The Space Congress® Proceedings

1982 (19th) Making Space Work For Mankind

Apr 1st, 8:00 AM

Space Platform

Larry P. Morata
McDonnel Douglas, Astronautics Company, Huntington Beach, California

Marshall W. Novick
TRW Space and Technology Group, Redondo Beach, California

MCDONNELL DOUGLAS

TRW SPACE AND TECHNOLOGY GROUP

SPACE PLATFORM

MR. LARRY P. MORATA
MCDONNELL DOUGLAS
ASTRONAUTICS COMPANY
HUNTINGTON BEACH, CALIFORNIA

MR. MARSHALL W. NOVICK
TRW SPACE AND TECHNOLOGY GROUP
REDONDO BEACH, CALIFORNIA 90278

ABSTRACT

The Space Platform (SP) will provide a cost effective long-term host vehicle for scientific and applications payloads beginning in the late 1980's. SP will take advantage of STS capabilities for delivery to orbit, assembly, check-out, maintenance and servicing. Services provided to multiple payloads include electrical power, heat rejection, attitude control and high-rate data handling communications. The system includes self-contained altitude maintenance and is designed for indefinite orbital operation.

MDAC and TRW are currently studying Space Platform for NASA/MSFC to develop optimum configurations for the eventual development-phase competition. Included in the study is development of plans for evolution into an eventual Science and Applications Manned Space Platform (SAMSP).

INTRODUCTION

During the past few years NASA's Marshall Space Flight Center and its contractors have evolved a concept for a low-earth orbiting Space Platform (SP) which will provide various resources for a wide variety of scientific and applications payloads beginning in the late 1980's. As an extension of the Space Transportation System, SP will use Shuttle Orbiter capabilities for delivery to orbit, activation, payload installation and change-out, and maintenance. SP will offer cost effective central services including electrical power, thermal control, communications, data handling and attitude control for extended time periods.

At present orbiting scientific and applications payloads are limited to individual free-flying spacecraft, each with its own set of supporting subsystems and requiring separate launch and mission operations capability. Payloads can now also use the Spacelab to gain space operation for relatively short periods, on the order of a few days.

Space Platform offers the possibility of extended operation (months to years) and the economies of scale by simultaneously hosting several different payloads. As a free-flyer, SP also features an attractive contamination-free environment.

SYSTEM FEATURES AND PAYLOAD ACCOMMODATION

The Space Platform design offers the following features:

- Compatibility with the STS for delivery, payload exchange, maintenance and retrieval.
- Capability of operation in any STS accessible orbit.
- Continuous electrical power, heat rejection, high-rate data communications (via TDRSS) and non-propulsive attitude control.
- Self-contained orbit maintenance and control.
- Capability for evolution or on-orbit growth to expand mission.
- Indefinite life on orbit.

Both the MDAC and TRW SP concepts (Figure 1) offer a high degree of flexibility to tailor the spacecraft to specific mission requirements. For example the solar array and radiator are modular in design and can be grown in orbit to provide additional capability. SP's data system offers the TDRSS communication link for both low and high-rate data handling.

Identified candidate payloads for SP (Table I and Figures 2A and 2B) cover the full spectrum of research areas including:

- Astronomy
- Cosmic Ray
- Solar Physics
- Space Plasma Physics
- Materials Science
- Environmental Observation
- Life Sciences

The basic SP can carry up to three payloads at berthing ports which provide electrical, data and fluid interfaces. If needed the payloads can be installed on rotation arms which provide oriented pointing through an orbit, e.g., continuous nadir pointing. This added flexibility permits combining different types of instruments on a given flight to gain the synergism of simultaneous operation.

Initial SP payloads will probably be those which have already flown on Spacelab flights and which require more flight exposure than the 7-10 days available on the Orbiter. SP is therefore designed with the goal of simplifying interfaces and minimizing changes to existing payloads.

SP activation places heavy dependancy on the capabilities of the STS including its Remote Manipulator System (RMS). The RMS is used to deploy the SP from the cargo bay (initial flight), berth to the Orbiter, install/exchange payloads and assist EVA servicing and maintenance as appropriate.

SPACECRAFT DESCRIPTION

The Space Platform as currently baselined provides approximately 12 kilowatts of electrical power to payloads at the end of five years on-orbit. Capabilities and characteristics are summarized in Table II. Active thermal control is provided through a pumped Freon fluid loop. Steerable wide-band antennas provide communications access through NASA's Tracking and Data Relay Satellite System (Figure 3). Attitude control is attained by a series of control moment gyros (CMGs) with unloading performed by magnetic torquers to avoid payload contamination.

The solar array for SP is the subject of an MSFC parallel competitive procurement with TRW and LMSC as contenders. The array consists of accordian-fold panels of very light-weight film construction. Through the use of extendible masts the array wings can deploy, extend and retract as required. The SP solar array will be the largest ever flown with a tip-to-tip span of about 250 feet. Similarly the 50-foot tall radiator has the ability to extend and retract as needed.

The Reboost Module (RM) contains adequate hydrazine propellant for orbit maintenance for a 6-12 month period. A fresh supply of propellant is delivered with normal Orbiter revisits (every six months) to service the SP or exchange its payloads.

The SP will be a large spacecraft with an overall length of about 50 feet and weight (without payloads) on the order of 30,000 pounds.

To minimize cost, SP makes use of existing technology and even off-the-shelf hardware. For example the thermal fluid pumps and valves are used from the Shuttle Active Thermal Control Subsystem. The CMG's are improved units from Skylab, even to the use of some residual hardware. Standard rate gyros, transponders and computers are incorporated. The Ku-band communication system was developed and qualified for the Landsat D program.

Space Platform promises intriguing use of Orbiter capabilities. The spacecraft will be designed for a minimum on-orbit life of five years, but has the capability for indefinite mission length. Components or even subsystems which have degraded beyond economic use or which have failed, can be replaced on orbit by crew members in extravehicular operation during normal Shuttle revisits. Thus the great expense of a return flight-refurbishment-relaunch cycle is avoided. Nevertheless SP is designed with redundant-drive retractable (and even back-up jettison capability) appendages for restowage in the Orbiter cargo bay should the need arise.

Safety of Shuttle crew members during all phases of SP activation and operation is a major design consideration. As the core of an eventual manned system, SP is designed with a high degree of redundancy and fault tolerance. All critical functions are required to be at least fail operational/fail safe.

SPACE PLATFORM INTERFACES

During the design evolution of the Space Platform, the Orbiter, payloads, TDRSS and solar array interfaces were analyzed and design solutions derived as an integral part of the preliminary design activity. Interface concepts were developed and final approaches selected based on the following criteria:

- Minimal Orbiter modifications/scars required.
- Payloads provided functionally same interfaces as in Spacelab/Orbiter
- Command/data support compatible with TDRSS services (Figure 3).
- Use existing launch base facilities (Figure 4).
- Compatible with Government-Furnished Equipment (GFE) items.

SPACE PLATFORM OPERATIONAL CONCEPT

Operational considerations have been an integral part of the development of the Space

Platform (SP) preliminary design. These considerations have been focused on providing enhanced payload benefits and maximum crew safety along with operational reliability and maintainability (Figure 5).

The SP is designed to operate in three primary modes: (1) free flyer -- multiple payload support free flight; (2) Shuttle-tended -- attached to the Orbiter for servicing and payload changeout; and (3) storage -- reduced-power free flight. In each mode the SP is capable of providing services to its attached payloads. To provide these services, an operational scenario has been developed which addresses the requirements associated with launch, orbital and mission operations (Figure 6). Interfaces, logistics and maintenance requirements and operational scenarios have been defined.

Operational Design Requirements

The main operational requirements that paced the Space Platform design are described as follows (Figure 7):

- Orbit-based with on-orbit maintenance for extended life.
- Compatible with STS delivery and operation.
- Provide resources to multiple berthed payloads.
    - Electrical power
    - Heat rejection
    - Communications via TDRSS
    - Non-propulsive attitude control
- Provide capability for payload changeout.
- Provide capability for orbit maintenance/station keeping.
- Design for modular growth.

Launch Operations

The activities at the launch site, both at KSC and WTR have been tailored to conform to standard STS flows and timelines (Figure 4). Transportation from the contractor facility will be via air carrier. The SP will undergo a CITE test including an end-to-end demonstration in conjunction with the SP Control Center (SPCC). Installation of the SP into the Shuttle will occur at the launch pad where additional Orbiter integration checks will be made. For launch, the SP will be dormant with no in-flight umbilical to the Orbiter. Reboost module processing will be offline with STS integration in the Vertical Processing Facility (VPF). The GSE to support SP checkout will be available both at the factory and at the launch site for checkout and vehicle processing.

Orbital Operations

SP on-orbit activities have been designed to provide maximum payload support while minimizing Orbiter impacts. Deployment by the RMS and mechanized appendage extension readies the SP for use. A parking port has been added to permit temporary storage during the payload exchange process.

Mission Operations

The Space Platform mission will be controlled by a SPCC which will interface with payload scientists and NASA institutional communications and data elements. During Shuttle-tended mode operations, the SPCC will interface with the SP/Orbiter via the STS Mission Control Center. Prime communications will be through the TDRSS except for brief periods utilizing the Orbiter-SP link. Onboard redundancy and command storage capability permit the SP to operate for at least 72 hours without ground contact. High-rate scientific data from the SP will be routed directly from the TDRSS Ground Station to the Science Operations Center via the DOMSAT spacecraft (Figure 8).

Logistics/Maintenance Approach

The approach to Logistics is based on an SP design which permits a high degree of on-orbit maintenance. The operational support system will be based on planning which is compatible with STS logistics systems. The orbital maintenance concept is to exchange as necessary black box-level units (orbital replacement units, ORU) (Figure 9). Repair of ORU's will be accomplished by the ground via contractor support at his facility. SP design permits an indefinite stay on-orbit with return-to-Earth as a design for contingency. Consequently, ground refurbishment of the SP will be unscheduled activity unless major problems occur during its operational life.

Verification

To assure a successful mission and reduce project risk, system verification will be achieved through a phased program of analysis, test and demonstrations. Subsystem and system qualification will be accomplished through tests on the flight unit that will demonstrate system compatibility and performance. Flight software will be developed and verified off-line at a software development facility. Validation of the flight software and hardware/software compatibility demonstration will be conducted on the flight hardware during subsystem and integrated system testing. Ground Support Equipment (GSE) and ground software will be developed in parallel with development of the flight hardware. The software and GSE will be verified and validated prior to utilization of the GSE for subsystem and system testing.

SPACE PLATFORM GROWTH/EVOLUTION

Space Platform has been designed in a modular manner to permit system growth up/down with greater capability and flexibility (Figure 10). The Space Platform design easily accommodates subsystem/system growth for increased power levels as well as for future technological subsystem improvements. The modular design of Space Platform provides for higher power levels with growth flexibility occuring both on orbit or on the ground during the manufacturing flow and/or prior to launch. In addition, the Space Platform is adaptable to a manned occupancy without requiring technological or operational breakthroughs (Figure 11).

Space Platform Growth

Space Platform modular growth capability was a major design consideration, and the goal was to be able to provide this growth both on orbit as well as on the ground with no significant increase in program costs or risks. This has been accomplished by designing the basic Space Platform frame/structure to accommodate the increased growth capability of the individual subsystems (Figure 12).

System requirements analysis determined that an initial 12 kW Space Platform with growth potential to 25 kW and higher would provide logical increments for future applications. The basic power growth increments are accomplished by adding modular units of the solar array blankets in pairs per wing. Our concept/design adds matching pairs of arrays to each wing to eliminate eccentric loads on the solar array mast. Thus, the logical increments of power provided to the payloads are established approximately as 12, 25, 40 kW, etc.

Space Platform subsystems are designed with growth flexibility and are affected in degrees by the growth scenario. The most affected subsystem when considering growth is the Electrical Power Subsystem which is directly proportional to the solar array, battery and power distribution equipment requirements. The least affected subsystems are the Attitude Control Subsystem (ACS) and the Communications and Data Management Subsystem (CDMS) as they are service and capability oriented. Subsystems are designed for both conventional growth and/or by technological evolution. On-orbit subsystem growth is provided by equipment carriers on the STS and installed via crew member EVA with RMS assistance. Therefore, additional growth equipment can be provided and/or new technology can be accommodated and/or preplanned either in existing space or by exchange of equipment.

Space Platform Evolution

The modular capability of the Space Platform provides evolutionary paths leading to an all-up operational platform (Figure 13). It includes both a scientific as well as a manned capability. The Space Platform can evolve into handling large scientific payloads by adding structural elements to its existing frame and converting into Science and Applications Space Platforms which will be free-flying low-Earth-orbit systems adaptable to large scientific payload configurations consisting of four to six payload elements. These payload elements utilize the structural appendages that have been added to the initial Space Platform. These structures can rotate and provide for full viewing capabilities. Each of the payloads can operate independently and can be removed and replaced without affecting the other elements. The STS would periodically visit the SP permitting replacement or servicing of payload elements and refurbishment of the payloads or the SP.

The SP provides capability for a manned growth scenario. The capability and elements associated with a manned Space Station are presently available and could be assembled on orbit via STS delivery. Initially, the Space Platform could accommodate the pressurized module which could be left on orbit attached to the SP and periodically refurbished during STS revisits. An initial Space Station could consist of the SP, pressurized manned control module and experiment modules, a safe haven module and logistics module and growth capability for Orbital Transfer Vehicle (OTV) berthing and launch capability (Figure 14).

The Space Platform will provide a great benefit to the scientific community by allowing multiple long-term tracking observations to be made, as well as allowing new, more complex instruments to be installed during STS revisits. In the manned scenario, the evolution of the SP will not be limited to the Life Science discipline area, but is a typical approach for any activity requiring a pressurized operational volume. Due to its modularity, the Space Platform could provide the basic capability for a permanent manned habitat (Figures 15 and 16).

TRW SPACE AND TECHNOLOGY GROUP

TABLE I. CANDIDATE PLATFORM PAYLOADS

Space Platform

MISSION	PORT A	PORT B	PORT C
88-2	UV ASTRONOMY (OSS-3)	ELECTROPHORESIS (EOS)	COSMIC RAYS (CRN)
89-1	IR ASTRONOMY (IRT)	ELECTROPHORESIS RESUPPLY (EOS)	X-RAY ASTRONOMY (OSS-2)
89-2	SOLAR OPTICAL TELESCOPE (SOT)	EARTH RADAR (SAR/OWDS/ALS)	ACTIVE PLASMA EXPS. (SEPAC/WISP)
90-1	SHUTTLE IR TELESCOPE (SIRTF)	MATERIALS PROCESSING	RADIO ASTRONOMY (VLBI)
90-2	UV ASTRONOMY (STARLAB)	ENVIRONMENTAL OBS. (LIDAR)	COSMIC RAYS (TRIC)
91-1	ADVANCED SOLAR OBSERVATORY	MATERIALS PROCESSING	SOLAR-TERRESTRIAL OBSERVATORY
91-2	SHUTTLE IR TELESCOPE (SIRTF)	EARTH RADAR (SAR/OWDS/ALS)	X-RAY ASTRONOMY (LAMAR)

NASA HQ EM82-399 (1)
12-29-81

PROGRAM MANAGEMENT DIVISION

TRW SPACE AND TECHNOLOGY GROUP

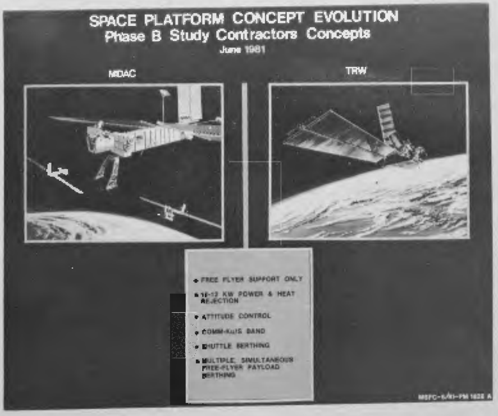
TABLE II. SPACE PLATFORM CHARACTERISTICS

Space Platform

OVERALL LENGTH (DEPLOYED)	50 FEET
OVERALL WIDTH (DEPLOYED)	250 FEET
TOTAL LIFTOFF WEIGHT	30,000 LBS
NUMBER OF PAYLOAD PORTS	3
NET ELECTRICAL POWER TO PAYLOADS (5 YEARS)	12 kW
HEAT REJECTION CAPACITY FOR PAYLOADS	12 kW
SELF-CONTAINED ALTITUDE MAINTENANCE (HYDRAZINE)	ONE YEAR
POINTING ACCURACY	1 ARC MIN
COMMUNICATIONS SERVICES	
TDRSS	KSA, SSA, MA
OMNI	S-BAND
MAXIMUM DATA RATES	
FORWARD (UPLINK)	300 KBPS
RETURN (DOWNLINK)	225 MBPS

PROGRAM MANAGEMENT DIVISION

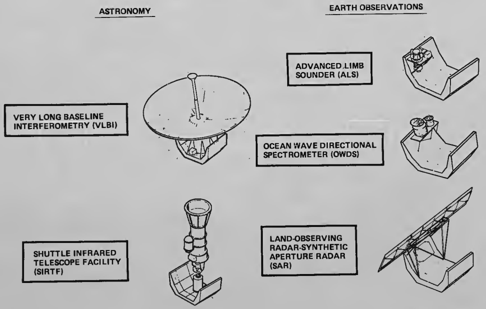
FIGURE 1. MDAC AND TRW SPACE PLATFORM CONCEPTS



TRW SPACE AND TECHNOLOGY GROUP

FIGURE 2A. SP REFERENCE PAYLOADS

Space Platform

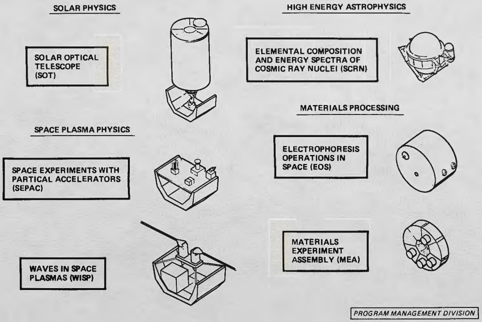


PROGRAM MANAGEMENT DIVISION

TRW SPACE AND TECHNOLOGY GROUP

FIGURE 2B. SP REFERENCE PAYLOADS (CONT'D)

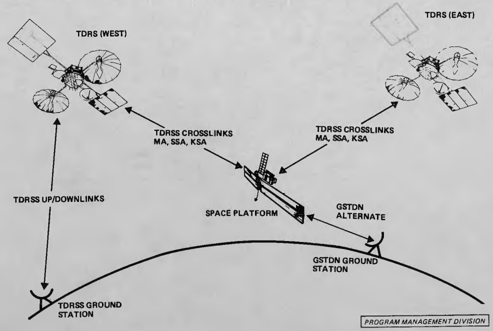
Space Platform



TRW SPACE AND TECHNOLOGY GROUP

FIGURE 3. SPACE PLATFORM COMMUNICATIONS

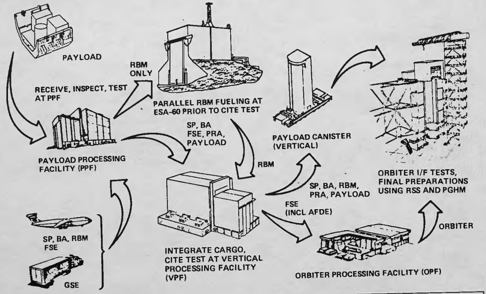
Space Platform



TRW
SPACE AND TECHNOLOGY GROUP

FIGURE 4. SPACE PLATFORM LAUNCH BASE PROCESSING

Space Platform



PROGRAM MANAGEMENT DIVISION

VFH029N

FIGURE 5. OPERATIONAL CONCEPT SUPPORTS MULTIPLE MISSIONS

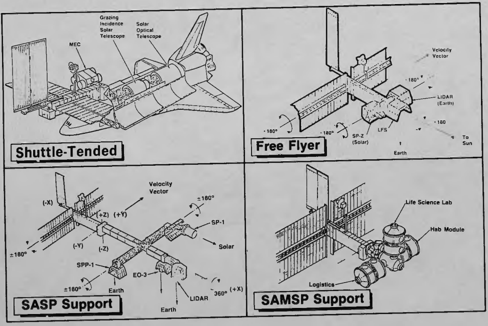


FIGURE 6. SPACE PLATFORM OPERATIONAL SCENARIO

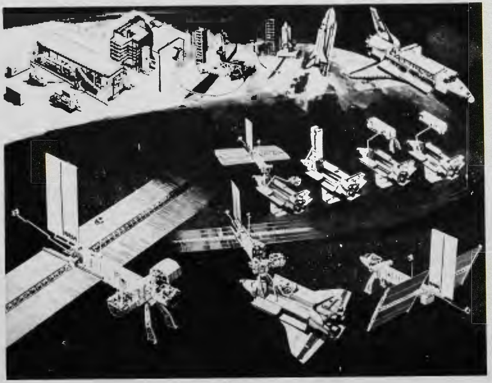
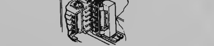


FIGURE 7. SPACE PLATFORM OPERATIONS

VFF469N

Ground Operations
- Delivery
- Final Assembly/Checkout
- Cite
- Propellant Loading
- Payload Installation
- Verify Interfaces
- End-to-End Test
- Battery Trickle Charge
- Launch



Flight Operations
- Ascent
- Deploy
- Checkout
- Rendezvous/Berth
- Free-Flyer Mode
- Payload Change Out
- Shuttle-Tended Mode
- Storage Mode

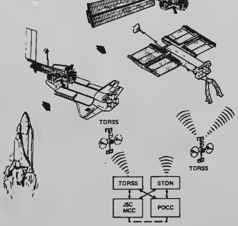


FIGURE 8. MISSION OPERATIONS - SHUTTLE-TENDED

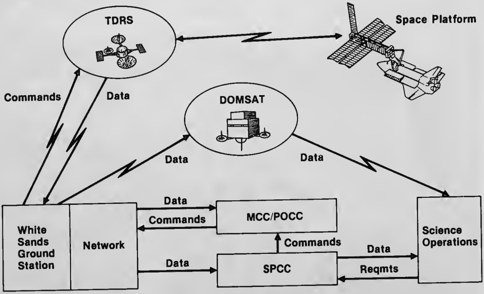
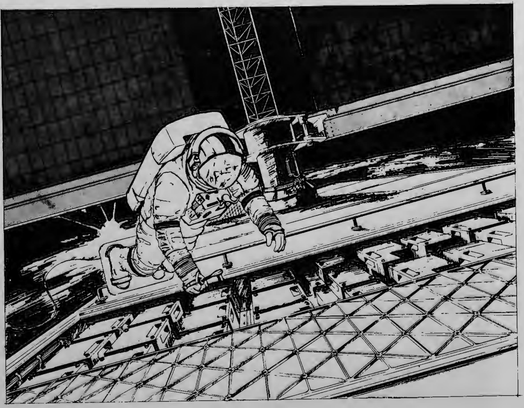
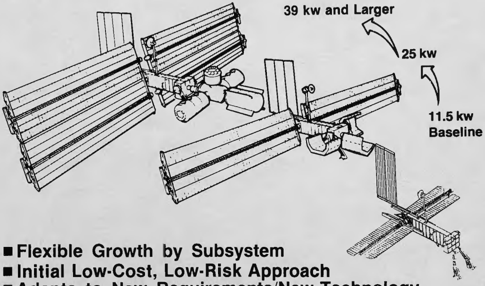


FIGURE 9. ON-ORBIT MAINTENANCE



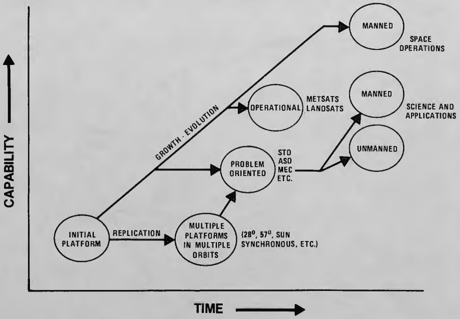
VFB262N

FIGURE 10. MODULAR GROWTH



- Flexible Growth by Subsystem
- Initial Low-Cost, Low-Risk Approach
- Adapts to New Requirements/New Technology

FIGURE 11. SPACE PLATFORM EVOLUTION



VFE276N

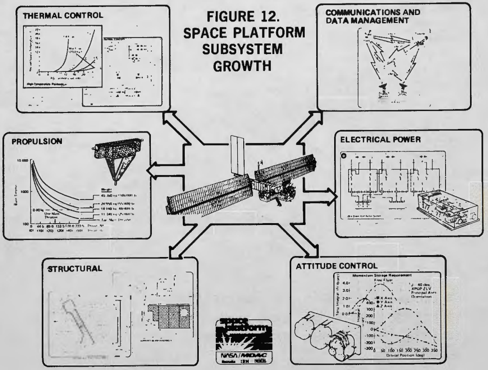


FIGURE 12. SPACE PLATFORM SUBSYSTEM GROWTH

FIGURE 13. KEY BUILDING BLOCKS ARE AVAILABLE FOR CREATING A MANNED DEVELOPMENT PLATFORM

VFM 978N

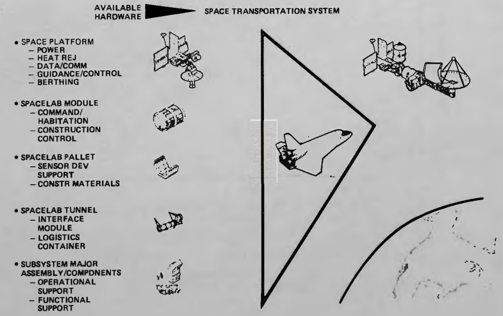


FIGURE 14. SPACE STATION GROWTH

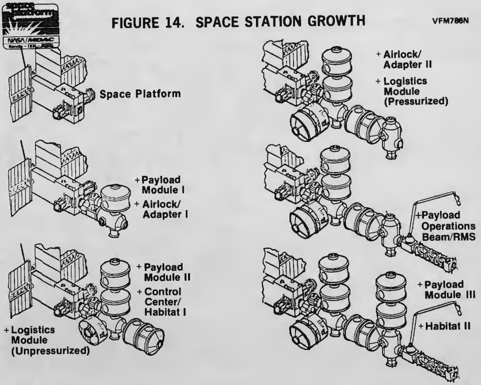


FIGURE 15. SCIENCE AND APPLICATIONS MANNED SPACE PLATFORM

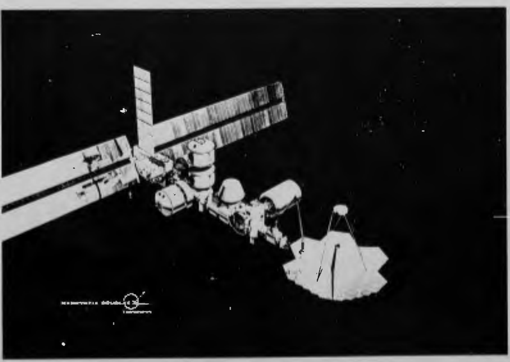
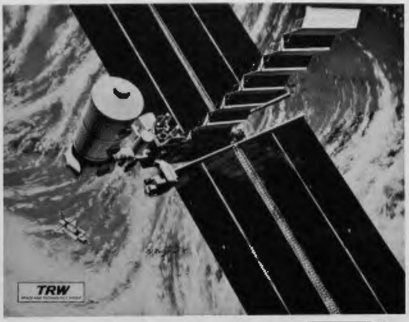


FIGURE 16. SCIENCE AND APPLICATIONS MANNED SPACE PLATFORM



PROGRAM MANAGEMENT DIVISION