1 year following on-orbit assembly completion. First SSMB servicing of the MTFF is currently scheduled for June 1998. Frequency of Space Station servicing of the MTFF is being debated, with the time between servicing missions ranging anywhere from 6 months to 4 years.

SPACE STATION POLAR PLATFORM AND MTFF MANAGEMENT CONCEPT, AVAILABILITY

MANAGEMENT CONCEPT

- POLAR PLATFORM WILL BE MANAGED BY NASA SPACE STATION PROGRAM
- MISSION AND DATA MANAGEMENT WILL BE CONDUCTED FROM A PLATFORM OPERATIONS CENTER
- OPERATIONALLY THE POLAR PLATFORM WILL BE GROUND-BASED RATHER THAN SPACE STATION-BASED
- ALL USERS WILL HAVE ACCESS TO THE PLATFORM ON THE SAME BASIS AS ACCESS TO THE SHUTTLE OR SPACELAB



AVAILABILITY

- LAUNCH OF U.S. POLAR PLATFORM PLANNED FOR 1995
- LAUNCH OF ESA POLAR PLATFORM PLANNED FOR 1997
- LAUNCH OF ESA MTFF PLANNED FOR 1998
- U.S. PLATFORM COMPATIBLE WITH USER-PROVIDED ENCRYPTED DATA/COMMANDS (USER MUST PROVIDE ENCRYPTION/DECRYPTION)

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The U.S. POP could be attractive to the DOD. It will be managed and controlled by NASA, with availability and access on the same basis as the Shuttle or Spacelab. The polar platform will be managed from the ground, with access either from the Shuttle or from an ELV. The U.S. platform will not provide encrypted up- or downlinks; however, it is compatible with user-provided encrypted data and commands. That is, the user must provide encryption and decryption.

Launch of the U.S. POP is planned for the fourth Quarter 1995 (October 1995), with the European polar platform being launched in early 1997 (March 1997), and the MTFF in early 1998. The U.S. and ESA platforms will operate independently of one another. A separate ESA control center will control the ESA platforms. While the ESA platform and MTFF are in free-flying mode, the ESA will manage their operations, but while they are being serviced by the STS or the Space Station, NASA will manage their operations.

SPACE STATION POWER BUDGET

	IOC STATION AVERAGE (kW)
• TOTAL STATION	75
—USERS OF STATION	37.5
• U.S. POLAR PLATFORM	5
—USERS OF POLAR PLATFORM	3.2
• ESA POLAR PLATFORM	14 EST
—USERS OF POLAR PLATFORM	3-3.5 EST
• ESA MAN-TENDED FREE-FLYER	7-12(?)
—USERS OF FREE-FLYER	5

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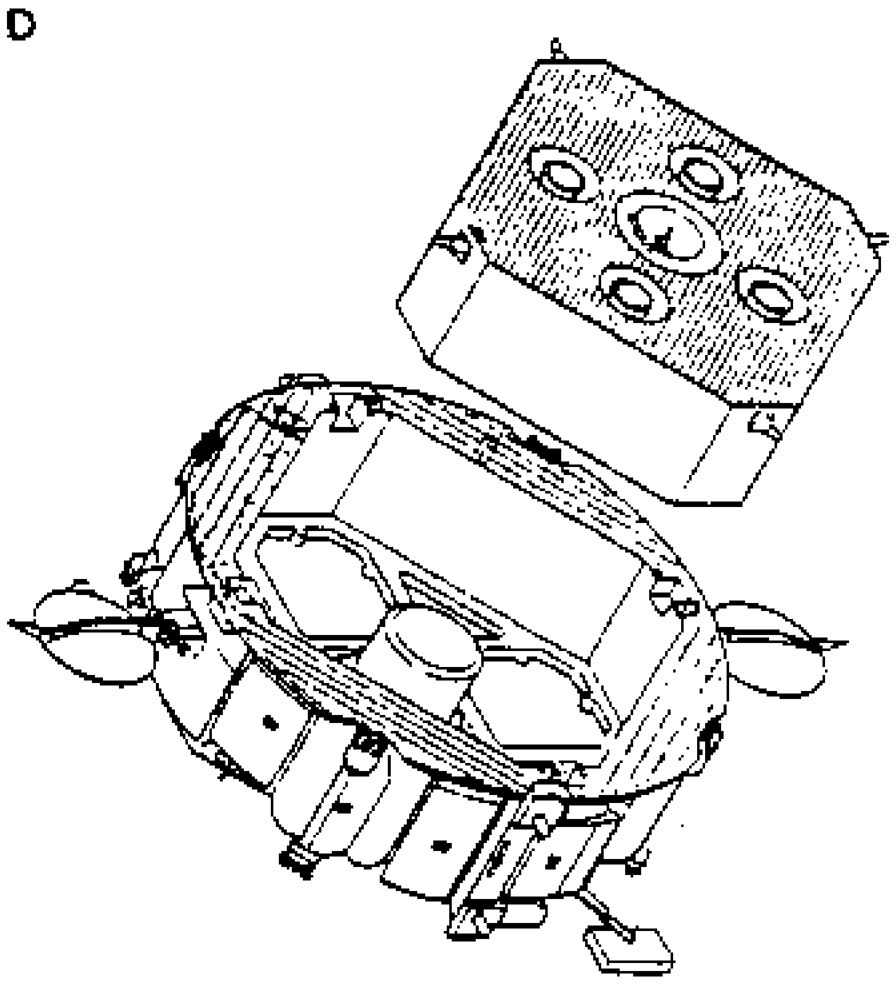
Shown on this chart is the power budget for the IOC Space Station. The initial station will provide 75 kW of power, half of which will be available for users. It should be emphasized that the SSMB's power availability has not been finalized. Some recent studies indicate that it may require up to 50 kW of power for housekeeping alone, which would leave only 25 kW to the users. This would produce an extremely limited Space Station capability. As a result, NASA is investigating a 95 kW station power capability, with 50 kW designated for housekeeping and 45 kW for station users.

The IOC U.S. POP will provide 5 kW, 3.2 kW of which will be available for users. The power budgets for the ESA polar platform and MTFF listed above are rough estimates, since the final ESA platform configurations have not been selected.

Growth is planned for the Space Station and platforms, but potential future capacity is unknown at present. (The Nation's long-term space program goals must be clarified before enhanced Space Station capabilities can be finalized.)

ORBITAL MANEUVERING VEHICLE (OMV)

- MANAGED BY NASA OFFICE OF SPACE FLIGHT (NOT BY SPACE STATION OFFICE)
- TRW SELECTED IN JUNE 1986
- CONTRACT FOR ONE OMV WITH OPTION FOR A SECOND
- OMV CHARACTERISTICS
  - —REMOTELY CONTROLLED
  - —ABOUT 5 FEET DEEP (56 INCHES)
  - —ABOUT 15 FEET IN DIAMETER (176 INCHES)
  - —18,000 LB FULLY LOADED WEIGHT
  - —DESIGN LIFE OF 10 YEARS
  - —INITIALLY DEPLOYED FROM SHUTTLE
  - —LATER SPACE STATION-BASED
  - —FIRST FLIGHT FROM SHUTTLE IN JUNE 1993
- OMV WILL BE USED TO TRANSFER (DEPLOY/RETRIEVE) SATELLITES TO HIGHER ORBIT (EXTENDS SHUTTLE REACH BY 1,000 NAUTICAL MILES). ALSO USED TO REBOOST SATELLITES IN DECAYING ORBITS, REFUEL AND OTHER SERVICING



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In June 1986, NASA selected TRW to build the OMV. Contract negotiations were for one OMV, with an option for a second dedicated to the Space Station. The dimensions and configuration are displayed on the above chart.

The OMV's Preliminary Design Review (PDR) occurred in June 1988. The Critical Design Review (CDR) will take place next year. The OMV's first test flight has been scheduled for June 1993, in time for Space Station support in January 1994.

The OMV is a reusable, remotely controlled free-flyer capable of deploying and retrieving satellites to and from orbits beyond the operating range of the Shuttle, reboosting satellites in decaying orbits, conducting refueling and servicing missions, and providing the energy and control required to bring ELV-launched payloads from a safe parking orbit to the station for routine logistics support.

Initially, the Space Shuttle will carry the OMV to orbit and return it to earth following each mission.

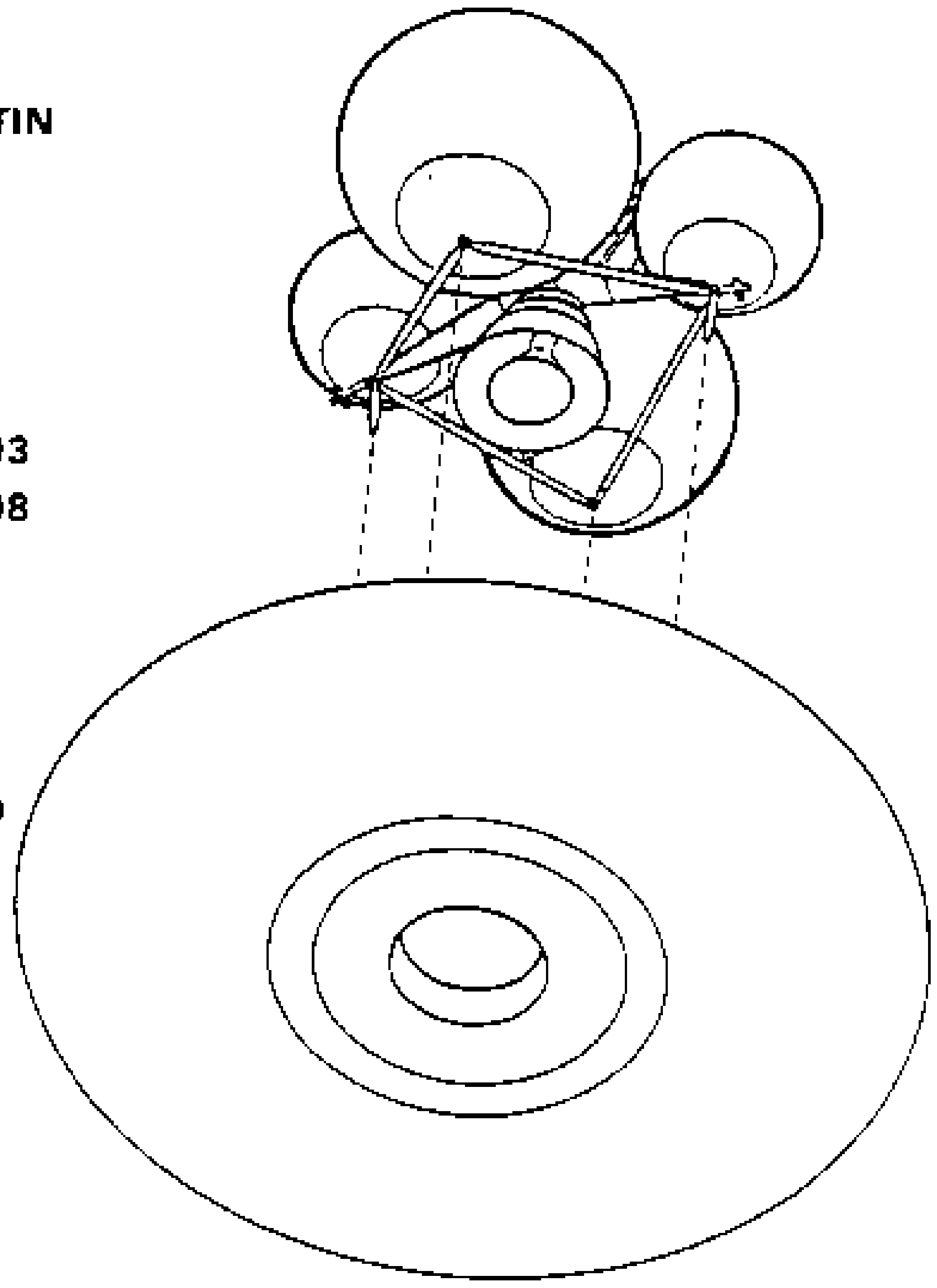
Future scenarios visualize a space-based OMV in standby condition utilizing add-on solar panels. The space-based OMV could be reactivated from the Space Station or the ground. Permanent housing accommodations for the OMV at the Space Station are under consideration.

When missions require that the OMV operate in polar orbit, it is more efficient to launch the OMV directly to that orbit. Due to the mothballing of the STS launch facility at VAFB, a dual-launch capability for the OMV is being considered in order to place it into polar orbit. Modifications of the OMV for a Titan IV launch from VAFB would assist in servicing U.S. surveillance and communications satellites. This capability could be of interest to the DOD.

Depending on the weight of the payloads, the OMV's maximum operating range is approximately 1,000 NM. As a result, servicing spacecraft in place becomes feasible and highly advantageous. Spacecraft downtime required for servicing is significantly reduced. In-place servicing should take only a few hours, whereas several days may be required to service a spacecraft which first needs to be brought down to a servicing altitude (e.g., the STS altitude), then serviced and refueled, and finally returned to its operational orbit. In-place servicing has also been shown to be cost-effective.

It is possible for the OMV to go from the Shuttle to geosynchronous orbit with about a 1,000 lb payload, but it would require replacing the OMV's 9,000 lb tank of bipropellants with a larger 36,000 to 40,000 lb tank. As described next, the Space Transfer Vehicle would be more appropriate for attaining these altitudes.

SPACE TRANSFER VEHICLE (STV)



- STUDIED AT NASA's MSFC WITH BOEING AND MARTIN MARIETTA SUPPORT
- ADDRESSED BY STAS
- POTENTIAL SCHEDULE

REQUIREMENTS AND ANALYSIS	IN PROGRESS
SYSTEMS DEFINITION	THROUGH 1993
DEVELOPMENT	THROUGH 1998
INITIAL OPERATING CAPABILITY	2000

- CAPABILITY (TYPICAL)

MISSION	WEIGHT
GEO	13,000 LB, 0 LB RETURNED
GEO	12,000 LB, 2,000 LB RETURNED
GEO (MANNED)	7,500 LB, 7,500 LB RETURNED

- FLEET SIZE: 2 FOR GEO TRAFFIC
- BASELINE STV PRELIMINARY DESIGN PRESENTED AT SPACE STATION SRR

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Present planning anticipates the Space Transfer Vehicle (STV) [formerly known as the Orbital Transfer Vehicle (OTV)] development to take place several years after the OMV and to be operational in about the year 2000. A baseline STV preliminary design was presented to the Space Station Systems Requirements Review (SRR) Group to focus on interface compatibility issues between the STV and the Station. The final configuration is by no means near completion. The STV configuration and requirements are still being studied. Phase A (Requirements and Architecture) studies are being conducted by NASA. A potential development schedule shows Phase B (Definition and Preliminary Design) studies being completed around 1993, Phase C and D (Detailed Design and Development) taking place from 1994 to 1998, test flight occurring in 1999, and an operational phase beginning in late 1999 or early 2000.

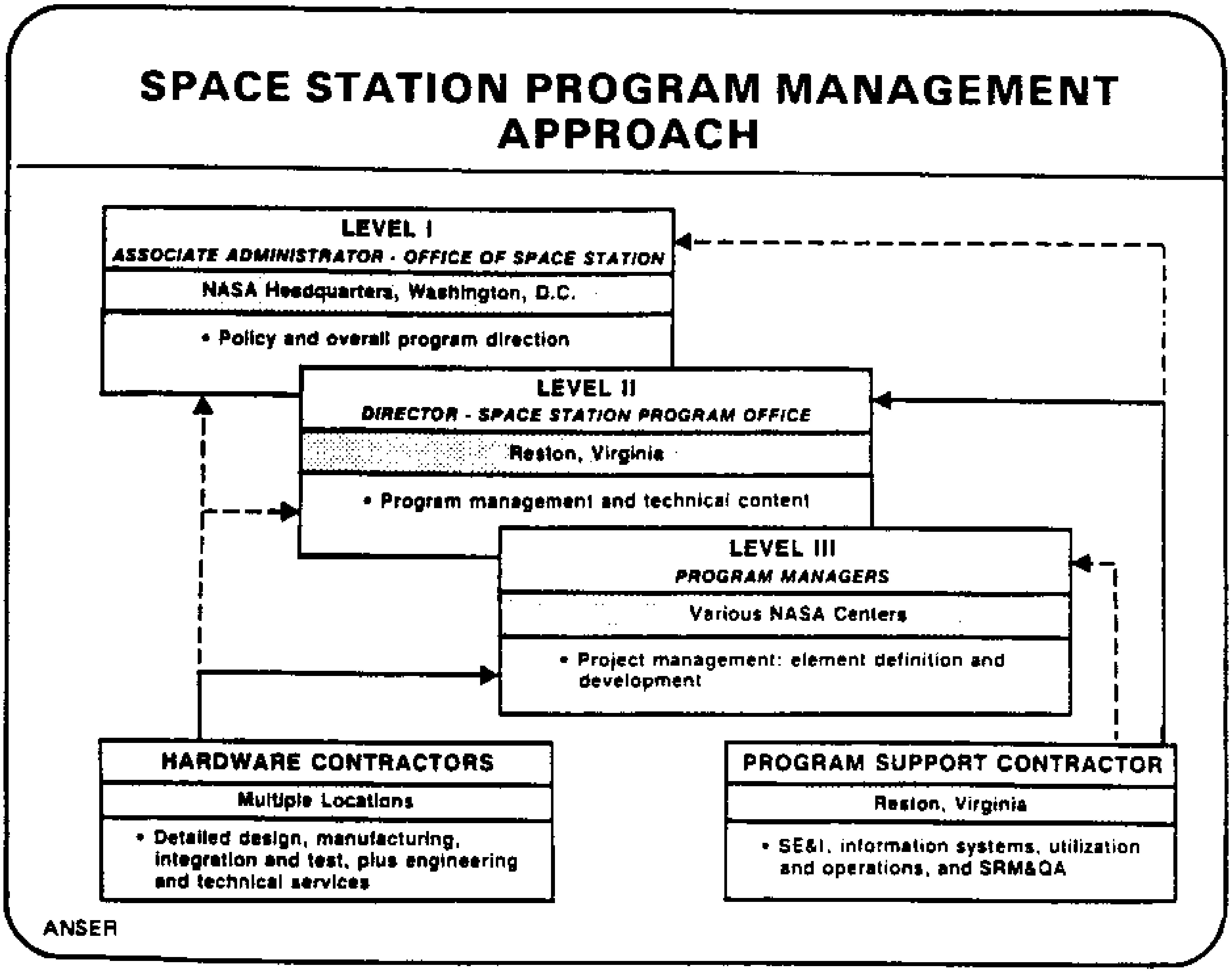
Under the Space Transportation Architecture Study (STAS), a variety of STV reference configurations were considered, from the totally expendable to the fully reusable. Implemented technologies also varied with storable versus cryogenic propellants to provisions for aerobraking. With wide variety of potential STV concepts, no final configuration has been selected.

The STV configuration illustrated on the chart proposes the following characteristics: a reusable vehicle, a 40-mission life, space serviceable, advanced cryogenic engines, and utilizing aero-assist technology. A man-rated full-redundancy vehicle includes an engine-out capability. The planned propulsion capability of the proposed STV would be sufficient to carry a manned mission of from two to four astronauts to geosynchronous orbit (19,300 NM) for satellite servicing, maintenance, and repair missions, greatly exceeding the performance of the OMV. (Other configurations are also being considered for transporting crew or cargo from LEO to the Moon's surface or to operate as an "Earth-to-Mars cycling spaceship.")

Cost savings associated with a space-based STV compared with a ground-based system were addressed by STAS. Preliminary results indicated that there is no real difference between the two. The economic impact of using the STV for on-orbit servicing, maintenance, and repair is an unresolved issue.

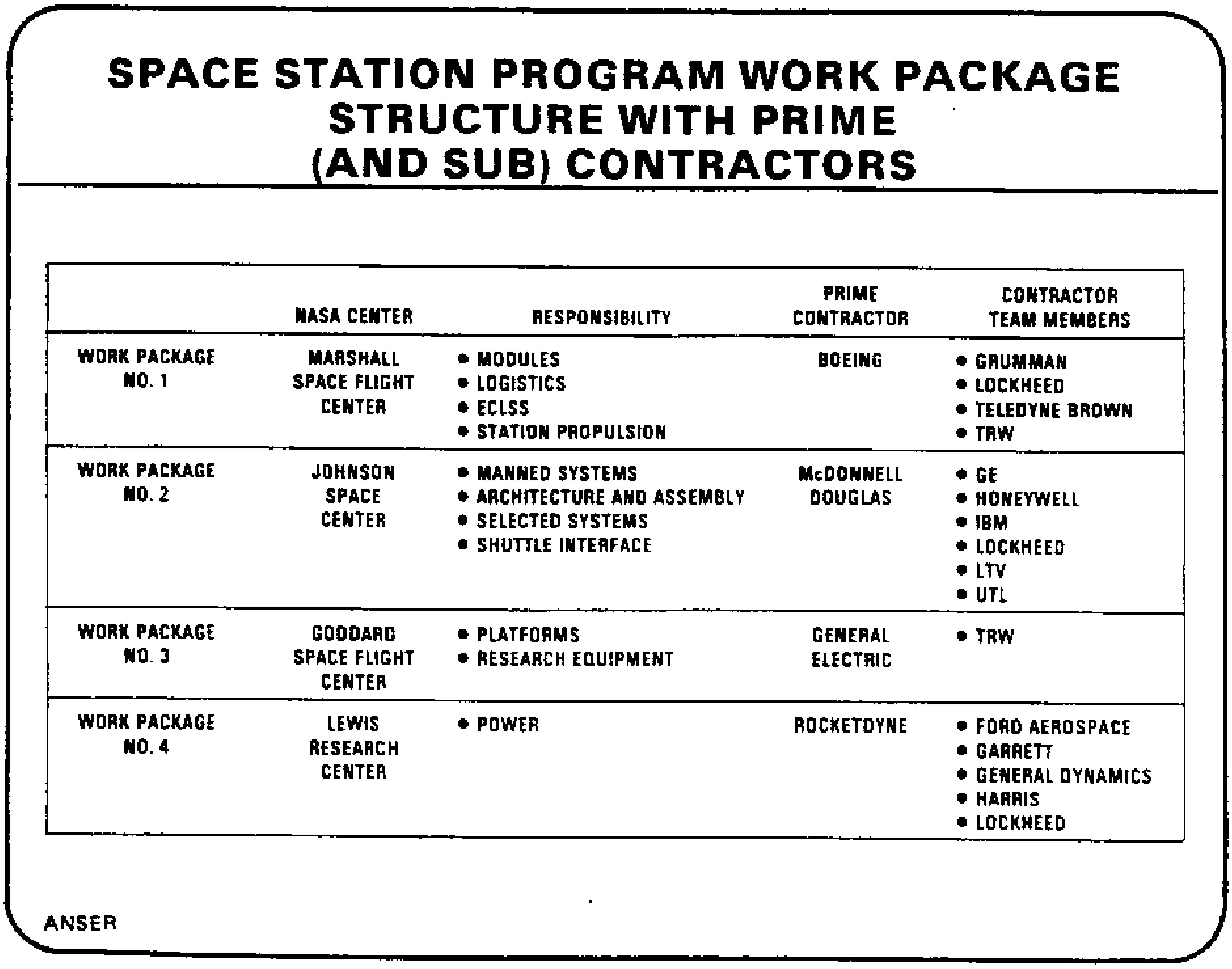
One STV payoff is the ability to provide a large payload capability to high earth orbit (HEO). This enables construction of large structures (e.g., antennas) in LEO with later transfer to HEO. An STV "smart front end" for performing repairs would be provided from the OMV technology base.

B. NASA Management



Program management for the NASA Space Station is conducted at three main levels. Level I, the Office of the Associate Administrator for the Office of Space Station (OSS) at NASA Headquarters in Washington, DC, is responsible for overall management and strategic planning. Level II, the Space Station Program Office in Reston, VA, is responsible for program-level systems engineering and integration. The Level II integration function is critical in light of the multiple U.S. contractors and international partners. Level III comprises Space Station Project Offices at each of four NASA development centers and the Kennedy Space Center. The development centers are responsible for the four Work Packages which represent the major portion of the Space Station hardware. Principal responsibilities include Design, Development, Testing and Evaluation (DDT&E); element, evolution, and engineering support; and operation of hardware and software systems.

For completeness, there is also a Level Zero (the NASA Administrator) at NASA Headquarters in Washington, where other elements of the Space Station support infrastructure (transportation, communications, and life sciences) are integrated. And, finally, Level IV consists of the contractors supporting the Space Station Work Packages.



SPACE STATION PROGRAM WORK PACKAGE STRUCTURE WITH PRIME (AND SUB) CONTRACTORS

	NASA CENTER	RESPONSIBILITY	PRIME CONTRACTOR	CONTRACTOR TEAM MEMBERS
WORK PACKAGE NO. 1	MARSHALL SPACE FLIGHT CENTER	• MODULES • LOGISTICS • ECLSS • STATION PROPULSION	BOEING	• GRUMMAN • LOCKHEED • TELEDYNE BROWN • TRW
WORK PACKAGE NO. 2	JOHNSON SPACE CENTER	• MANNED SYSTEMS • ARCHITECTURE AND ASSEMBLY • SELECTED SYSTEMS • SHUTTLE INTERFACE	McDONNELL DOUGLAS	• GE • HONEYWELL • IBM • LOCKHEED • LTV • UTL
WORK PACKAGE NO. 3	GODDARD SPACE FLIGHT CENTER	• PLATFORMS • RESEARCH EQUIPMENT	GENERAL ELECTRIC	• TRW
WORK PACKAGE NO. 4	LEWIS RESEARCH CENTER	• POWER	ROCKETDYNE	• FORD AEROSPACE • GARRETT • GENERAL DYNAMICS • HARRIS • LOCKHEED

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Program management responsibilities are further delineated on the chart above in terms of Work Packages (WPs) and assigned Space Station elements being managed by each of the four NASA development centers (Level III). These efforts at the centers are coordinated by the Space Station Program Office (Level II). The prime contractor for each WP and the major subcontractors are also shown here.

In summary, Marshall Space Flight Center is responsible for the U.S. Laboratory and Habitation Modules, the resource node primary structure fabrication, and logistics elements. The Johnson Space Center is responsible for the Station's external truss, EVA systems, airlock, distributed subsystems, and resource node design and outfitting. The Goddard Space Flight Center is responsible for the U.S. POP, attached payload accommodations, and servicing capability. The Lewis Research Center is responsible for the Space Station's power systems.

The four WPs do not represent the entire Space Station program contractual effort in terms of design, development, and integration. Additional contracts support the development work, contribute to the operations and utilization capability, launch Space Station hardware, and participate in management and integration activities. Also, non-WP centers such as the Kennedy Space Center, Langley Research Center, and the Jet Propulsion Laboratory will have Space Station responsibilities. Finally, the ESA, Canada, and Japan will also be developing their own elements.

Three separate procurements were conducted to support the Space Station detailed design and development phase. The Technical Management and Information System (TMIS) contract was awarded to Boeing Computer Services Company, the Software Support Environment (SSE) contract was awarded to Lockheed Missiles and Space Company, and the Program Support Contract (PSC) was awarded to Grumman Aerospace Company. The TMIS will support program control and engineering. The SSE will establish a set of tools and rules for Space Station software. And the PSC is responsible for systems engineering and integration (SE&I); information systems; utilization and operations; and safety, reliability, maintainability and quality assurance (SRM&QA).

A separate procurement for the Flight Telerobotic Servicer (FTS) will be made after a Request for Proposals (RFP) for detailed hardware design and development is issued later this year. Goddard Space Flight Center is project manager for the FTS, and Grumman Space Systems and Martin Marietta Astronautics are the competing major contractors. Each completed a 9-month FTS definition and preliminary design (Phase B) study in August 1988.

SPACE STATION PROGRAM

LONG-RANGE PLANNING FOR INTERNATIONAL COOPERATION

GOALS

- DEVELOP A SINGLE, INTEGRATED SPACE STATION WHOSE CAPABILITIES ALL WILL SHARE
- ACHIEVE A GENUINE PARTNERSHIP BETWEEN U.S., CANADA, ESA, AND JAPAN

APPROACH

- INCORPORATE INTERNATIONAL PARTICIPANTS EARLY ON IN U.S. PLANNING
- ENCOURAGE PARTNERS TO DEVELOP SPACE STATION USER INTERESTS
- HAVE PARTNERS PARTICIPATE IN PROGRAM ACROSS THE BOARD
  - USERS
  - OPERATIONS
  - ENGINEERING
- EXCHANGE ONLY TECHNICAL INFORMATION NECESSARY TO ASSURE COMPATIBILITY OF SYSTEMS
- EXPECT INTERNATIONAL PARTNERS TO ASSUME FULL FINANCIAL AND TECHNICAL RESPONSIBILITY FOR THEIR SPACE STATION ELEMENTS

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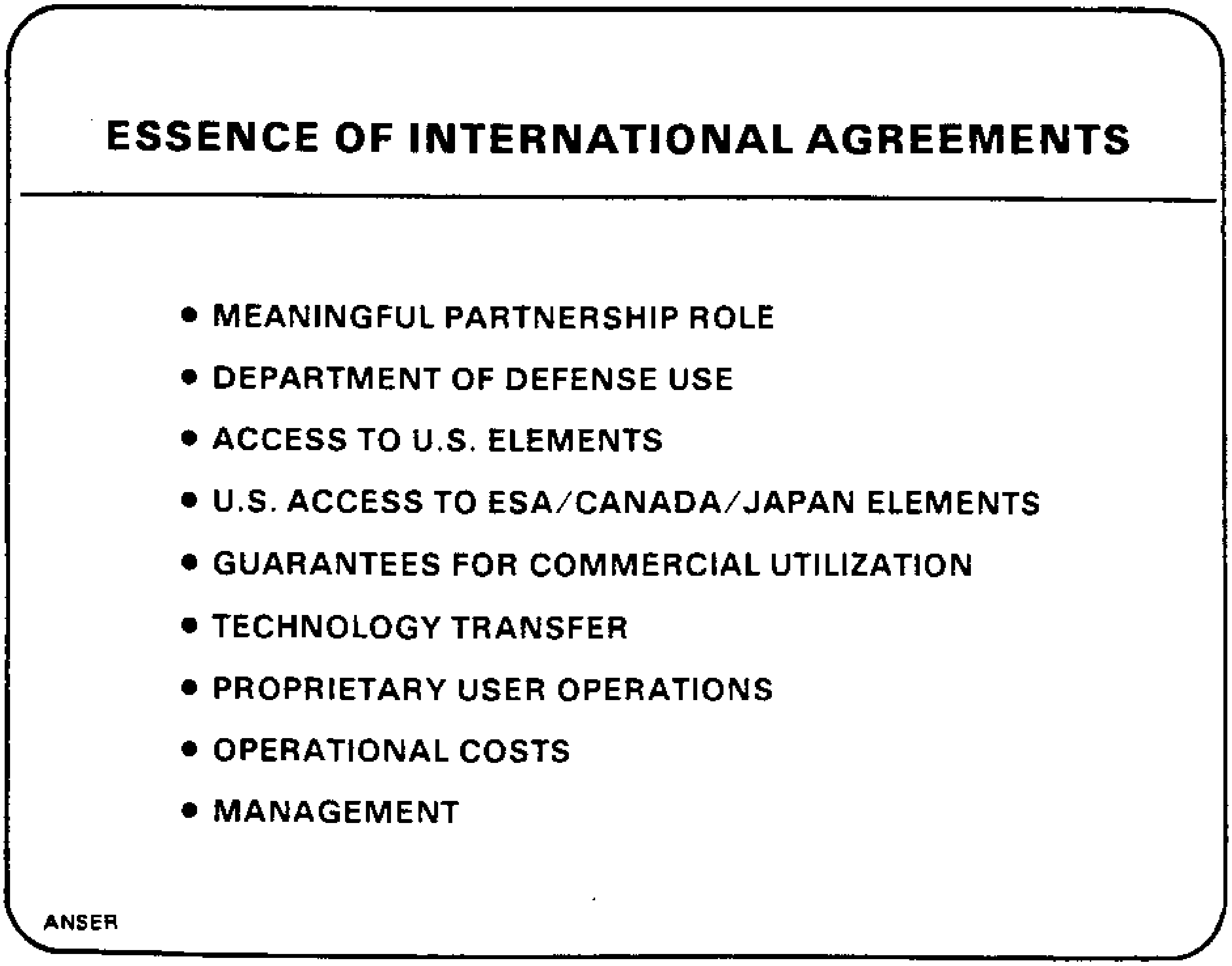
The Space Station has been planned as an international venture with Canada, Japan, and European countries sharing the development with the United States. While these international partners are assuming financial and technical responsibilities, the only exchange of user technical data will be that which is required to ensure systems compatibility. The underlying philosophy of internationalization is that there be no national enclaves, no exclusivity, and minimum duplication of common facility type equipment. No national enclaves and no exclusivity--restricting partners access to the Station in times of international crisis, for example--could preclude <u>full</u> DOD utilization of the Space Station.



ESSENCE OF INTERNATIONAL AGREEMENTS

- MEANINGFUL PARTNERSHIP ROLE
- DEPARTMENT OF DEFENSE USE
- ACCESS TO U.S. ELEMENTS
- U.S. ACCESS TO ESA/CANADA/JAPAN ELEMENTS
- GUARANTEES FOR COMMERCIAL UTILIZATION
- TECHNOLOGY TRANSFER
- PROPRIETARY USER OPERATIONS
- OPERATIONAL COSTS
- MANAGEMENT

ANSER

Since President Reagan's invitation to our allies to participate in the development of the permanently manned Space Station, much negotiating has occurred. During the spring of 1985, NASA signed bilateral Memoranda of Understanding (MOU) with our international partners for Phase B (Definition and Preliminary Design) Space Station cooperation. Formal negotiations for Phase C and D (Design, Development, Operation, and Utilization) of the Space Station began in June 1986 and lasted nearly 2 years. All fundamental issues have finally been resolved and negotiations are completed. The official signing ceremony was held on 29 September 1988 at the State Department.

The essence of the major agreements reached between the United States and our international partners is as follows:

- A meaningful partnership role has been established. International participation is significant financially and technologically. (Approximate financial contributions to the Space Station will be: $16 billion from the United States, $4 billion from Europe, $2 billion from Japan, and $1 billion from Canada.)

- The DOD has the right to use the Space Station for national security purposes, subject to international and domestic laws.
- Access to each other's (U.S. and international) elements has been negotiated as follows:
  - In return for the MSS, Canada can use 3 percent of the space time available on the U.S. Laboratory Module, the two U.S. payload attachment accommodations on the truss structure, and the ESA and Japanese Laboratory Modules.
  - The ESA and Japan have no rights to the U.S. elements.
  - The United States can use 46 percent of the space time available for each of the international laboratories, i.e., ESA Columbus, JEM, and Exposed Facility.
  - The ESA and Japan have the remaining 51 percent use of their respective laboratories, while the United States has the remaining 97 percent use of its laboratory.
  - The ESA will have full use of the MTFF, but the United States has the annual option to purchase up to 25 percent of the space time.
  - Canada can have 3 percent use of each of the polar platforms, U.S. and ESA.
  - On each other's polar platforms, the United States and the ESA will have the opportunity to trade instruments on a "balanced reciprocal" basis.
  - Japan has no rights to the polar platforms at this time, but it may make arrangements at a future time by either purchasing or bartering time. (Although not part of the Phase I Space Station, it should be noted that Japan has plans for developing and launching a Japanese Polar

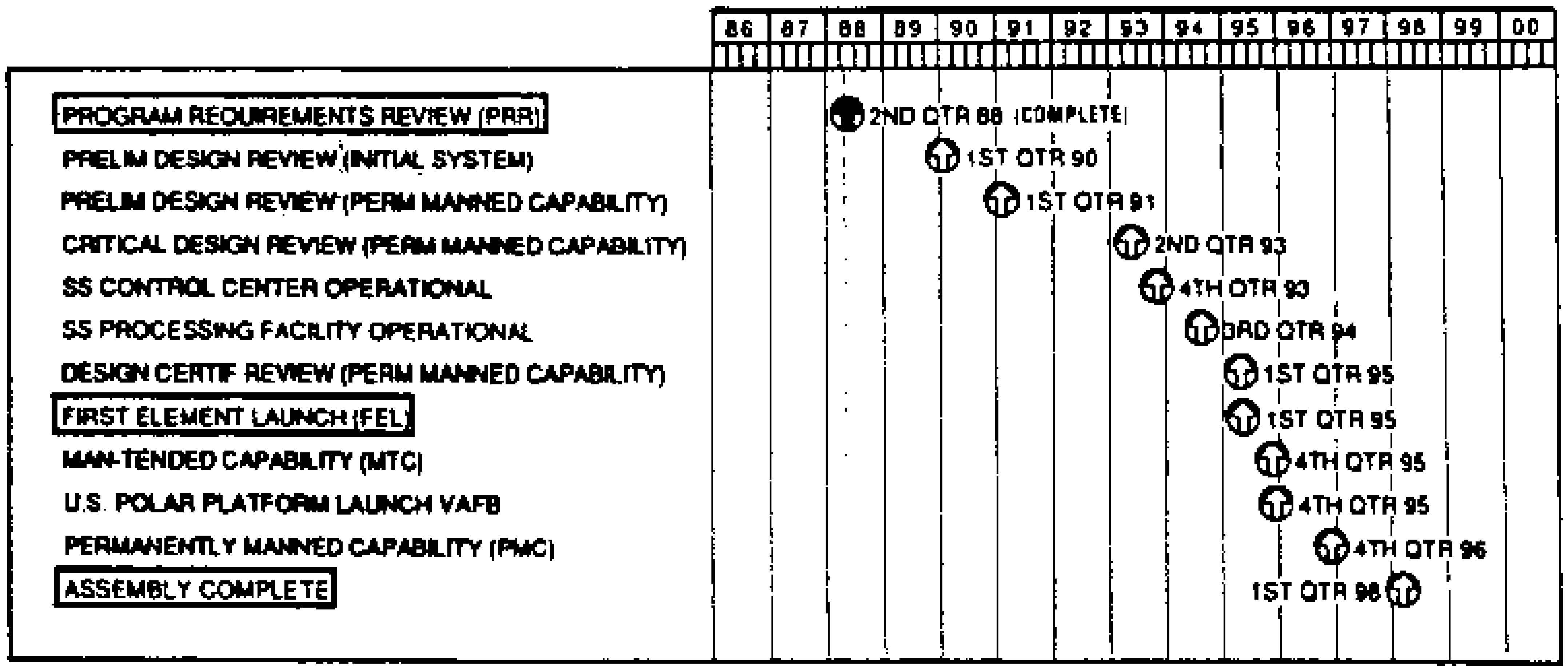
Platform in mid-1998. Launch will probably occur on its H-2 heavy-lift vehicle, scheduled to become operational in 1992.)

-- Allocation of resources to users for experimental work (utilization resources) will be divided up as follows: 71.4 percent for the United States, 12.8 percent for Europe, 12.8 percent for Japan, and 3 percent for Canada.

- Although the Space Shuttle will be the baseline means of transportation to and from the Space Station, the ESA and the NASDA are also allowed to use their respective launchers for reaching the Space Station. This means that the ESA Ariane launcher and Hermes spaceplane and Japan's H-2 launcher will need to be designed so as to dock compatibly with the station.
- Commercial utilization is guaranteed. (Each country is free to do what it wants on its elements.)
- Technology transfer will be dictated by Intergovernmental Agreements (IGAs) which limit technology transfer to that which is required to ensure system compatibility.
- Proprietary information will be protected. Handling of classified work is also mentioned in the agreements. The procedures for this still need to be worked out.
- Handling of operational costs has been negotiated. The provider of an element will financially support part of the expense for running experiments in that element and all of the expense for maintaining its hardware. Common costs will be shared by formula. Costs for use of the Space Shuttle, NASA's TDRSS, and ESA's DRS system will be charged as appropriate.
- NASA will manage operations of the manned base and the U.S. POP. The ESA will manage operations of the ESA polar platform and MTFF while they are in free-flying mode. NASA will manage operations while they are being serviced by the STS or Space Station.

C. Schedule

SCHEDULE OF SPACE STATION PROGRAM MILESTONES



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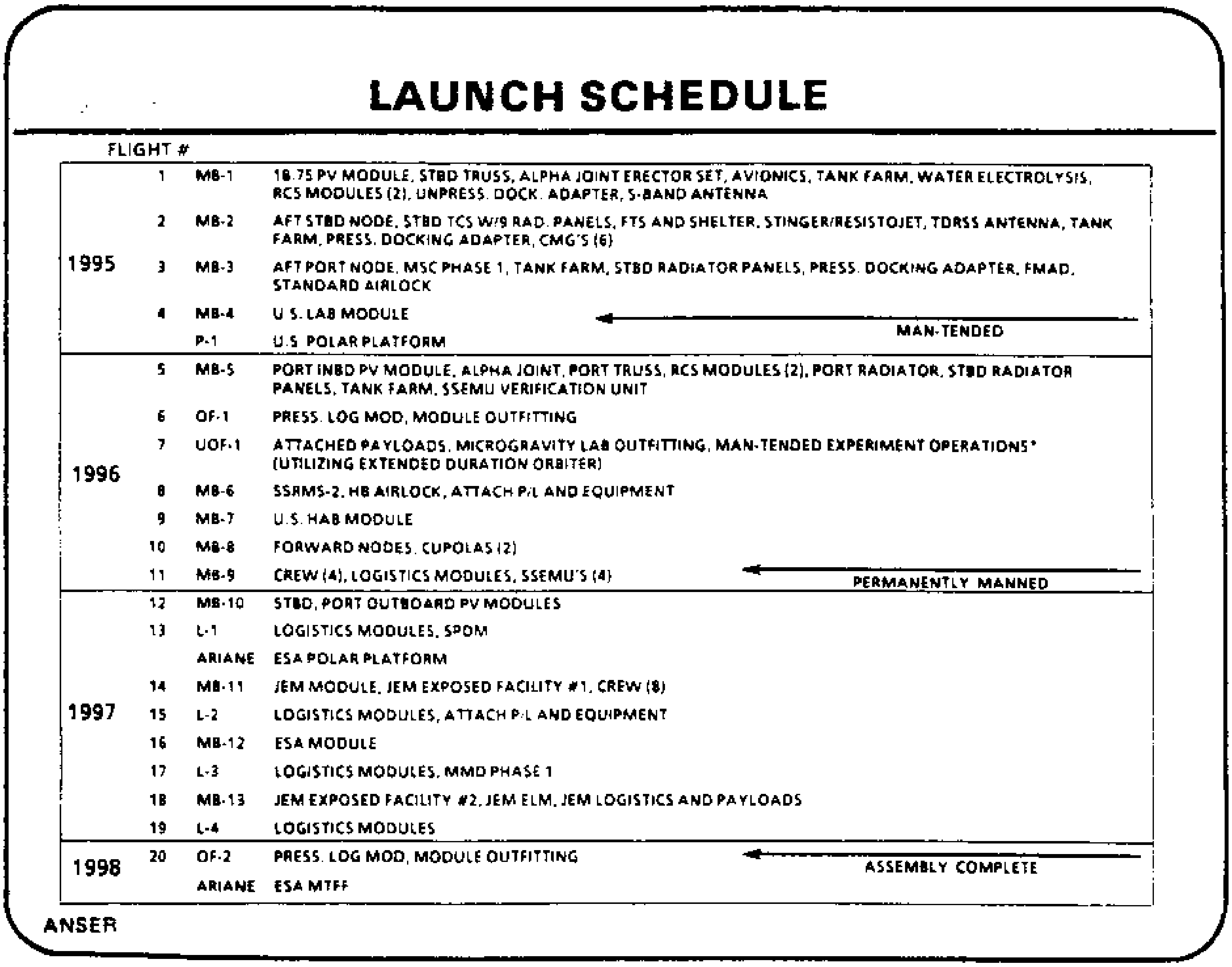
As of September 1988, the Space Station schedule is as indicated above. The Program Requirements Review (PRR) began at Level II in May 1988 and is now completed. The PRR process verifies the program requirements and ensures their achievability within the available fiscal and technical resources. It initiates the detailed design and development process. PDR, scheduled for first Quarter 1990 to first Quarter 1991, will review and assess the Space Station system design to ensure that it satisfies the program requirements. CDR, scheduled for second Quarter 1991 to second Quarter 1993, will be the final critical review of the design and all planned flight aspects of the program.

The current schedule establishes the First Element Launch (FEL) in early 1995, a Man-Tended Capability (MTC) in late 1995, a Permanently Manned Capability (PMC) in late 1996, and assembly completion in early 1998. The U.S. POP will be launched in late 1995.

The budget will have a significant impact on this schedule; budget decisions have already delayed IOC by several years. Recent budget reductions have slipped FEL by 1 year, delaying major program milestones. Future budget changes could further delay the program. A hold on FY 89 money until after the new administration takes office is an immediate schedule threat.



LAUNCH SCHEDULE

	FLIGHT #			
1995	1	MB-1	18.75 PV MODULE, STBD TRUSS, ALPHA JOINT ERECTOR SET, AVIONICS, TANK FARM, WATER ELECTROLYSIS, RCS MODULES (2), UNPRESS. DOCK. ADAPTER, S-BAND ANTENNA	
	2	MB-2	AFT STBD NODE, STBD TCS W/9 RAD. PANELS, FTS AND SHELTER, STINGER/RESISTOJET, TDRSS ANTENNA, TANK FARM, PRESS. DOCKING ADAPTER, CMG'S (6)	
	3	MB-3	AFT PORT NODE, MSC PHASE 1, TANK FARM, STBD RADIATOR PANELS, PRESS. DOCKING ADAPTER, FMAD, STANDARD AIRLOCK	
	4	MB-4	U.S. LAB MODULE	← MAN-TENDED
		P-1	U.S. POLAR PLATFORM	
1996	5	MB-5	PORT INBD PV MODULE, ALPHA JOINT, PORT TRUSS, RCS MODULES (2), PORT RADIATOR, STBD RADIATOR PANELS, TANK FARM, SSEMU VERIFICATION UNIT	
	6	OF-1	PRESS. LOG MOD, MODULE OUTFITTING	
	7	UOF-1	ATTACHED PAYLOADS, MICROGRAVITY LAB OUTFITTING, MAN-TENDED EXPERIMENT OPERATIONS* (UTILIZING EXTENDED DURATION ORBITER)	
	8	MB-6	SSRMS-2, HB AIRLOCK, ATTACH P/L AND EQUIPMENT	
	9	MB-7	U.S. HAB MODULE	
	10	MB-8	FORWARD NODES, CUPOLAS (2)	
	11	MB-9	CREW (4), LOGISTICS MODULES, SSEMU'S (4)	← PERMANENTLY MANNED
1997	12	MB-10	STBD, PORT OUTBOARD PV MODULES	
	13	L-1	LOGISTICS MODULES, SPOM	
		ARIANE	ESA POLAR PLATFORM	
	14	MB-11	JEM MODULE, JEM EXPOSED FACILITY #1, CREW (8)	
	15	L-2	LOGISTICS MODULES, ATTACH P/L AND EQUIPMENT	
	16	MB-12	ESA MODULE	
	17	L-3	LOGISTICS MODULES, MMD PHASE 1	
	18	MB-13	JEM EXPOSED FACILITY #2, JEM ELM, JEM LOGISTICS AND PAYLOADS	
	19	L-4	LOGISTICS MODULES	
1998	20	OF-2	PRESS. LOG MOD, MODULE OUTFITTING	← ASSEMBLY COMPLETE
		ARIANE	ESA MTFF	

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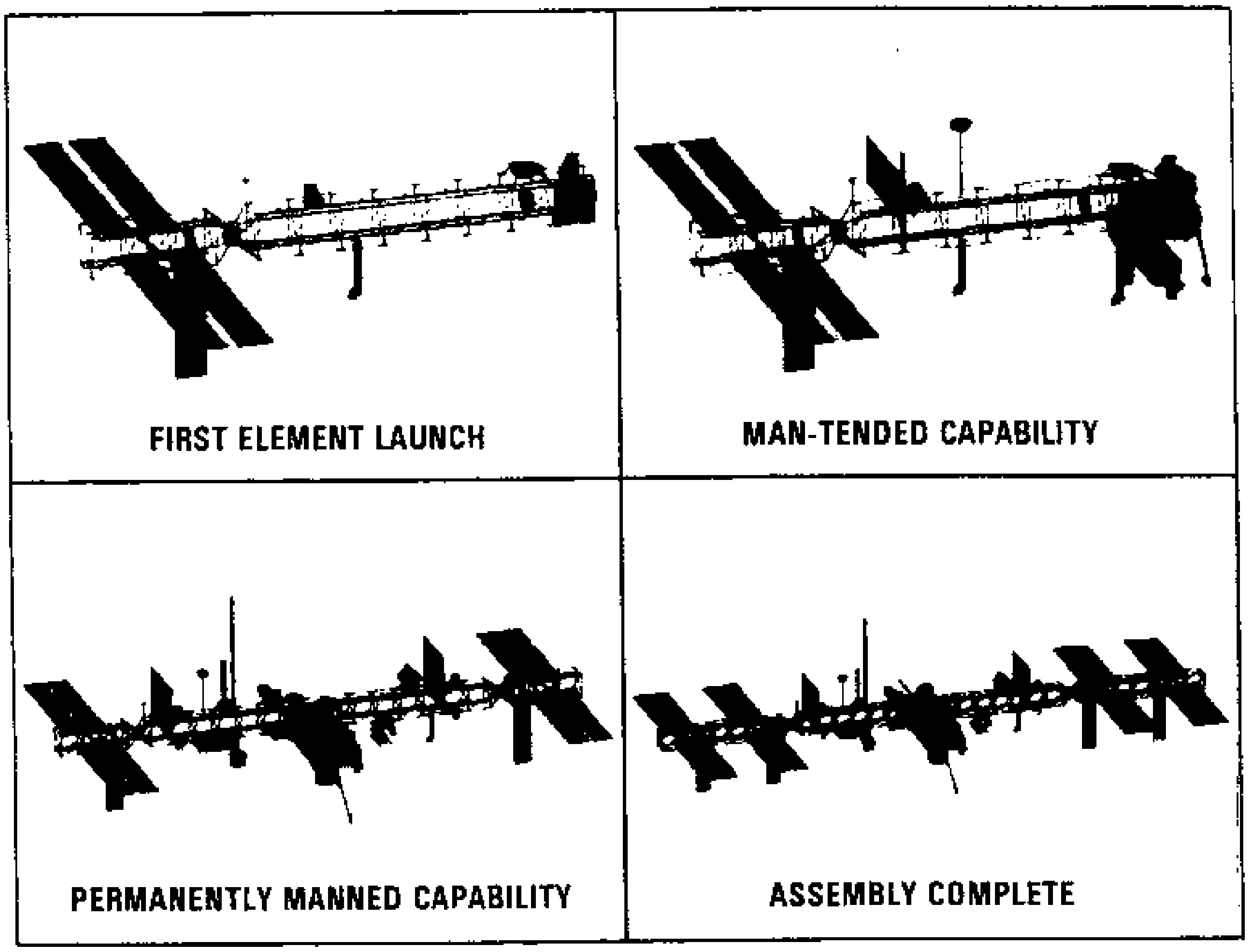
The assembly sequence depicted above was developed jointly by the Space Station and Space Transportation offices in NASA using the reduced performance of the post-Challenger Space Shuttle. Since 1986, significant changes have been made in the design of certain Space Station elements, in the sequence of elements deployed, and in the packaging of flights to match assembly requirements with transportation capabilities. A number of iterations were made as Space Shuttle performance was redefined and flight rates reassessed. In late 1987, a formal transportation study was performed that evolved into the above plan. This new orbital assembly plan features a launch packaging concept that is fully deployable with today's Space Shuttle but will take advantage of enhanced Shuttle performance (i.e., advanced solid-rocket motors) and a heavy-lift launch vehicle should they be available. The transportation study showed that Shuttle deployment with the added performance of the advanced solids would eliminate at least three Shuttle flights. Off-loading selected cargo to a heavy-lift launcher would further reduce the number of Shuttle flights to as few as 10.

SPACE STATION ASSEMBLY HIGHLIGHTS



FIRST ELEMENT LAUNCH

MAN-TENDED CAPABILITY

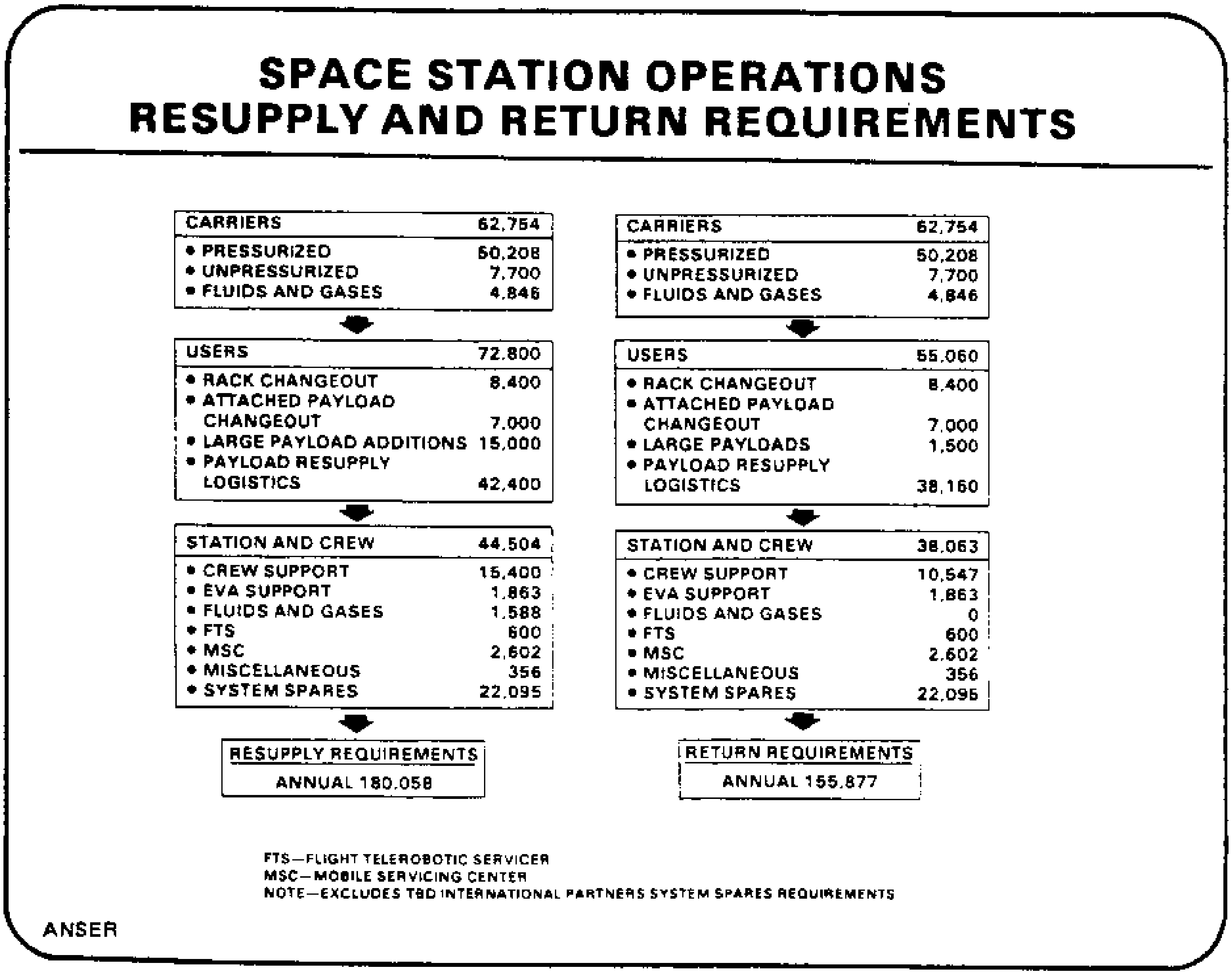
PERMANENTLY MANNED CAPABILITY

ASSEMBLY COMPLETE

ANSER

Milestones in the evolution of the Space Station from the first Space Shuttle assembly flight to the completed Phase I Space Station are depicted above. The MTC is a significant milestone, since it allows for an early man-tended scientific experimentation capability a year before the Station is permanently manned. The original scenario was for experimentation to commence during the PMC. The MTC would occur with assembly Flight 4--the deployment of the U.S. Laboratory Module equipped with two experiment double racks. Initial power availability would be 18.75 kW, with 8 kW allotted for research and 10 kW for housekeeping. At MTC, only half the truss structure will be present. Because of the mass imbalance, the quality of the laboratory's microgravity environment will be degraded. However, Flight 5 will deploy the other half of the truss structure along with more power, i.e., 25 kW availability for research. By Flight 8, the U.S. Laboratory Module will be outfitted with 22 double racks. The STS will be attached to the laboratory module during the early flights.

The Station will be assembled at an altitude of 220 NM and operated at an altitude of 250 NM after orbit transfer. The 28.5° inclined orbit was selected because of the high traffic volume and optimum lift capability from Cape Kennedy into this orbit.



SPACE STATION OPERATIONS RESUPPLY AND RETURN REQUIREMENTS

CARRIERS	62,754
• PRESSURIZED	50,208
• UNPRESSURIZED	7,700
• FLUIDS AND GASES	4,846

USERS	72,800
• RACK CHANGEOUT	8,400
• ATTACHED PAYLOAD CHANGEOUT	7,000
• LARGE PAYLOAD ADDITIONS	15,000
• PAYLOAD RESUPPLY LOGISTICS	42,400

STATION AND CREW	44,504
• CREW SUPPORT	15,400
• EVA SUPPORT	1,863
• FLUIDS AND GASES	1,588
• FTS	600
• MSC	2,602
• MISCELLANEOUS	356
• SYSTEM SPARES	22,095

RESUPPLY REQUIREMENTS

ANNUAL 180,058

CARRIERS	62,754
• PRESSURIZED	50,208
• UNPRESSURIZED	7,700
• FLUIDS AND GASES	4,846

USERS	55,060
• RACK CHANGEOUT	8,400
• ATTACHED PAYLOAD CHANGEOUT	7,000
• LARGE PAYLOADS	1,500
• PAYLOAD RESUPPLY LOGISTICS	38,160

STATION AND CREW	38,063
• CREW SUPPORT	10,547
• EVA SUPPORT	1,863
• FLUIDS AND GASES	0
• FTS	600
• MSC	2,602
• MISCELLANEOUS	356
• SYSTEM SPARES	22,095

RETURN REQUIREMENTS

ANNUAL 155,877

FTS—FLIGHT TELEROBOTIC SERVICER
MSC—MOBILE SERVICING CENTER
NOTE—EXCLUDES TBD INTERNATIONAL PARTNERS SYSTEM SPARES REQUIREMENTS

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Once the Space Station is operational, a regular schedule for resupply and return of materials must be provided. In addition, a crew rotation schedule must be established. The chart above indicates the annual logistics requirements (excluding crew members) for the operational phase. As indicated, 180,000 lb of up-mass and 156,000 lb of down-mass are required each year in support of Space Station operations. The international partners are expected to increase the up-mass by 10,000 to 15,000 lb per year with a corresponding increase in down-mass. NASA's plans to dedicate five Shuttle flights per year to the Space Station should satisfy the logistics needs. Typical Shuttle logistics flights will last 5 days. ELVs will complement the Space Shuttle, as needed, for transporting payloads and supplies.

The baseline Space Station crew complement begins with a crew of four on Flight 11 and grows to a crew of eight in less than 1 year (Flight 14). The first crew rotation will occur on Flight 13 after a 90-day staytime. The Shuttle will provide a delivery and return capability of four Space Station crew members. It is planned that early crews will stay on orbit for 90 to 120 days each, and, as the Station complement increases, the nominal staytimes will increase to 180 days. At a rate of five Shuttle flights a year, there will be flexibility in crew rotation to permit staggered tours of duty or unscheduled crew rotations.

SPACE STATION CREW

- INTERNATIONAL CREW
- QUALIFICATIONS
  - —MEDICAL STANDARDS
  - —SUITABILITY REQUIREMENTS
  - —SECURITY
- TRAINING
  - —INTEGRATED TEAM
  - —PROPRIETARY WORK
- CODE OF CONDUCT
- MANAGEMENT
- TOUR OF DUTY
- AVAILABLE CREW TIME

ANSER

All the international partners will be providing astronauts to make up the Space Station crew. They will be entitled to use their corresponding crew when they begin paying the common operational costs at the time of launch of their respective elements. Their allowable crew on the Station will correspond to the same percentage allotted to them for utilization resources. This percentage will be satisfied over time, not on all specific individual crew rotations.

Standards will be established for qualifying astronauts as members of the Space Station crew; these will include medical standards, suitability requirements for long-duration flights, and security. Upon certification, the astronauts will be trained as an integrated team, commencing about 2 years before flight. The astronauts will not be assigned exclusively to their country's elements and experiments; they will work in all Space Station areas. The exception to this is when classified or proprietary work is conducted on the Station. At that time, appropriate provisions will be made.

With the full involvement of our international partners, NASA will develop the Code of Conduct for the Space Station. It will establish a chain of command; provide the appropriate authority and responsibility to the Space Station commander; and establish disciplinary regulations, security guidelines, element and equipment responsibilities, and work standards. The management of the station will be by consensus; if the partners cannot agree, NASA will make the final decision. But there will be an appeals process.

A full Space Station crew will consist of eight members. Regarding crew rotation, two teams of four persons (blue team and red team) are planned to serve overlapping on-orbit staytimes. The teams will have 12-hour shifts, providing around-the-clock operations. There will be a 6-day workweek. Each workday will consist of 9 hours of work, 8 hours of sleep, and 7 hours of personal time, exercise, and proficiency training. (See Appendix B for a layout of a typical day on the SSMB.) Each team will consist of one station operator, one or more station scientists, and one payload scientist.

For a full eight-member crew, the total available crew time will be 22,464 on-duty manhours per year. Of these eight, six equivalent crew members will provide the total crew time availability to users, which includes both EVA and Intravehicular Activity (IVA). To support users, at least 15,000 hours per year of IVA crew time and 350 hours of EVA crew time will be provided.

ASSURED CREW RETURN CAPABILITY (ACRC) OPTIONS

- GROUND-BASED CREW EMERGENCY RETURN VEHICLE (CERV)
- SPACE STATION-BASED CERV
- MODIFIED ORBITER FOR EXTENDED ON-ORBIT STAY TIME (EDO-EXTENDED DURATION ORBITER)
- GROUND-BASED SHUTTLE LAUNCH ON NEED (LON)
- UNMANNED REMOTELY PILOTED SHUTTLE (RPS)

ANSER

Crew safety is a major consideration in Space Station design and operations plans. This concern has been especially heightened since the Challenger accident. In the event of crew illness or injury, fire, explosion, collision, toxic contamination, major system failure (life support failure, attitude control failure, or loss of pressurization), or unavailability of the Shuttle, there must be a means to protect the lives of the Space Station crew and to return them safely to earth.

The Space Station has been designed with a "safe haven" philosophy whereby the crew can survive the loss of any single isolatable volume for a minimum of 45 days. Such capability would allow the crew to remain safely on orbit until a reserve Shuttle mission could be flown given worst-case launch processing and weather delays. In addition to the safe haven, NASA has studied a variety of options for crew return. Some are listed above. NASA has not yet decided on the method or methods for assured crew return from the Space Station.

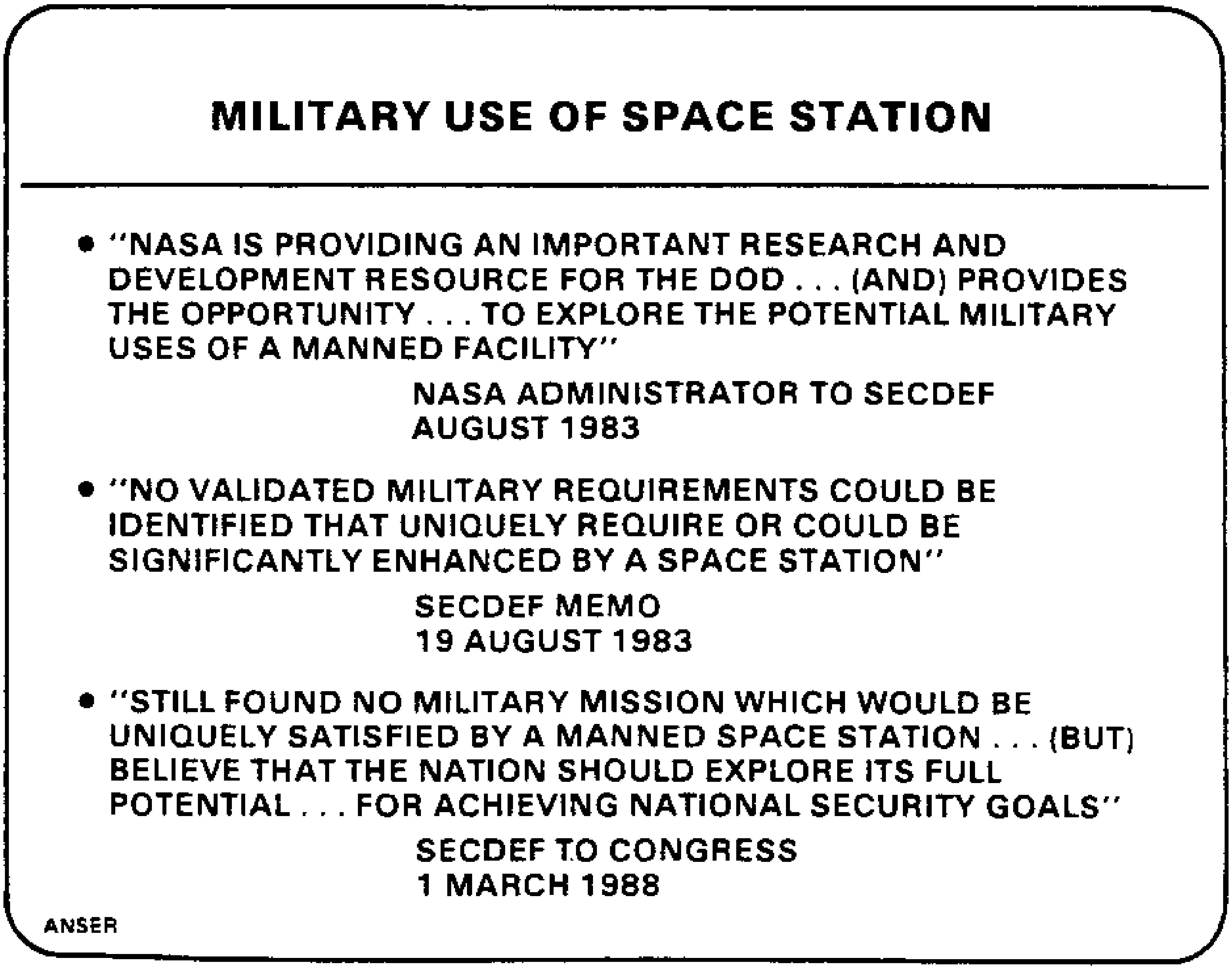
D. Military Use

MILITARY USE OF SPACE

- TREATIES PERMIT ANY ACTIVITY NOT SPECIFICALLY PROHIBITED OR OTHERWISE CONSTRAINED BY INTERNATIONAL LAW, FOR EXAMPLE
  - —MAY NOT ESTABLISH MILITARY BASE ON MOON
  - —MAY NOT DEPLOY WEAPONS OF MASS DESTRUCTION IN SPACE
- MILITARY SUPPORT FUNCTIONS PERMITTED
  - —NAVIGATION
  - —SURVEILLANCE
  - —METEOROLOGY
  - —COMMUNICATIONS
- MILITARY SPACE STATION NOT PROHIBITED
- PERMITS TESTING AND DEPLOYMENT OF NONNUCLEAR NON-ABM WEAPONS
- IN MOST INSTANCES, TREATIES REGULATE ACTIVITIES IN PEACETIME ONLY

ANSER

International law permits a broad use of space. Two items specifically prohibited by treaty are establishing military bases on the moon and deploying weapons of mass destruction (generally thought of as nuclear weapons) in space. The normal military support functions are permitted, and a dedicated military Space Station is not prohibited. Treaties and national space policy permit the testing and deployment of nonnuclear, non-ABM weapons. Most of the treaties, however, regulate activities only during peace; prohibitions against environmental modification are an exception.



MILITARY USE OF SPACE STATION

- "NASA IS PROVIDING AN IMPORTANT RESEARCH AND DEVELOPMENT RESOURCE FOR THE DOD . . . (AND) PROVIDES THE OPPORTUNITY . . . TO EXPLORE THE POTENTIAL MILITARY USES OF A MANNED FACILITY"

  NASA ADMINISTRATOR TO SECDEF
  AUGUST 1983

- "NO VALIDATED MILITARY REQUIREMENTS COULD BE IDENTIFIED THAT UNIQUELY REQUIRE OR COULD BE SIGNIFICANTLY ENHANCED BY A SPACE STATION"

  SECDEF MEMO
  19 AUGUST 1983

- "STILL FOUND NO MILITARY MISSION WHICH WOULD BE UNIQUELY SATISFIED BY A MANNED SPACE STATION . . . (BUT) BELIEVE THAT THE NATION SHOULD EXPLORE ITS FULL POTENTIAL . . . FOR ACHIEVING NATIONAL SECURITY GOALS"

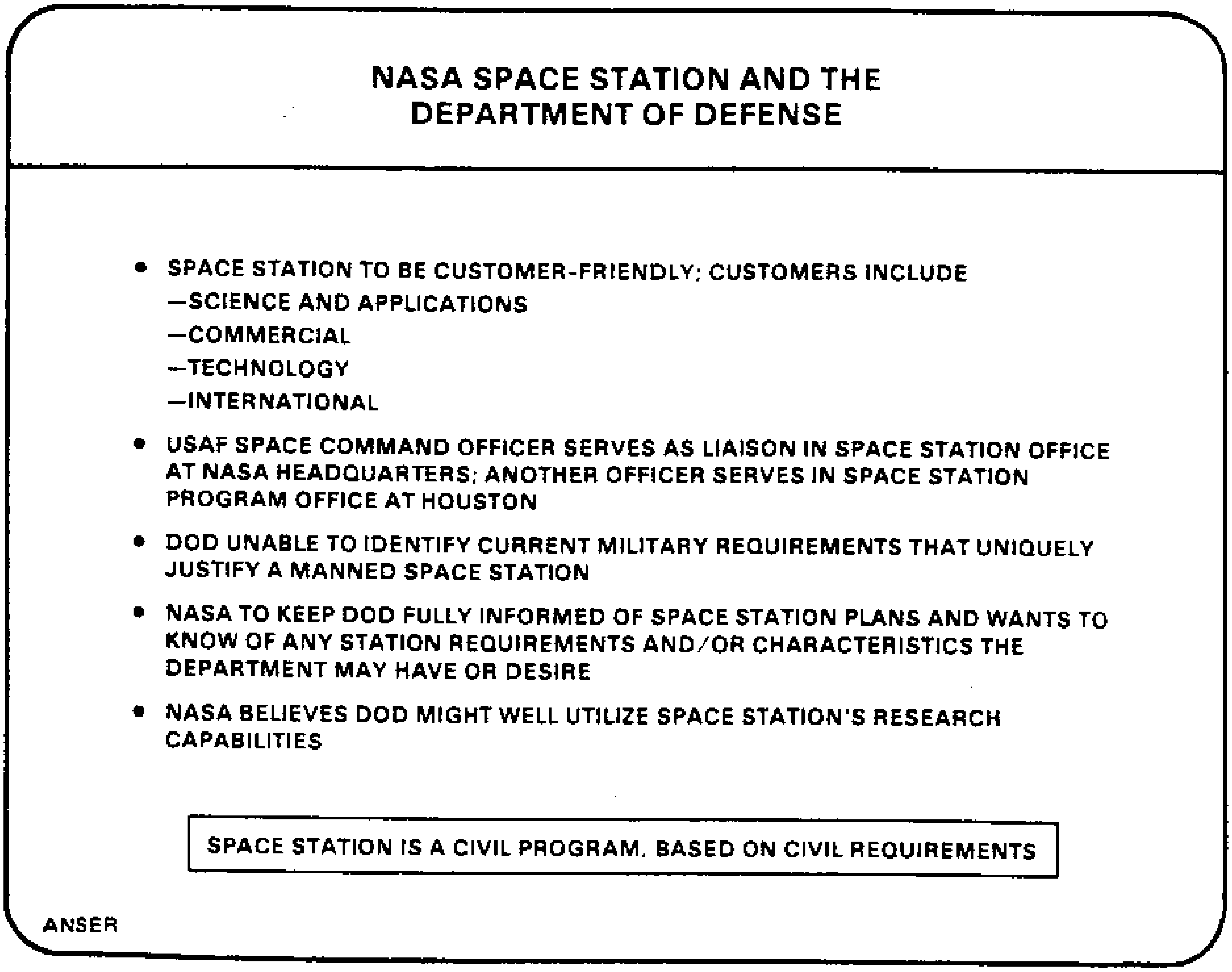
  SECDEF TO CONGRESS
  1 MARCH 1988

ANSER

In 1983, NASA suggested that the DOD could make good use of a manned Space Station facility, particularly for long-duration research and development (R&D) activities which required either extensive manned involvement or utilized specific Station capabilities. Following an Air Force study, that same year, the Secretary of Defense (SECDEF) responded that although the Space Station looked promising, there were no military requirements for it at that time. This did not mean that if such a Station were built, the DOD would not be able to make use of it.

Later, after international participation on the Station was assured, the SECDEF insisted that the DOD keep the right to "conduct national security activities on U.S. elements of the Space Station, without the approval of other nations." In the international negotiated agreements, this right was clearly preserved. The United States has the right to use its elements for national security purposes and to determine whether these uses are consistent with international law and with the international Space Station agreements. The agreements do not impose any new restrictions on military use of space beyond existing domestic and international laws and treaties.

In March 1988, the SECDEF reiterated that the DOD has no requirements that can be met only by a permanently manned Space Station, but acknowledged the Station as a unique national resource whose full potential should be explored and assessed, especially in the area of military man-in-space.



NASA SPACE STATION AND THE DEPARTMENT OF DEFENSE

- SPACE STATION TO BE CUSTOMER-FRIENDLY; CUSTOMERS INCLUDE
  - —SCIENCE AND APPLICATIONS
  - —COMMERCIAL
  - —TECHNOLOGY
  - —INTERNATIONAL
- USAF SPACE COMMAND OFFICER SERVES AS LIAISON IN SPACE STATION OFFICE AT NASA HEADQUARTERS; ANOTHER OFFICER SERVES IN SPACE STATION PROGRAM OFFICE AT HOUSTON
- DOD UNABLE TO IDENTIFY CURRENT MILITARY REQUIREMENTS THAT UNIQUELY JUSTIFY A MANNED SPACE STATION
- NASA TO KEEP DOD FULLY INFORMED OF SPACE STATION PLANS AND WANTS TO KNOW OF ANY STATION REQUIREMENTS AND/OR CHARACTERISTICS THE DEPARTMENT MAY HAVE OR DESIRE
- NASA BELIEVES DOD MIGHT WELL UTILIZE SPACE STATION'S RESEARCH CAPABILITIES

SPACE STATION IS A CIVIL PROGRAM, BASED ON CIVIL REQUIREMENTS

ANSER

Space Station customers plan to use the Station for scientific, commercial, and technological endeavors. Although the DOD could not identify current requirements that uniquely justify a manned Space Station, the Air Force did establish liaisons in the Space Station Offices at NASA Headquarters and in Houston. (The Air Force liaison at NASA Headquarters is being discontinued.)

NASA has expressed the desire to keep the military informed on the program and is interested in knowing of any Station requirements or characteristics that the DOD may want. The research capabilities provided by a Space Station are of interest to the DOD and will be explored further. However, since the DOD has not requested specific capabilities, the NASA Space Station remains a civil program, based entirely on civil requirements.

DOD USE OF NASA SPACE STATION

- 1983 AIR FORCE SCIENTIFIC ADVISORY BOARD RECOMMENDATIONS
  - —APPEARS TO BE POTENTIAL FOR
    - RESEARCH, DEVELOPMENT, TEST, AND EVALUATION
    - TRANSPORTATION NODE CONCEPT
- STUDY COMPLETED BY AIR FORCE SPACE COMMAND 30 DECEMBER 1985
  - —APPEARS TO BE POTENTIAL FOR
    - RESEARCH AND DEVELOPMENT
    - MAINTENANCE AND REPAIR
    - COMMAND AND CONTROL
    - TRANSPORTATION NODE
- DOD SHOULD PLAN TO USE THE SPACE STATION

ANSER

In 1983, the Air Force Scientific Advisory Board recommended that the DOD use the NASA Space Station for research, development, test, and evaluation (RDT&E). However, it felt that additional study would be needed to define more fully specific Space Station requirements. Using the Space Station as a transportation node to reduce the costs of getting to higher orbits had also been suggested, but remains unproven at this time.

An Air Force study completed in 1985 also identified R&D as a potential DOD role for the Space Station. Maintenance and repair, command and control, and transportation node were also cited. Based on Air Force actions to date, a consensus seems to be forming about potential military use of the Space Station, focusing on each of the above areas. The remainder of this document addresses those topics.

MILITARY RDT&E

(REPRESENTATIVE AREAS)

- MAN-IN-SPACE RESEARCH AND EXPERIMENTATION
- SURVEILLANCE EXPERIMENTS (IR, RADAR, OPTICAL)
- OCEANOGRAPHIC RESEARCH
- ATMOSPHERIC RESEARCH
- VHSIC RESEARCH
- DIRECTED-ENERGY RESEARCH
- POWER PRODUCTION RESEARCH
- NUCLEAR HARDNESS AND SURVIVABILITY RESEARCH
- ZERO GRAVITY AND SPACE ENVIRONMENT EXPERIMENTATION (e.g., RADIATION)
- MISSION EQUIPMENT DEVELOPMENT, ASSEMBLY, SERVICING, AND TESTING
- METALLURGY

ANSER

The items listed above represent specific RDT&E technology areas applicable to the DOD that could benefit from a Space Station facility. The list is not meant to be all-inclusive.

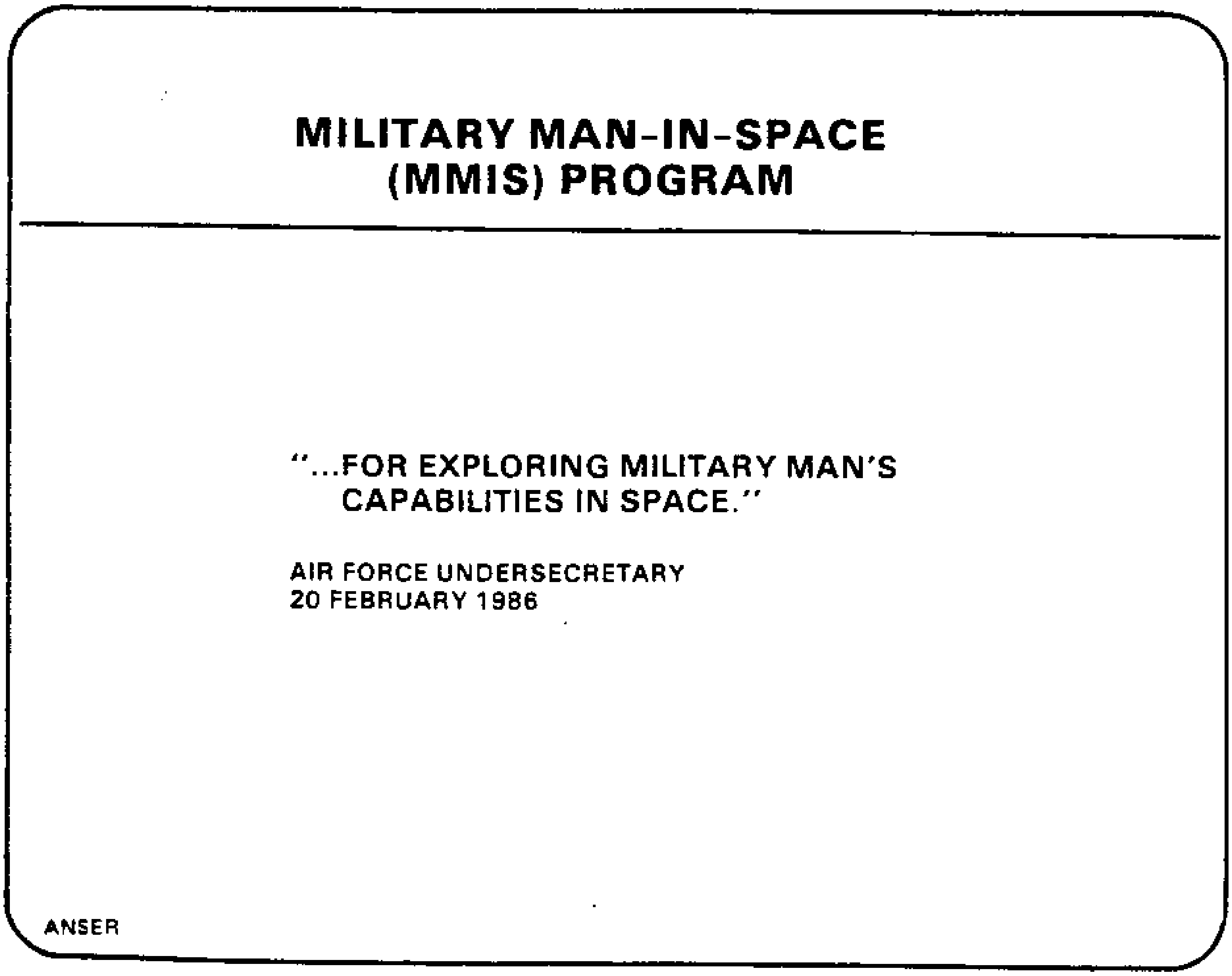
RDT&E BENEFITS FOR DOD

- EARLIER EVALUATION OF TEAL RUBY AND TALON GOLD USING NASA SPACE STATION SHOWED LITTLE OR NO BENEFIT OVER USE OF SHUTTLE
- POSSIBLE BENEFIT FOR REPAIR/MODIFICATION OF EXPERIMENTS
- ASSEMBLY OF LARGE STRUCTURES IN SPACE
- LONGER MISSION DURATION THAN SHUTTLE MAY ASSIST SOME EXPERIMENTS
- SOME BENEFITS CURRENTLY UNKNOWN: EXPERIMENTERS TEND TO DEVELOP EXPERIMENTS AROUND AVAILABLE TESTING FACILITIES

ANSER

To quantify the benefits of R&D using the NASA Space Station, two experiments were evaluated in detail. The conclusion was that although the Space Station could be used, it offered little or no advantage over the Shuttle. It was recognized, however, that the Space Station could offer real benefits when experiments required on-orbit repair/modification or longer duration than the Shuttle could provide. Assembling large structures in space also was seen to be better suited to a Space Station.

A remaining unknown is the fact that the experimenters had never designed experiments for a Space Station. It is suspected that the experiments would be designed differently and perhaps achieve a different level of results given such a facility, but that possibility is difficult to factor into an evaluation.



MILITARY MAN-IN-SPACE (MMIS) PROGRAM

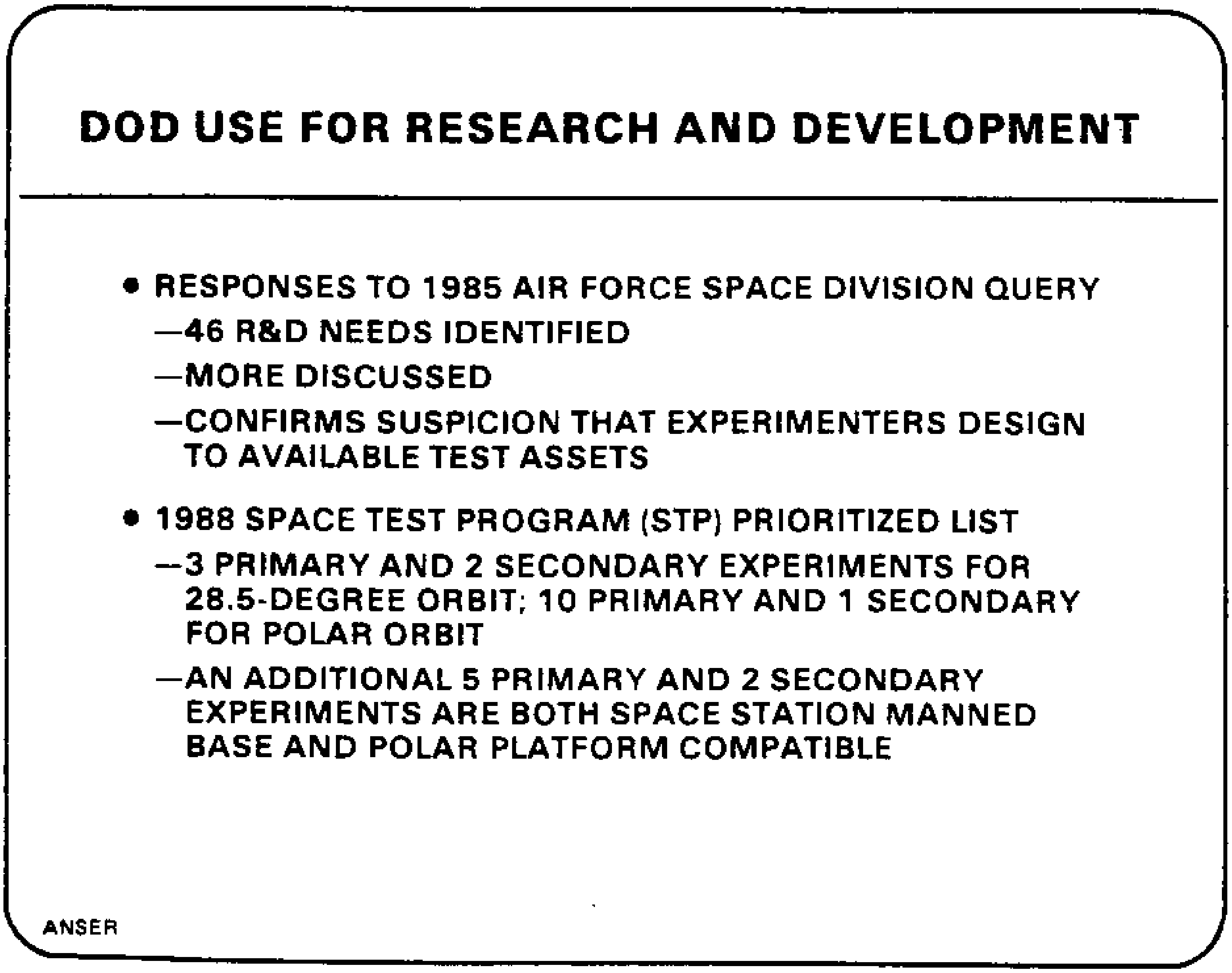
"...FOR EXPLORING MILITARY MAN'S CAPABILITIES IN SPACE."

AIR FORCE UNDERSECRETARY
20 FEBRUARY 1986

ANSER

As indicated earlier, a potential DOD R&D use of the Space Station falls in the realm of the Military Man-In-Space (MMIS) Program. On 20 February 1986, the MMIS program was approved by the Under Secretary of the Air Force. Its purpose is to evaluate man's ability to conduct military operations in or from space. These are concept evaluation missions to be performed on the Space Shuttle or the Space Station. Their goal is to determine the capability of man in space to improve the performance of potential military operations.

In the 1988 MMIS Tri-Service Meeting, 11 MMIS experiments were considered. Most are observation-type in nature requiring, at most, hand-held equipment. As the MMIS program evolves, especially during the Space Station era, the scope of the experiments can change significantly to incorporate highly advanced observation systems. To date, no MMIS experiments have flown. Since this is a new program and it takes time to manifest experiments on the STS, none has been firmly manifested to date. The long Shuttle standdown after the Challenger accident has contributed to the delay.



DOD USE FOR RESEARCH AND DEVELOPMENT

- RESPONSES TO 1985 AIR FORCE SPACE DIVISION QUERY
  - —46 R&D NEEDS IDENTIFIED
  - —MORE DISCUSSED
  - —CONFIRMS SUSPICION THAT EXPERIMENTERS DESIGN TO AVAILABLE TEST ASSETS
- 1988 SPACE TEST PROGRAM (STP) PRIORITIZED LIST
  - —3 PRIMARY AND 2 SECONDARY EXPERIMENTS FOR 28.5-DEGREE ORBIT; 10 PRIMARY AND 1 SECONDARY FOR POLAR ORBIT
  - —AN ADDITIONAL 5 PRIMARY AND 2 SECONDARY EXPERIMENTS ARE BOTH SPACE STATION MANNED BASE AND POLAR PLATFORM COMPATIBLE

ANSER

To determine whether or not the Space Station could be used productively for future experiments, in 1985, Air Force Systems Command's Space Division queried the DOD laboratories and medical community. They responded with 46 specific R&D needs that could be pursued, given the opportunity, and suggested several more that might be possible. These 46 needs were categorized by 21 missions, 9 functions, and 15 technology disciplines. They were conceptual in nature, as opposed to detailed experiment definitions. The assessment tended to confirm the position that the lack of experiments was more a factor of designing experiments to use existing capabilities rather than a lack of adequate research needs that could use the Space Station complex.

The DOD Space Test Program's (STP) 1988 list of 91 experiments was analyzed to determine how many could use the Space Station complex. Given the specified orbital inclinations, mission durations, perigees and apogees, and stability requirements, five experiments appeared to be promising candidates for the NASA SSMB. In addition to this, 11 could use the polar platform. Also, seven more experiments were identified as compatible with both SSMB and polar platform. This produced a total of 23 long-duration experiments. (See Appendices C and D for a list of these experiments.)

An additional 22 (3 primary and 19 secondary) experiments could use the Space Station. However, they were of such short duration (a few days) that they are better suited for the Space Shuttle.

DOD USE OF SPACE STATION MODULE

SHARE CURRENTLY DEFINED IOC FACILITIES

- PARTNER VERSUS USER
- KEEP REQUESTED DATA PROPRIETARY
- SHARE ONLY AGREED-UPON TECHNOLOGIES

SEPARATE MODULE

- STATION GROWTH ENVISIONS ADDITIONAL MODULES
- IOC SPACE STATION: VOLUME RICH, RESOURCE POOR
- IMMEDIATE INTENTIONS AND FUNDING NEEDED

NASA WANTS ASSURANCE THAT NO OPERATIONAL MILITARY MISSION IS PERFORMED

ANSER

If the DOD were to use the Space Station, options to be considered would be: (1) to use the modules being developed for the NASA program or (2) to develop a module of its own. NASA would prefer that the DOD use currently defined IOC facilities as a partner. The facilities would be shared, data would be kept proprietary, and only agreed technologies would be shared.

If the DOD were to pursue a separate module for its uses, NASA has indicated that planning for the initial capabilities is far enough along that immediate funding would be needed. It might also require that DOD resources be provided to support the module, such as power, since the IOC station is currently volume-rich but resource-limited. Space Station growth, after the initial Station is in place, may encompass additional modules.

If the DOD were to provide its own module for inclusion in the Space Station manned base, NASA has stated that it would need assurances that the DOD was not using its module to perform operational military missions. NASA has indicated that such assurances would enhance international use and reduce the probability of being treated as a military target in the event of hostilities.

POTENTIAL MILITARY USES OF POLAR PLATFORM

- RDT&E
  - —11 KNOWN STP EXPERIMENTS WOULD BE CANDIDATES (REQUIRE 24% AVAILABLE WEIGHT AND 14% AVAILABLE POWER)
  - —ADDITIONAL 7 KNOWN STP EXPERIMENTS COULD BE CANDIDATES (FOR COMBINED TOTAL OF 18, REQUIRE 36% AVAILABLE WEIGHT AND 23% AVAILABLE POWER)
- BUS FOR OPERATIONAL POLAR MISSIONS
  - —POWER
  - —COMMUNICATIONS
  - —POINTING AND STABILIZATION SYSTEMS
- ENCRYPTION CAPABILITY MUST BE USER-PROVIDED

ANSER

In addition to using the SSMB, the polar platform is a candidate for DOD use. For illustration purposes, it is assumed that the 11 previously cited polar orbit STP experiments would fit compatibly on the polar platform and would be manifested on the U.S. POP. (This is a hypothetical argument, since none are scheduled for the U.S. POP; some are already scheduled on other carriers.) On the U.S. POP, the 11 STP experiments would require 24 percent of the available weight and 14 percent of the power available for users. If the seven previously cited STP experiments, which were both polar platform and SSMB compatible, were also fitted on the U.S. POP, the combined total of all 18 experiments would require 36 percent of the available weight and 23 percent of the available user power. (Since STP experiments are generally ready for flight at widely different times, manifesting all these experiments at one time would not be likely.)

Another potential use of the polar platform would be as a bus for operational military support missions. In these cases, the power, communications, and pointing and stabilization systems of the polar platform would be used. No provision for encryption (up- or downlink) has been made yet, but the U.S. POP is compatible with user-provided encrypted data and commands. The DOD would need to provide its own encryption and decryption if required.

Based on a preliminary assessment, the polar platform is a viable option for DOD experiments. Since NASA will control the U.S. platform, and its communications may be encrypted, the polar platform may be appropriate for selected DOD missions.

SUPPORT OF SPACE EXPERIMENTS

	FREE-FLYER	SHUTTLE	SPACE STATION
MODIFY/REPAIR EXPERIMENT	Ⓨ	Ⓖ	Ⓖ
RECOVER EXPERIMENT	Ⓨ	Ⓖ	Ⓖ
CREW INVOLVEMENT (OBSERVATIONS, etc.)	Ⓨ	Ⓖ	Ⓖ
UNEXPECTED OCCURRENCE(S)	Ⓨ	Ⓖ	Ⓖ
LONG-DURATION EXPERIMENT	Ⓖ	Ⓨ	Ⓖ
HIGH-INCLINATION ORBITS	Ⓖ	Ⓨ○	Ⓨ*
HIGH-ALTITUDE ORBITS	Ⓖ	Ⓨ	Ⓨ
HAZARDOUS MATERIALS	Ⓖ	Ⓨ	Ⓨ
SECURITY	Ⓖ	Ⓖ+	Ⓨ△

○ "MOTHBALLED" SHUTTLE LAUNCH FACILITY AT VAFB

* POLAR PLATFORM COULD BE USED

Ⓖ = ADVANTAGE Ⓨ = DISADVANTAGE

+ SECURE OPERATIONS TO BE PHASED OUT BY END OF FY 91

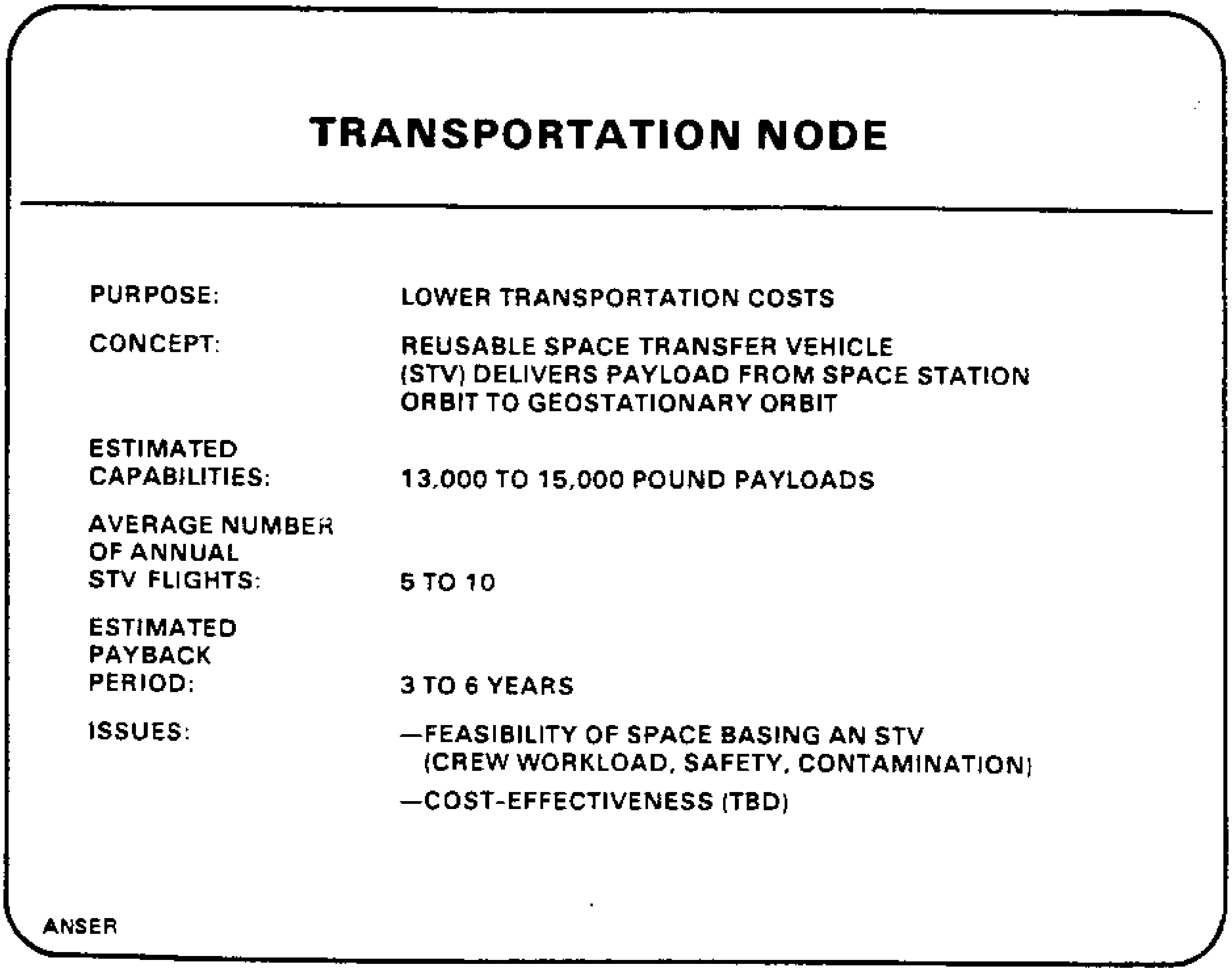
△ MUST PROVIDE ENCRYPTION CAPABILITY

NOTE: SPACE STATION AS USED HERE REFERS ONLY TO THE MANNED BASE; IT WILL ALSO INCLUDE PLATFORMS THAT CAN PERFORM SOME FREE-FLYER TASKS

ANSER

The above chart summarizes some of the advantages and disadvantages of using each of the space flight facilities previously discussed to perform DOD experiments. On the chart, the Free-Flyer is viewed as an expendable spacecraft. As shown, each test facility option has advantages or disadvantages, depending on the type of mission to be flown. While long-duration experiments could be conducted on either the SSMB or a Free-Flyer, any required crew involvement would necessitate use of the SSMB.

The chart illlustrates that the availability of all three of the space flight facilities is beneficial to conducting experiments in the desired manner.



TRANSPORTATION NODE

PURPOSE:	LOWER TRANSPORTATION COSTS
CONCEPT:	REUSABLE SPACE TRANSFER VEHICLE (STV) DELIVERS PAYLOAD FROM SPACE STATION ORBIT TO GEOSTATIONARY ORBIT
ESTIMATED CAPABILITIES:	13,000 TO 15,000 POUND PAYLOADS
AVERAGE NUMBER OF ANNUAL STV FLIGHTS:	5 TO 10
ESTIMATED PAYBACK PERIOD:	3 TO 6 YEARS
ISSUES:	—FEASIBILITY OF SPACE BASING AN STV (CREW WORKLOAD, SAFETY, CONTAMINATION) —COST-EFFECTIVENESS (TBD)

ANSER

The Space Station would be used as an internodal point of transfer (transportation node) for crew and cargo only if lower transportation costs to higher orbits, e.g., geostationary, could be achieved. A space-based reusable Space Transfer Vehicle (STV) used in conjunction with the Space Station has been proposed and is being evaluated.

Previous analysis has indicated that 5 to 10 STV flights a year would result in a payback within 3 to 6 years. The results depend on the operational concepts employed, the feasibility of space-basing an STV, and the costs of procuring and maintaining the STV versus an alternative candidate.

The joint NASA/DOD Space Transportation Architecture Study (STAS) of 1987 addressed the transportation node concept but did not analyze it in any depth. Transportation systems were proposed which most effectively satisfied future needs, reduced operational costs, were flexible and robust, and maintained a world leadership status in space transportation. However, cost-effectiveness results were presented for only the overall architecture.

In FY 89, the NASA Office of Exploration will conduct mission definition studies under a "transition definition" program. Part of this program will be dedicated to defining Space Station evolution concepts which satisfy the transportation node requirements of these missions.

ASSEMBLY, MAINTENANCE, AND REPAIR (REPRESENTATIVE AREAS)

- ON-ORBIT ASSEMBLY OF LARGE STRUCTURES AND MISSION PAYLOADS
- REPAIR, REFURBISHMENT, SERVICING, STORAGE, RECOVERY, AND DEPLOYMENT OF MISSION PAYLOADS
- DELIVERY OF CONSUMABLES AND REPLACEMENT PARTS
- MATERIALS PROCESSING FOR CONSTRUCTION

ANSER

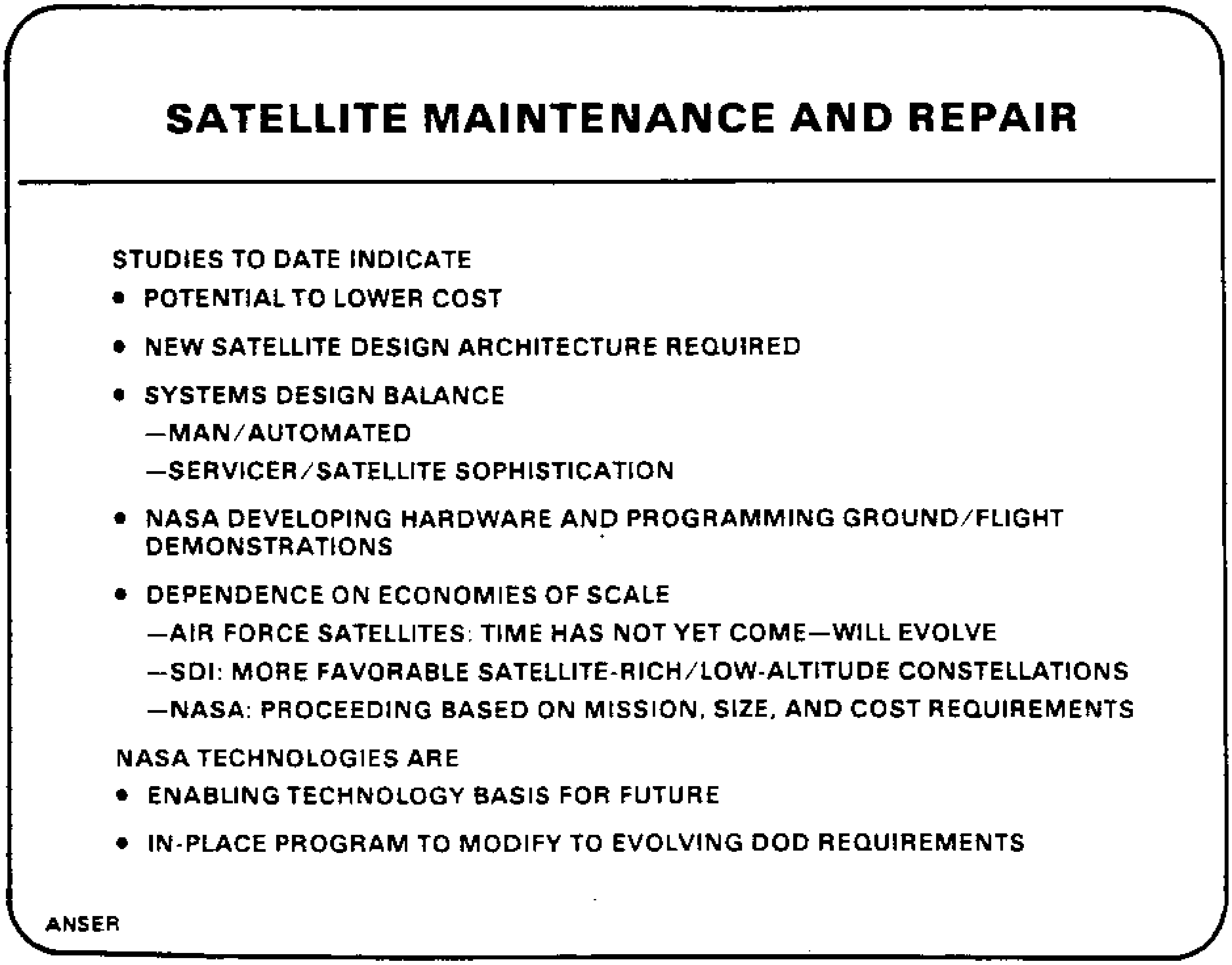
Another potential DOD use of the Space Station complex is on-orbit assembly, maintenance, and repair. The Space Station could become a logistics base for refurbishing and repair of DOD spacecraft. The Joint AF-SD/SDIO/NASA Space Assembly Maintenance and Servicing (SAMS) Study investigated this issue in terms of overall NASA/DOD spacecraft programs. The initial conceptual investigation was completed in June 1987, and a more detailed analysis is continuing.

The initial study demonstrated the cost-effectiveness of on-orbit assembly, maintenance, and repair. Two contractor teams, headed by Lockheed and TRW, addressed the most cost-effective approach for SAMS development implementation by generating space operational scenarios for five design reference missions (DRMs).

In addition to the SAMS study, NASA also investigated Space Station-specific servicing, assembly, and maintenance. The servicing study established an overall Space

Station user servicing system architecture and provided the means by which this system architecture could achieve payload assembly, restoration, consumables replenishment, storage (of free-flyers, OMVs, FTSs, attached payloads, and ORUs), transport (i.e., retrieve, deploy, or boost into orbit), and a telerobotic servicing capability. The assembly and maintenance study established the overall Space Station assembly and external (not internal) maintenance architecture.

The other opportunity areas shown on this chart are representative of those that require additional study.



SATELLITE MAINTENANCE AND REPAIR

STUDIES TO DATE INDICATE

- POTENTIAL TO LOWER COST
- NEW SATELLITE DESIGN ARCHITECTURE REQUIRED
- SYSTEMS DESIGN BALANCE
  - —MAN/AUTOMATED
  - —SERVICER/SATELLITE SOPHISTICATION
- NASA DEVELOPING HARDWARE AND PROGRAMMING GROUND/FLIGHT DEMONSTRATIONS
- DEPENDENCE ON ECONOMIES OF SCALE
  - —AIR FORCE SATELLITES: TIME HAS NOT YET COME—WILL EVOLVE
  - —SDI: MORE FAVORABLE SATELLITE-RICH/LOW-ALTITUDE CONSTELLATIONS
  - —NASA: PROCEEDING BASED ON MISSION, SIZE, AND COST REQUIREMENTS

NASA TECHNOLOGIES ARE

- ENABLING TECHNOLOGY BASIS FOR FUTURE
- IN-PLACE PROGRAM TO MODIFY TO EVOLVING DOD REQUIREMENTS

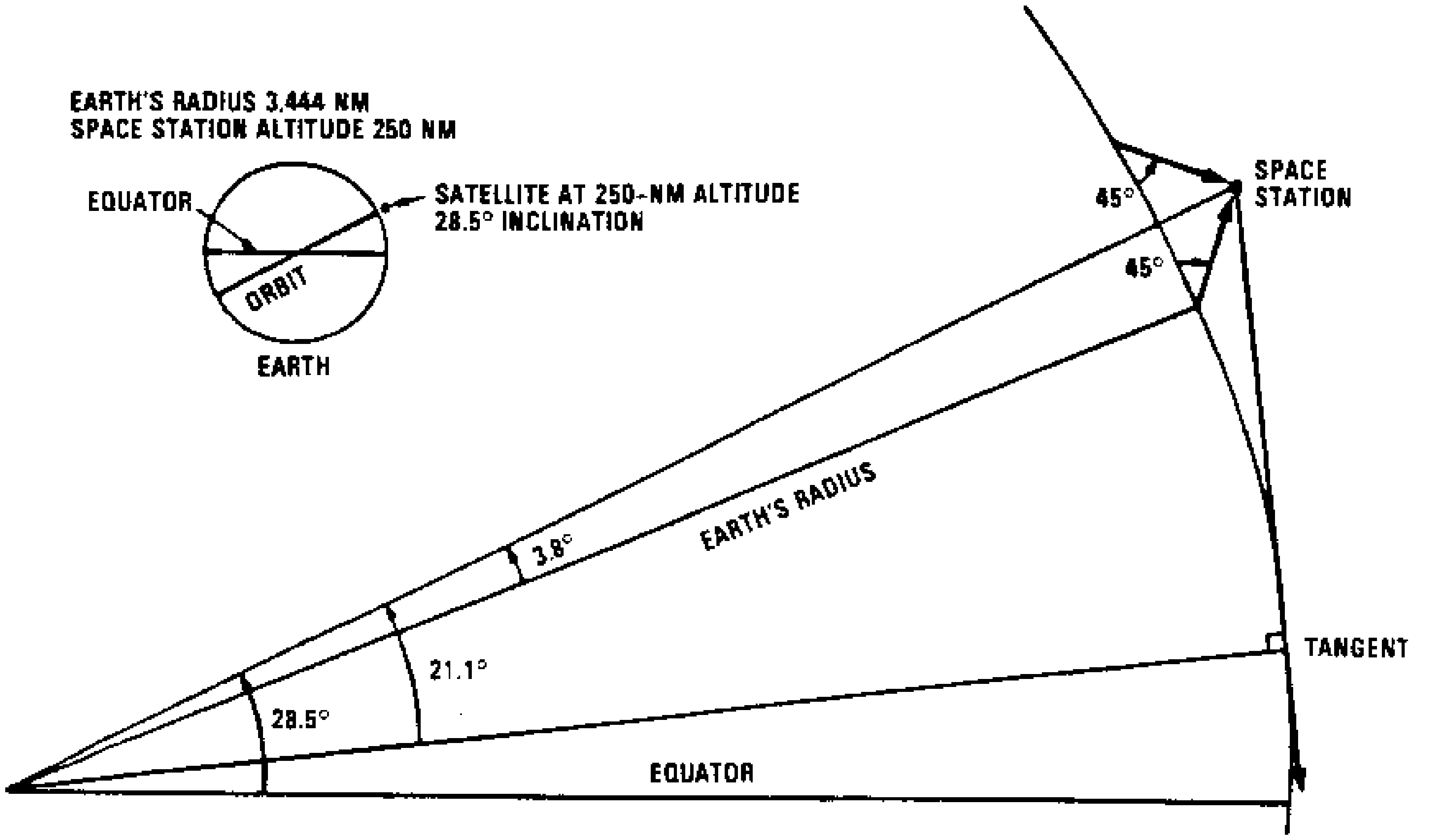
ANSER

Although several recent studies have indicated that on-orbit maintenance offers the potential for lower operational cost, a recent Air Force study concluded that it is not currently economical for Air Force space assets. Several preconditions must be met to achieve cost-effective on-orbit maintenance and repair. For example, a new satellite design architecture and associated standards and design criteria are required, such as replaceable modular units for some or most hard-wired systems and subsystems. This raises the question of the feasibility and overall cost-effectiveness of the redesign. Also critically important is the choice of astronauts versus robotic repair concepts and the need for a "smart front end" servicer on interorbit vehicles to effect robotic repairs, servicing, and change-out of modular units.

NASA has an aggressive space servicing and repair hardware development program. Several astronaut-tended satellites will utilize this technology. The first telerobotic demonstrations are scheduled for the POP in the late 1990s. A major challenge will be for the space community to complete flight demonstrations of an entirely redesigned satellite and servicer system. Also, major elements of a space logistics infrastructure are assumed, such as a smart front end for the OMV, additional ground control facilities, and a possible space warehouse.

On-orbit maintenance, to be cost-effective, is dependent on economies of scale and amortization of its design and infrastructure costs. Satellite weight (specifically, repairable weight), number per plane and multiple plane proximity, and orbital altitude and inclination are factors affecting economies of scale. Other important factors are ability to achieve full launch manifesting and satellite and ORU efficient quantity production schedules.

Typical Air Force satellite weights and constellations currently do not meet the necessary economies of scale. There is simply not enough accessible servicing and repair work in space, in the near term, to be cost-effective. It appears to be a good idea, but its time has not arrived. The results should not be construed as illustrative for programs such as SDI, which is satellite-rich per plane and in relatively low earth orbit; or the NASA programs which have high cost, weight, and technology payload mission requirements. The combination of these high-value assets (Space Station and large observatories) in the 28.5° inclination region offers unique opportunities. These NASA efforts establish an enabling technology base and provide the foundation for evolving DOD requirements.



FIELDS OF VIEW FROM THE NASA SPACE STATION

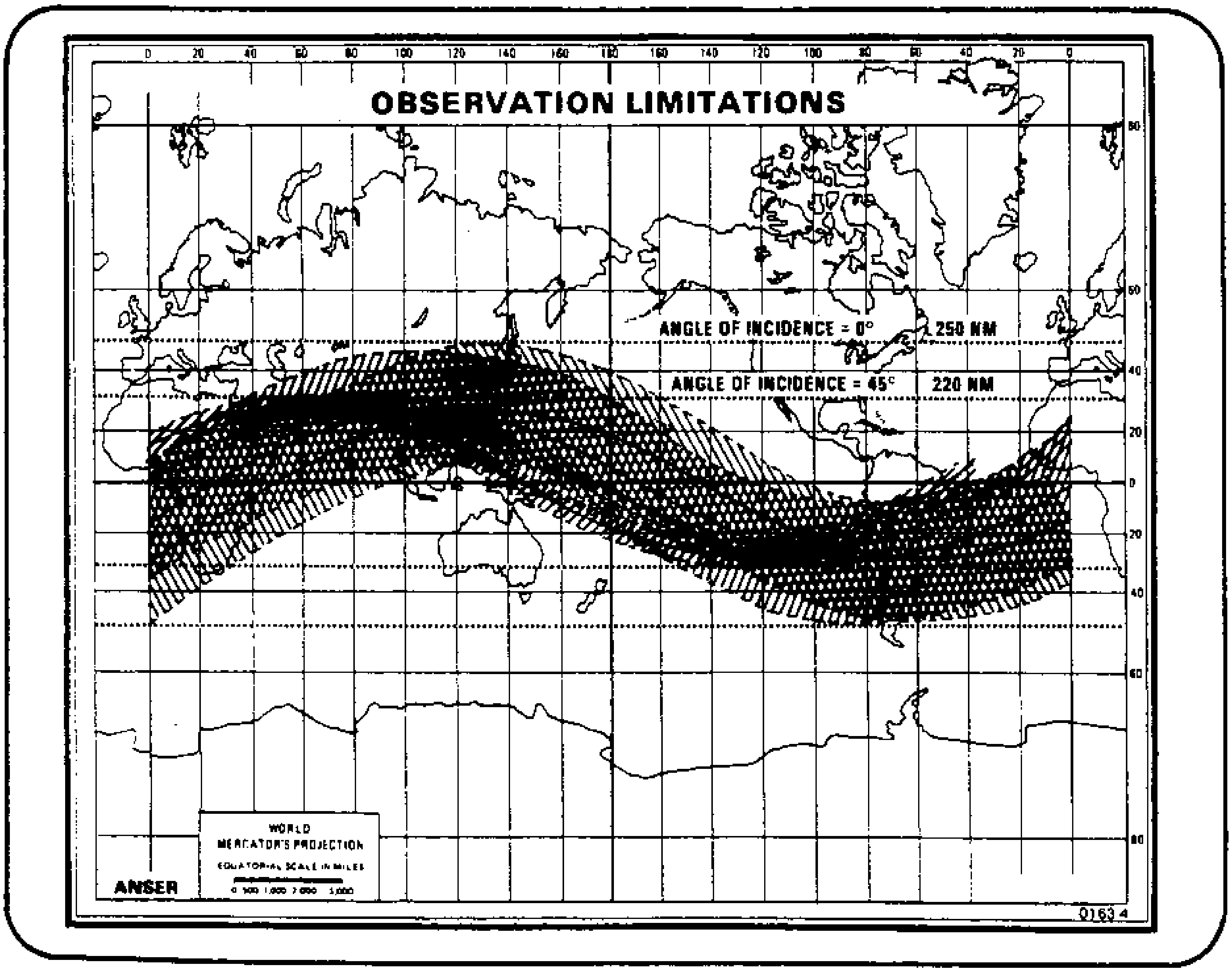
ANSER

The Space Station is depicted at its northernmost latitude, 28.5° N. The drawing is approximately to scale, demonstrating that the tangent to the earth is approximately 21° of latitude away from the satellite. If this 21° is added to the 28.5° latitude of the Space Station, a maximum viewing latitude of approximately 50° N or S is calculated.

The possible field of view (FOV) would be the current position of the Space Station plus or minus 21°, appearing to be a circle drawn on the surface of the earth with a radius of 21° of arc and the position of the Space Station at the center. The useful field of view (FOV) would depend upon the required angle of incidence at the object being viewed on the surface of the earth.

The angle of incidence is measured from the local horizon on the surface of the earth toward the vertical. The angle of incidence at the object at the point marked "TANGENT" is 0° when viewed from the Space Station. As the object moves closer to the Space Station, the angle of incidence increases. At a 45° angle of incidence, the object is approximately 4° in latitude away from the Space Station. Thus, if any angle of incidence greater than 0° were required at the object for useful observation purposes, the FOV from the Space Station would be decreased.

All these values are approximate due to simplifying assumptions of a perfectly spherical earth with a smooth surface.



This chart further demonstrates the limitations of the NASA orbit for productively viewing much of the earth. Productive viewing is defined as being able to identify an object and to obtain information from it, such as dimensions. This will vary, depending on the angle of incidence. As previously discussed, an object on the horizon would have a 0° angle of incidence. It would provide very limited information except to identify that something was there, and its dimensions would be difficult to determine since the object's orientation would be uncertain. This would be the physical limit of viewing an object because of the curvature of the earth. At a 250 NM altitude, a 0° angle of incidence will permit viewing within 21° of latitude on either side of the Space Station.

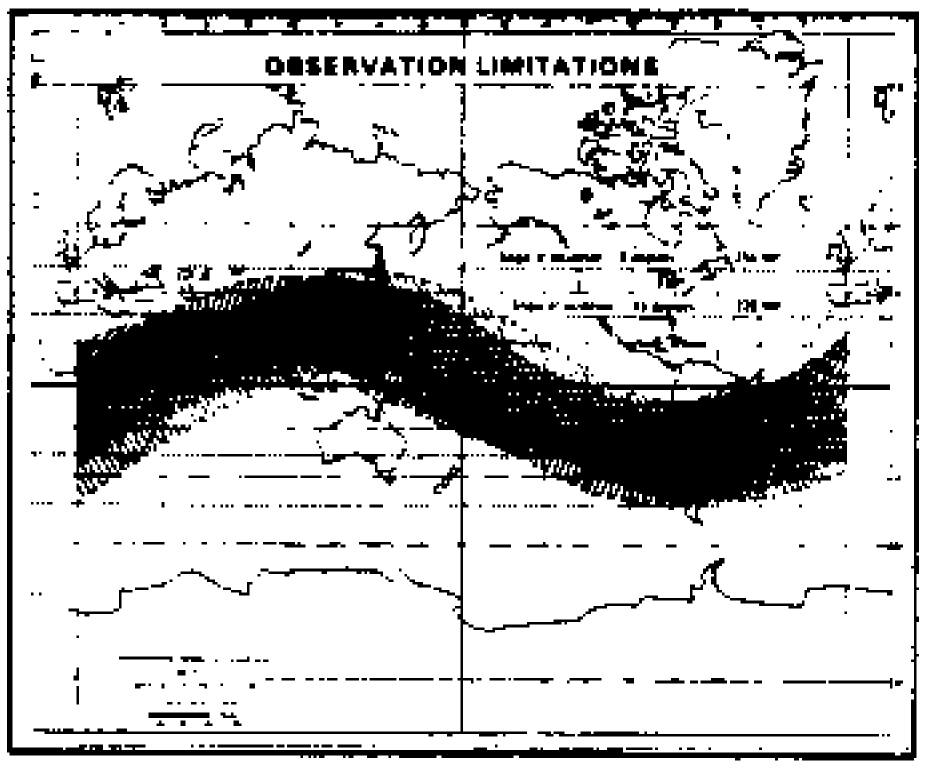
A 45° angle of incidence would provide much more information about the object being viewed. This would, however, permit viewing within only 4° of latitude of the Space Station. Lower altitudes (220 NM) would reduce the area viewed because of the earth's curvature but would improve imagery resolution.

These viewing areas are shown on the chart, with the latitudes varying from approximately 32° N and S for a 220 NM altitude and 45° viewing angle, to 50° N and S for a 250 NM altitude and 0° viewing angle.

It should also be noted that this is not continuous viewing. Instead, sixteen 90-minute orbits would be required to approximately repeat an orbit and see nearly the same area again. This occurs because the earth is rotating. Also, this varies with orbital altitudes.

COMMAND AND CONTROL LIMITATIONS

- MILITARY OPERATIONS ON BOARD COULD MAKE THE NASA SPACE STATION A MILITARY TARGET
- -28.5° ORBITAL INCLINATION COMBINED WITH 220-250-NM ALTITUDE WOULD LIMIT AREAS OF DIRECT OBSERVATION TO TWO-THIRDS OF EARTH'S SURFACE, CENTERED AROUND THE EQUATOR



ANSER

If the NASA SSMB were used for military command and control, it could become a military target in the event of armed conflict. However, it does not appear to offer great military utility in such a role, because the orbital inclination and altitudes that would limit observations of the earth to areas between 50° N and 50° S. High-quality observations would be much more restricted.

SECURE COMMUNICATIONS REQUIREMENT

ENCRYPTION MAY BE DESIRABLE TO PROTECT MILITARILY SIGNIFICANT RESOURCES

- DATA ACCUMULATION, DISPLAY, PROCESSING, STORAGE, AND TRANSMISSION FROM ONBOARD SENSORS
- DATA RELAY, DISPLAY, PROCESSING, STORAGE, AND TRANSMISSION FOR SPECIFIED RESIDENT SATELLITES
- REAL-TIME OBSERVATION, ANALYSIS, AND COMMUNICATIONS

ANSER

NASA's TDRSS will provide space-to-ground and ground-to-space communications for the manned base. Military use of the Space Station system for classified activities would require some degree of data and voice encryption. Encryption is not available to the SSMB as a whole but, if the user requires it, it can be provided. Discussions are still under way about providing the Space Station with encryption capability and about its practicality for the whole station. With so many international users having access to and knowledge about some portion of the encryption mechanism, the security of the system may not be able to be maintained. As a result, a common encryption capability for the whole Space Station does not seem feasible. In addition, it produces added overhead costs. User-provided encryption is the current capability.

E. Observations and Recommendations

OBSERVATIONS

- INITIAL SPACE STATION CAPABILITY IS DEFINED
- OPPORTUNITIES EXIST FOR DOD USE
  - —SOME EXPERIMENTS IN CURRENT DATA BASE
  - —SDI EXPERIMENTS
  - —EXPLORING MILITARY MAN-IN-SPACE ROLE
  - —OTHER STATION POTENTIALS
- NO PLAN FOR DOD TO EXPLORE POSSIBILITIES
- NO DOD MECHANISM TO DEVELOP OR EXERCISE A PARTNER OR USER ROLE WITH NASA

ANSER

Potential DOD use of the Space Station includes all of the Station's components: the manned base, polar platforms, and OMVs. NASA's initial Space Station capability is defined sufficiently for user planning. (This report merely gives an overview of the NASA Space Station program.)

A manned base laboratory or a platform can be used as an RDT&E laboratory providing an earth and astronomical observatory, a maintenance and repair station, a manufacturing facility, or a transportation node to achieve higher earth orbit. (It must be noted that the use of the station as a transportation node has not yet been proven cost-effective compared with other methods of achieving high earth orbits.) Some of the DOD R&D that could be performed on the Space Station includes STP, SDI, MMIS, and surveillance (infrared, radar, optical) experiments; atmospheric, very high speed integrated circuit (VHSIC), and directed-energy research; nuclear hardness and survivability; zero gravity and space environment (radiation) experiments;

metallurgy; and oceanographic research. Space-based mission equipment could be developed, assembled, serviced, and tested on or from the Station. These tasks can be performed on the Shuttle, with the exception of oversize structure assembly and any long-duration experiments.

In conclusion, although the DOD does not have a requirement for a manned Space Station, when the Station becomes available, the DOD could use its facilities to augment the capabilities of the Shuttle. Results to date indicate that the DOD may be able to effectively use the Space Station complex, even though there are no formal NASA/DOD mechanisms, i.e., MOUs, for DOD use of the Space Station.

RECOMMENDATIONS

- APPROPRIATE DOD ORGANIZATIONS SHOULD BE INFORMED ABOUT SPACE STATION CAPABILITIES
- DOD/NASA INTERFACE SHOULD BE ESTABLISHED TO EXPLORE DOD ROLE IN SPACE STATION

ANSER

The initial uses of the Space Station will be primarily R&D. The NASA Space Station provides an environment for some of the MMIS, STP, and SDI experiments, and the DOD should plan to use the Space Station for such experiments where appropriate.

DOD experimenters should be made aware of Space Station capabilities and the potential use of Space Station assets in time for them to plan experiments using its capabilities. This could be done by providing briefings and documents.

An experimenter's handbook--similar to that for the Quick Response Shuttle Payload (QRSP)--should be developed and distributed to DOD laboratory personnel. It would define available Space Station system test assets, interfaces, and limitations.

Formal NASA/DOD channels and procedures should be established to facilitate DOD planning for and use of Space Station assets. Procedures should be developed in conjunction with the NASA Office of Space Station to request and place DOD experiments aboard the Space Station as is now done with the Space Shuttle. These procedures should be established within the appropriate regulation (AFR 80-2/AR 70-43/OPNAVINST 3913.1).

APPENDIX A

LIST OF CONTACTS AND CONTRIBUTORS

LIST OF CONTACTS AND CONTRIBUTORS

During the course of this study, numerous discussions were held with government and industry managers associated with the Space Station Program. Each contact is listed below. Additional contacts, which contributed to the earlier study (September 1986), are listed in Report STDN 86-8. Although every attempt has been made to avoid errors, the authors accept responsibility for any that have been made. Numerous NASA documents and Air Force documents, briefings, and memos were also used.

Dr. Philip J. Cressy, Jr.	Chief, Space Station Utilization Branch Office of Space Science and Applications NASA Headquarters
Daniel H. Herman	Senior Engineer Office of Space Station NASA Headquarters
Lt Col Benjamin Higbie	Space Systems Division Los Angeles Air Force Station
Richard G. Kocinski	Senior Member Technical Staff General Electric Astro-Space Division
Dr. Franklin D. Martin	Deputy Associate Administrator Office of Space Station NASA Headquarters
William C. Morgan	Deputy Director, Program Integration Office Space Station Program NASA Headquarters, Reston, VA
Dr. Robert A. Parker	Dir. Space Flight/Space Station Integration (Act.) Office of Space Flight NASA Headquarters
Judy Robey	Office of Space Station NASA Headquarters
Maj William Shelton	SAF/OSN (Policy Office) Pentagon

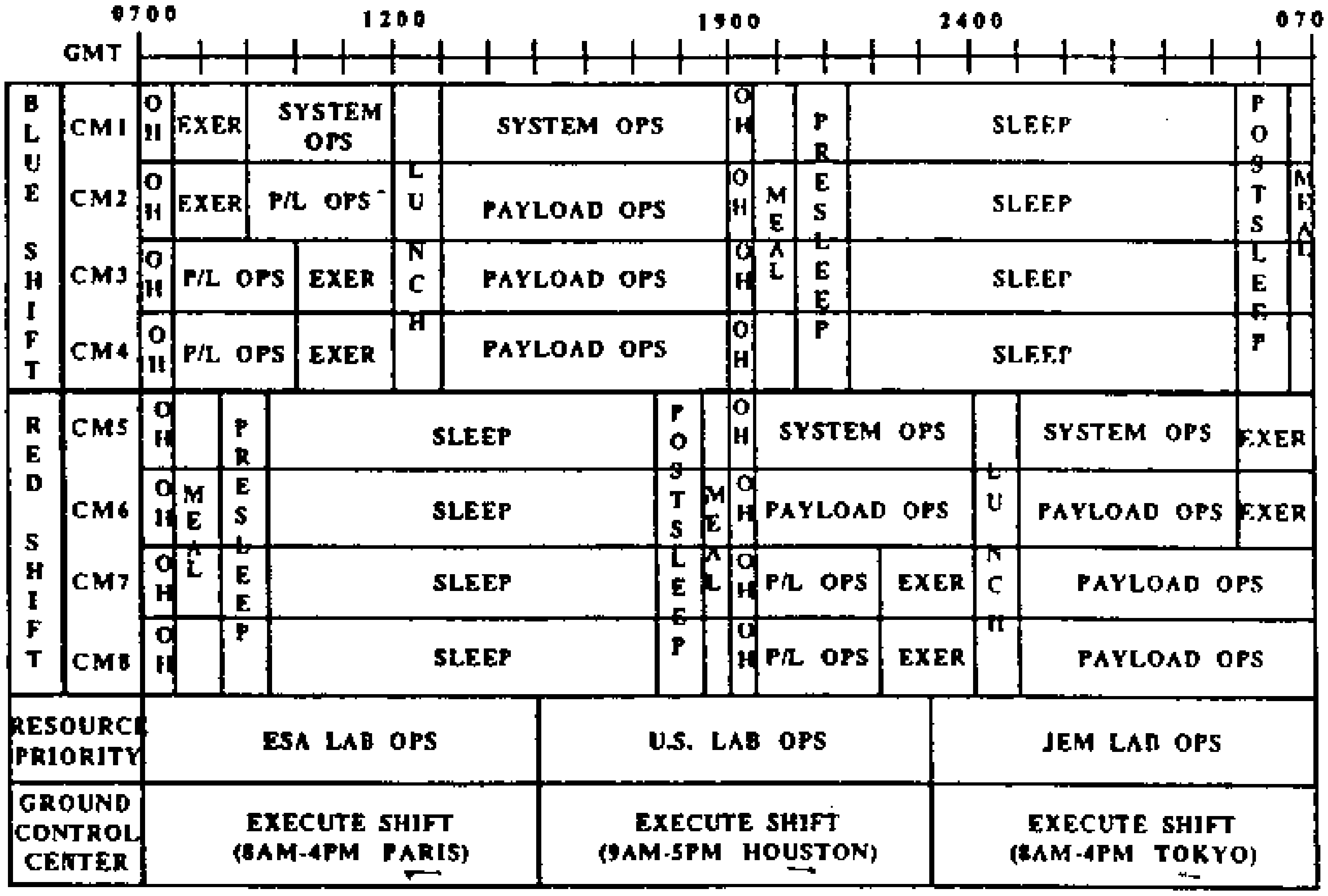
LIST OF CONTACTS AND CONTRIBUTORS--Continued

Dr. Judith Shinn	Office of Space Station NASA Headquarters
Mary Jo Smith	Office of Space Station NASA Headquarters
Donald Turner	Director, Concept Development Grumman Space Station Program Support, Reston, VA
Maj Michael Wortham	HQ USAF/XOXFD Pentagon

APPENDIX B

A TYPICAL DAY ON BOARD THE SSMB

A TYPICAL DAY ON BOARD THE SSMB



ANSER

KEY:

EXER= EXERCISE, INCLUDES PREP AND CLEAN UP

PRE/POST SLEEP = RECREATION and PERSONAL HYGIENE

OH = OVERHEAD (HANDOVER, TRAINING, AND REPLANNING) The time required for these activities may vary from day to day. The time shown is an average.

P/L OPS= PAYLOAD OPERATIONS

CM= CREW MEMBER

ESA LAB OPS= EUROPEAN LABORATORY OPERATIONS

JEM LAB OPS= JAPANESE LABORATORY OPERATIONS

U.S.LAB OPS= U.S. LABORATORY OPERATIONS

The timeline chart shown above illustrates a typical day for the crew members of the two teams (blue and red) on board the SSMB.

APPENDIX C

EXPERIMENTS FOR POLAR ORBIT

EXPERIMENTS FOR POLAR ORBIT*
FY 88

TYPE	SPACE TEST PROGRAM RANKING	EXPERIMENT	WEIGHT (KG)	VOLUME (CM^3)	POWER (W)	STABILIZATION (DEGREES)
P	2	ONR-801 (PROFILE)	<90.9	$<1.42 \times 10^4$	TBD	TBD
P	3	AFAL-403 (SOLPROP)	90	$<7.38 \times 10^4$	N/A	N/A
=P	5	AFTAC-701 (ARTEMIS)	125	1.37×10^4	60	TBD
P	8	ONR-603 (POAM II)	19	4.10×10^4	20	3 AXIS
P	10	AFWAL-501 (SCOPA)	25	8.50×10^4	20	1.0
P	15	CNO-701 (GLOW/SCAT)	178	6.96×10^4	280	0.067
P	19	AFTAC-601 (EPICENE)	49	TBD	30	0.5
P	22	ONR-602 (SPADUS)	14.51	$<1.50 \times 10^4$	11	10.0
=P	24	ONR-601 (LODUS)	181.44	1.16×10^4EST	150	10.0
P	25	NPS-802 (BUBBLE MEMORY-MBMR)	6.8	2.01×10^3	12	NONE
=P	26	LANL-801 (ALEXIS)	41	9.00×10^4	40	SPINNING
P	30	AFGL-702 (AURA)	20EST	1.08×10^4	20EST	1.0
=P	33	SD-801 (CREDO)	3-5	5.04×10^3	5	NONE
=P	39	AFWL-702 (SIIO)	7.28	3.30×10^4	28	MINIMAL
P	51	AERO-801 (GEM)	35	5.00×10^4	30	NONE
=S	5	NPS-603/NASA G-337 (STAR)	90	$<1.42 \times 10^6$	20	-
S	17	SD-804 (CRE)	294.84EST	3.11×10^5	0	NONE
=S	40	BMO-701 (MORE)	TBD	TBD	0	NONE
		APPROXIMATE TOTAL	1,272.77	248.34×10^4	736	
		ENGLISH UNITS	2,805.98 LB	87.70 FT^3		

*—ASSUMING U.S. POLAR PLATFORM OPERATIONAL ORBIT OF 500 TO 900 KM (270 TO 486 NM)
=—BOTH POLAR PLATFORM AND SPACE STATION COMPATIBLE
P—PRIMARY STP EXPERIMENT
S—SECONDARY STP EXPERIMENT

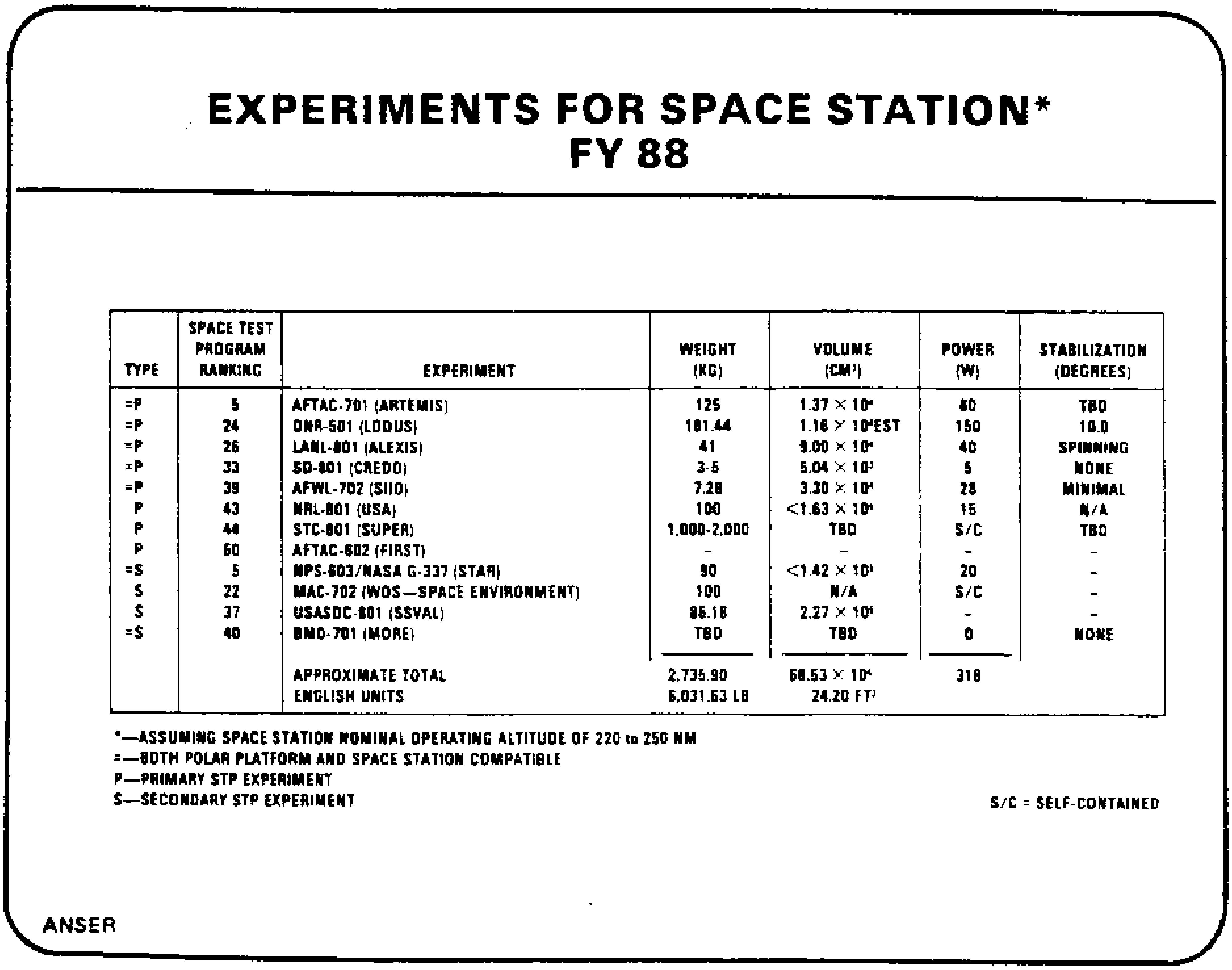
ANSER

The DOD 1988 STP experiments that could be flown on the polar platform are listed above. Listed experiments would fly in polar orbit at the altitudes of the polar platform. Since a 1- to 2-year change-out of experiments is currently planned for the polar platform, those experiments that would require less than a 1-year change-out period were eliminated from consideration.

The only questionable experiment is SD-804 (CRE). Depending on how accurate the weight estimate is for the experiment, it may be too heavy to fly. Although the aggregate payload mass available to the user is 3,500 kg, each U.S. POP standard payload mounting plate can accommodate only 204 kg of payload. Some modifications could possibly be made to accommodate this experiment.

APPENDIX D

EXPERIMENTS FOR SPACE STATION MANNED BASE



EXPERIMENTS FOR SPACE STATION*
FY 88

TYPE	SPACE TEST PROGRAM RANKING	EXPERIMENT	WEIGHT (KG)	VOLUME (CM³)	POWER (W)	STABILIZATION (DEGREES)
=P	5	AFTAC-701 (ARTEMIS)	125	1.37×10^6	80	TBD
=P	24	ONR-501 (LODUS)	181.44	1.16×10^6EST	150	10.0
=P	26	LANL-801 (ALEXIS)	41	9.00×10^6	40	SPINNING
=P	33	SD-801 (CREDO)	3-5	5.04×10^3	5	NONE
=P	39	AFWL-702 (SIIO)	7.28	3.30×10^4	28	MINIMAL
P	43	NRL-801 (USA)	100	$<1.63 \times 10^6$	15	N/A
P	44	STC-801 (SUPER)	1,000-2,000	TBD	S/C	TBD
P	60	AFTAC-602 (FIRST)	-	-	-	-
=S	5	NPS-803/NASA G-337 (STAR)	90	$<1.42 \times 10^5$	20	-
S	22	MAC-702 (WOS—SPACE ENVIRONMENT)	100	N/A	S/C	-
S	37	USASDC-801 (SSVAL)	85.16	2.27×10^6	-	-
=S	40	BMD-701 (MORE)	TBD	TBD	0	NONE
		APPROXIMATE TOTAL	2,735.90	68.53×10^4	318	
		ENGLISH UNITS	6,031.63 LB	24.20 FT³		

*—ASSUMING SPACE STATION NOMINAL OPERATING ALTITUDE OF 220 to 250 NM
=—BOTH POLAR PLATFORM AND SPACE STATION COMPATIBLE
P—PRIMARY STP EXPERIMENT
S—SECONDARY STP EXPERIMENT

S/C = SELF-CONTAINED

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The DOD 1988 STP experiments that could be flown on the SSMB are listed above. Listed experiments would fly in a 28.5° orbit at the altitudes of the manned base. Only the experiments requiring long duration are listed above. An additional 22 experiments (not listed here) that could use the Space Station require only a few days to conduct, and thus would be better suited for the Space Shuttle.

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Space Station, NASA management, international agreements, schedule, military, command and control, transportation node, research and development, maintenance and repair.

STRACT *(Continue on reverse if necessary and identify by block number)*

This division note is the result of a study that ANSER conducted for SAF/AQSS,
Robert Preston. It is a complete revision of an earlier study dated September 1986
ON 86-8). This note, in the form of an annotated briefing, portrays the current status
the NASA Space Station program as well as the potential military uses of the Space
tion. The material herin is current as of October 1988. It will be further revised as
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