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## SPACEHAB: A Manned Space Station Testbed

Robert Citron\*  
Spacehab, Inc.

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SPACEHAB, Inc. is a Commercial Space Venture creating a manned Space Station Testbed based in the Shuttle. It is creating a near term pressurized equipment test bed module and developmental scenario for Space Station. SPACEHAB, Inc. is committing early to Space Station with a pressurized module built with private financing. The Spacehab Module research capability simulating the Space Station interior environment will be available three to five years before IOC. Other emerging space commercialization companies and government organizations planning research and development at the Space Station are confronted with the cost and development risk barriers associated with evolving a space experiment research process into a viable commercial process at Space Station. The Spacehab Module has created a low cost, lower risk development scenario for the commercial customer at Space Station through our Space Station Simulation Module. The Spacehab Module is to be fabricated for later attachment to the Space Station, to provide an evolutionary research capability in orbit, to evolve as the industry and station hardware emerges, and to provide cost effective service through a private space commercialization organization.

### INTRODUCTION

The Spacehab Module is a commercial pressurized research volume in the Payload Bay of the Space Shuttle. It is in development by a private company and will provide, by 1989, a commercial research volume capable of low cost access to space. It will be launched to orbit in the Space Shuttle as shown in Figure 1.

The SPACEHAB, Inc. commitment to the NASA Space Station is in the form of a low cost commercial scenario for space research using the Spacehab shuttle based pressurized module prior to IOC and a continuing supporting role in the space commercialization industry after IOC. **THE GOAL IS THE REDUCTION OF THE DEVELOPMENTAL RISKS FOR DEVELOPERS, CUSTOMERS AND USER'S AT SPACE STATION.** One

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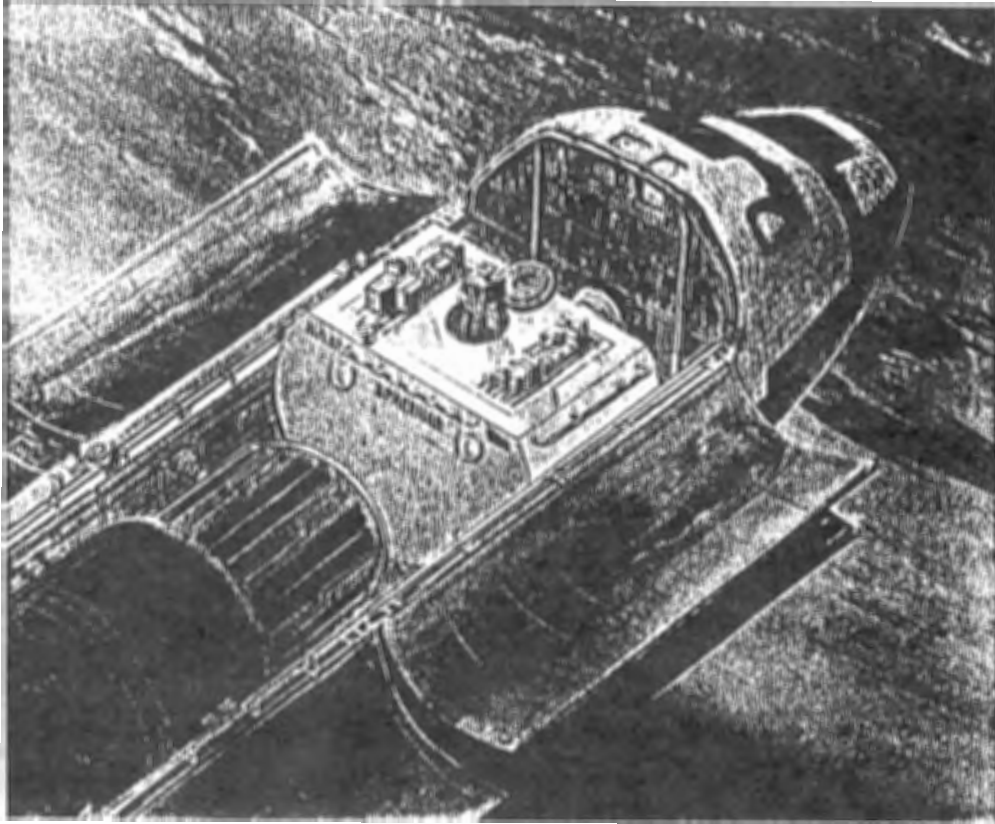


Figure 1 Spacehab Module in the Orbiter Payload Bay

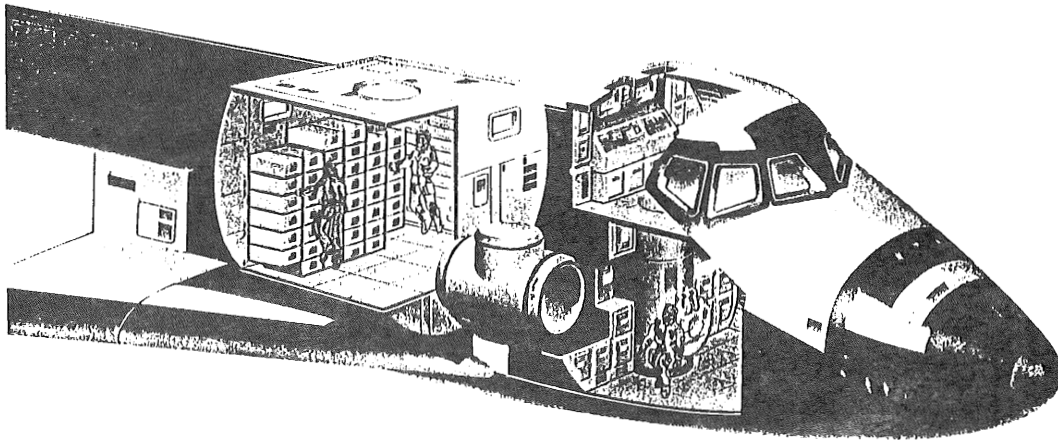


Figure 2 Spacehab Middeck Augmentation Module

of the risks is the cost and development risk associated with bringing a space research process to a viable commercial process at Space Station. The Spacehab Module will be launched in the Space Shuttle using the tunnel adapter as shown in Figure 2. Future Spacehab Module configurations will be at Space Station as shown in Figure 3.

The Spacehab Module creates a low cost lower risk testbed development sequence for the commercial customer at Space Station. The basic module is designed to address the middeck locker market with a 3 year backlog, to maximize the cost reduction aspect of a simple, existing technology shell, and to permit the customer to control the cost of orbital research operations.

Later, an advanced module will utilize the same cost effective module shell, but will evolve toward greater interior complexity, additional customer utilities and more cost. It is this module that will simulate the Space Station interior volume that is described in this paper. A later deployable version, probably circular, is expected to be attached to the Space Station and to provide a commercial interface for space research and production facilities.

The Spacehab Module Concept can offer the space commercialization industry significant cost reduction opportunities and other advantages. The utilization of commercially developed hardware has the many advantages. The development cost of the module is to be from private sources.

The Spacehab Module is designed to attach to the Space Station and provide an evolutionary research capability in orbit, change as the industry and station hardware emerges, and provide cost effective service through a space commercialization organization.

#### REDUCTION OF DEVELOPMENTAL RISK

Looking ahead to Space Station and the technology required to maintain the facilities in orbit, most commercial customers can see a variety of barriers to successful operations. These barriers include government policies, hardware and interfaces which are still evolving, international competition, proprietary issues vs the freedom of information act, lack of long duration research time in microgravity, long duration development time required for equipment, frequent flights in microgravity required for significant breakthroughs and the high cost of doing business in space.

The biggest barrier to most developers of hardware is the cost, time and development risk associated with bringing a space research process to a successful commercial end process at Space Station. In most previous manned hardware programs, the industry has not had the opportunity for frequent flight tests available through out the development process. When these frequent testbed flights are not available, then expensive and extensive ground testing is required. Maybe the frequent flight test capability will reduce the cost of developing space hardware. Spacehab is committed to create a low cost scenario to permit the customer to control costs. The Spacehab commitment is in the form of a low cost commercial scenario for space research using the Spacehab shuttle based pressurized module. It is expected to make frequent flights and provide services to the commercial space development community and other organizations including government and international groups.

The Spacehab Module creates a low cost lower risk development scenario for the commercial customer at Space Station. Three types of modules are anticipated. Each module builds on the previous module and adds more capability for the researchers in orbit. The anticipated schedule is shown in Figure 4. Each module provides the Space Station customer with a method of orbital research focusing on the Space Station.

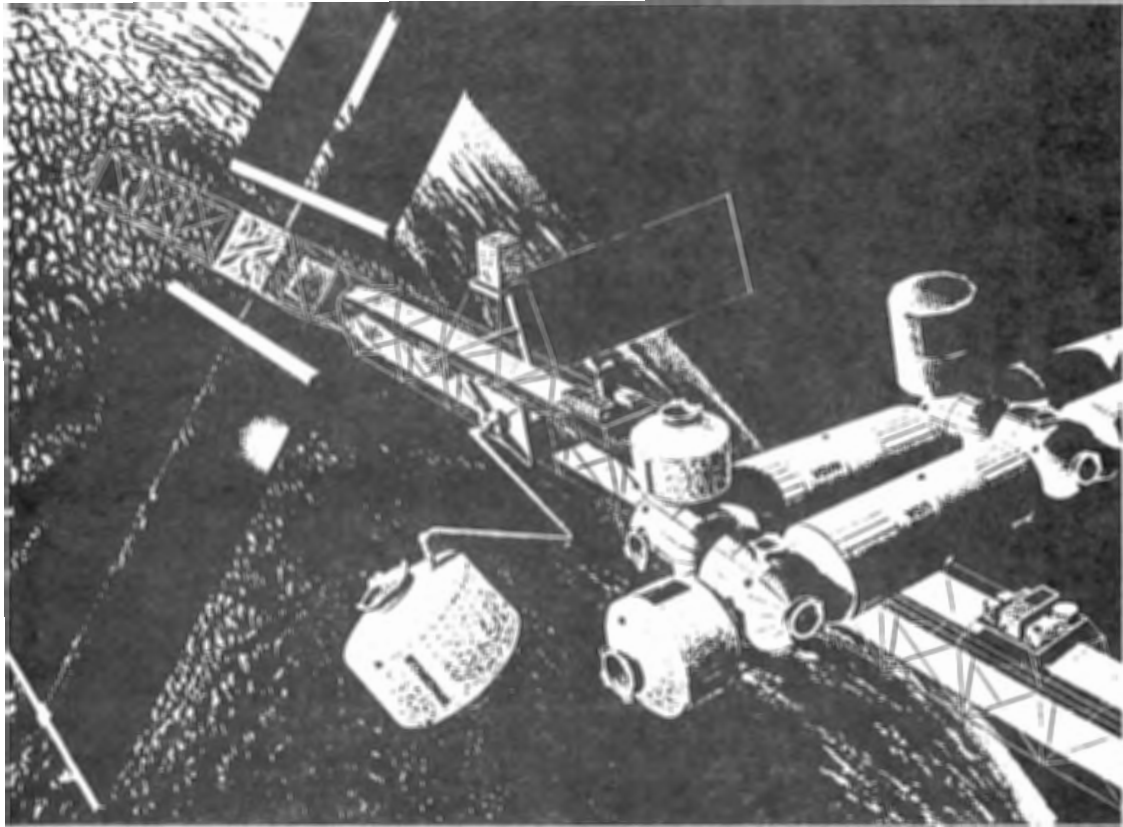


Figure 3 Spacehab Module at Space Station

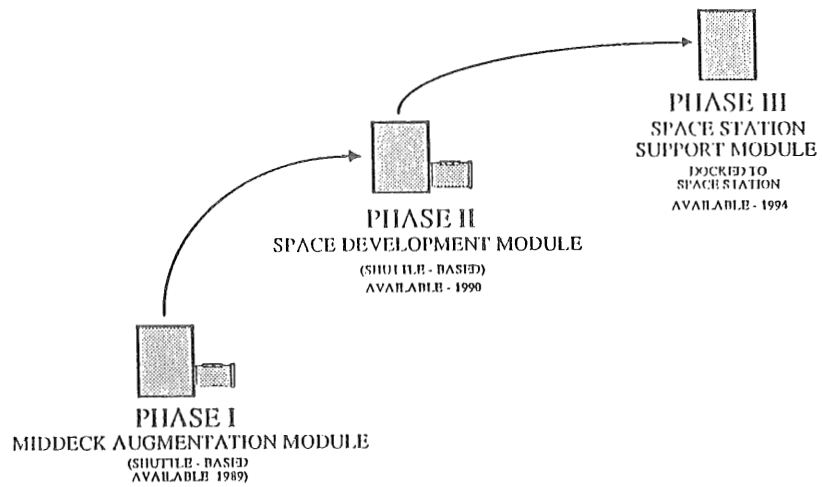


Figure 4 Spacehab Module Growth Scenario

The basic module is designed to address the middeck locker market with a 3 year backlog, to maximize the cost reduction aspect of a simple, existing technology shell, and to permit the customer to control the cost of orbital research operations. Later, an advanced module will utilize the same cost effective module shell, but will evolve toward greater interior complexity, additional customer utilities and more cost. The NASA Space Station Program is introducing a new interior configuration (Ref 1). It is this module that will simulate the Space Station interior simulation volume some five years before Space Station IOC (Ref. 2). It is this module interior that can provide a significant Space Station Test Bed Module. A later deployable version is expected to be attached to the Space Station and to provide a commercial interface for space research and production facilities.

#### THE SPACE STATION TEST BED MODULE

The Space Station Advanced Development Program will draw from a generic technology base and perform a variety of flight related experiments. In the past aerospace programs, flight testing has been more difficult and expensive to provide than it is today. The Spacehab Module can provide a low cost scenario for Space Station flight testing through an interior configured like the Space Station Common Module and expects to capture some of these orbital research and development missions. One Spacehab Configuration based on the present Common Module interior configuration is shown in Figure 5. In NASA/Spacehab discussions to date at the various NASA field centers, it appears the NASA staff are quick to realize the original plans of miniaturizing the Space Station proof of concept experiments of such technologies as shower, EC/LS equipment, utility systems and others in middeck lockers, would be more meaningful and less costly to develop and test the full size version in a Spacehab Module (Ref 3). The following testbeds appeared in the Space Station Advanced Development Review Oct/Nov 1986.

1. Antenna Test Bed
2. Data Management Test Bed
3. ECLSS Test Bed
4. EVA System Test Bed
5. Interior Architect/Crew Station Conf. Test Bed
6. Man-System Integration Test Bed
7. Medical Test Bed Component Development
8. Manned Systems Integrated Test Bed
9. Instrument Thermal Bus Test Bed
10. Thermal Test Bed Expert System Tech Demo
11. GN&C Instr. & On-orbit Test
12. Test Bed CMG Refurbishment
13. Rotary Joint Test Bed
14. PV/PMAD Test Bed
15. SV/PMAD Test Bed
16. Human Factors Testbed
17. Life Science Equipment Development Testbed

Not all the above test beds will require a pressurized environment, but most would profit from Spacehab Module with hands on development capability in orbit. Several NASA and international TEA's with SPACEHAB, Inc. are in various stages of completion (Ref 4, 5, 6, 7).

The NASA Space Station interior configuration is still evolving at this time, but Figure 6 depicts the present interior configuration thinking as adapted for the Spacehab Module interior. The Spacehab Module design is still evolving and major trades are in Phase B remain.

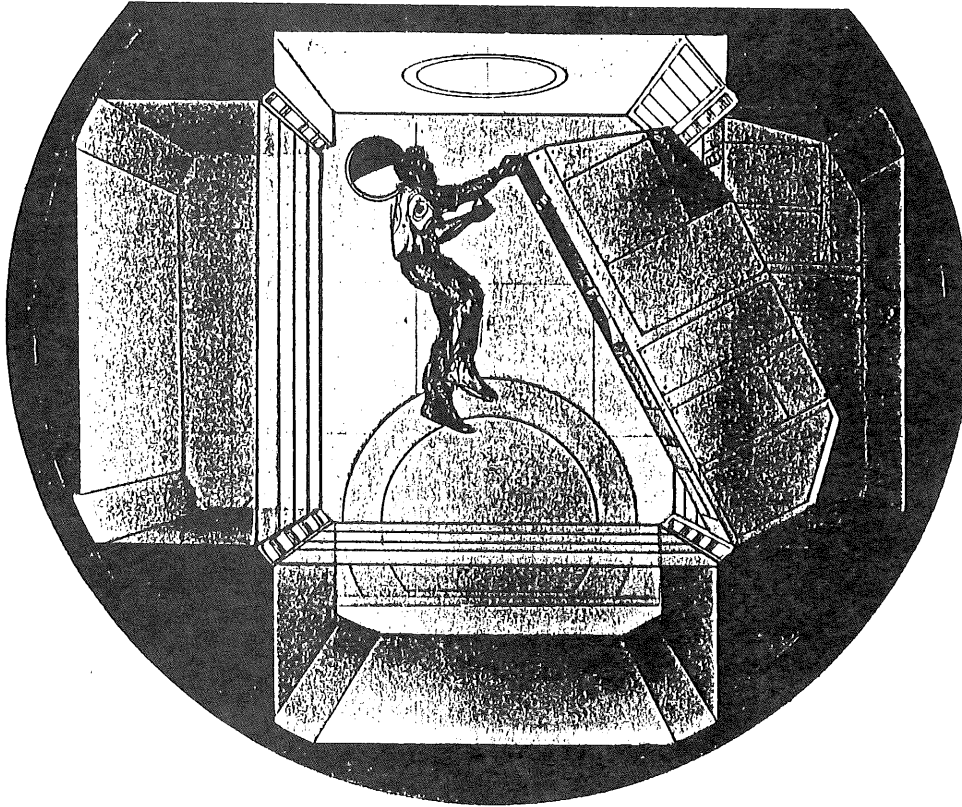


Figure 5 Spacehab Space Station Simulation Module

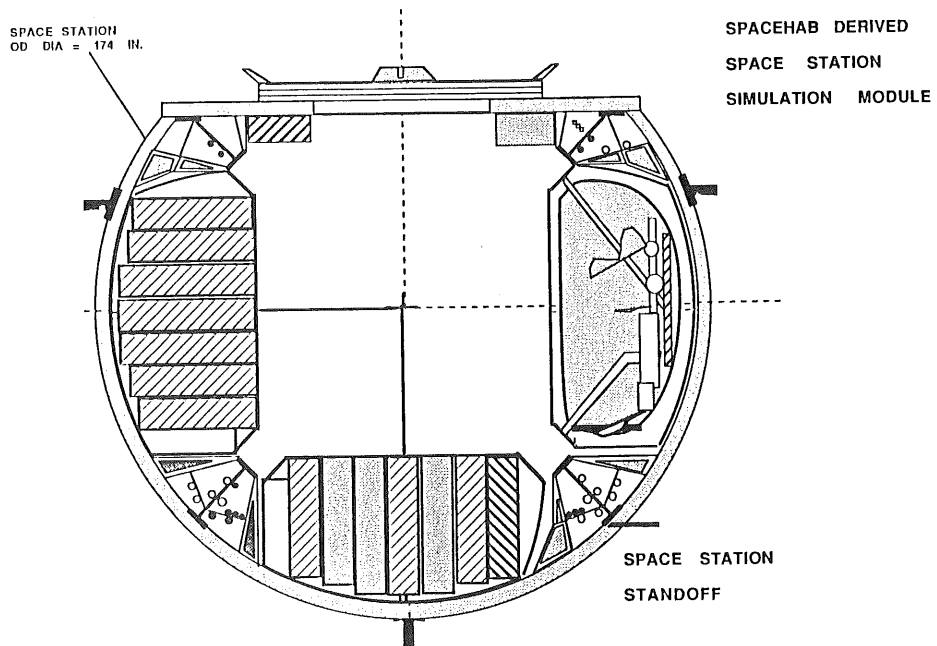


Figure 6 Simulation Module Interior Configuration

Three Phase A studies have been completed by Martin Marietta Aerospace, Michoud, Aeritalia and MBB-ERNO. (Ref. 8,9,10.) This interior Space Station Simulation configuration is designed to fully simulate the interior of the Space Station in a Spacehab Module approximately five years before the similar facilities are available at the station. The Spacehab interior has the facilities, interfaces and utilities required for the testing of racks and other equipment designed for the Space Station. The Spacehab interior is expected to interface with the new Space Station racks as well as the older Spacelab rack, the expected Columbus rack with an insert and a variety of payload carriers. It provides the commercial customer with a frequently flown pressurized module able to reduce some of the development risk for commercial equipment at Space Station. It is a module system that will evolve with the commercial customer as requirements and the Space Station evolve.

The Spacehab Module interior would contain the rack attachment corner standoffs, utility lines, utility access doors, repair provisions, fluid storage tanks, rotation mechanisms for the racks to provide access to the module skin, and other yet to be determined aspects of the future NASA Space Station interior.

The Space Station will require a new level of technology for a variety of orbital operations. The list of Technology Development issues for Space Station is long. The Space Station will require the development of technology probably considered by most as lower level issues, but essential to the effective operation of the Space Station. These include electrical connectors, maintenance and repair procedures, standardization of equipment, fasteners and tools/support hardware, outer module skin monitoring and repair and a variety of other microgravity specific "new" technology issues within each major Space Station technology discipline.

The data base of projected station users contains 27 percent commercial type customers. The goal of the Spacehab Module is to capture that commercial market at Space Station and other Space Facilities. Commercial companies are sensitive to the developmental risk and cost of placing new equipment in a Space Facility for 90 days without some assurance of success. Spacehab can provide this development lead-in volume in the microgravity environment of space for a low cost systematic research, development, checkout, flight testing and full simulation of the future Space Station interior volume.

Several other space technologies and a different focus on existing technology development is expected when the commercial companies explore the industrial service market at Space Station. NASA is actively seeking those firms willing to research commercial operations in orbit. Because the traditional development time for Space Technology and operational hardware is long, Spacehab is actively stimulating the formation of Commercial Consortia to move Commercial Technology from the conceptual stage to orbital flight test in the shortest possible time. Spacehab can provide pressurized volume at Space Station for the development of commercial operations at IOC.

Now the typical idea moves through the present aerospace environment from inception to operational orbital hardware in an eight to twelve year time span. Spacehab can be instrumental in decreasing this time span and is now signing agreements with interested parties. This commercial technology development market can become significant when predictions of a \$ 40 billion per year orbit industrial market are realized in the future.

Robots, for example, react differently in a microgravity environment and the research simulations and development on the ground have some difficulty in totally duplicating the microgravity conditions in orbit. Simple things like grappling and translation of the arm take on a new dimension when no gravity is present. Operations ultimately designed to occur outside the module can benefit from early tests and research on orbit inside the Spacehab



Module, because of the human intervention capability in the research and development process. Spacehab can provide this inside volume for "Hands-on" interface with the development process.

Most Space Station Studies mention the proprietary information security concerns expressed by commercial companies and researchers. The attitudes and depth of concern within the commercial companies and the military appears to be significantly deeper than previously thought or reported. It is the same reason two companies on the surface don't normally share development laboratories when the economics of the situation would point to advantages and cost savings. The investment in technology leading to commercial products or services is at best a very risky and extremely competitive business with corresponding high return on investments for the companies involved.

The Spacehab Module can provide a proprietary volume from the inception of the research to final production facilities and still be compatible with the Space Station Program. The Spacehab Module can be integrated in the commercial customer's surface facility, transported to orbit, utilized by company staff only and returned to the customer's surface facility. The scenario can be used in the early stages of development as well as later stages including the final production facility attached to Space Station. All scenarios can occur in a commercial environment of proprietary security. Certain, to be determined, NASA Safety and interface requirements will, however, exist.

The later production of commercial products at Space Station using the industrial process and equipment developed is likely to be similar in some respects to surface manufacturing operations and may not fit the interior rack philosophy of the current Space Station Design. By taking the simplified manufacturing flow of the typical surface manufacturing operation one can begin to see the emerging commercial orbital requirements when the commercial/industrial operations and production planning is applied to orbital conditions. Some of the issues are:

1. Raw materials or liquid transported to the production location
2. Surge storage of raw materials or liquid
3. Raw materials or liquid processed by equipment
4. Processed raw materials or liquid quality checked in orbit
5. Surge storage
6. Final product transported to the surface on equipment available every 90 days.

In the heightened risk and cost environment of Space Station, the Spacehab Module seems to fit several ways. First, Spacehab is, as a single module volume, capable of near term basic proprietary research and development and capable of evolving with requirements of the commercial customers to a final production facility. It is capable of cost effectively slaving off the station and limiting the risk of the commercial customer to utilities and services used rather than a prorated share of the entire facility. Second, Spacehab can perform supplemental logistics module functions by being specifically designed to interface with the Spacehab derived production module and create the surge storage and changeout of module required for efficient operations.

One area of developmental research at Space Station which is able to utilize the Spacehab module effectively is the Life Science community. Both the centrifuge vibrations and animal contamination problems may make it difficult for realistic Life Science research inside the communal Common Module. A variety of Life Science experiments have been proposed and Spacehab is working out the Technical Exchange Agreements (TEA) and M.O.U.'s now. One suggested Life Science related T.E.A. proposes a Life Science oriented centrifuge in the Spacehab Module.

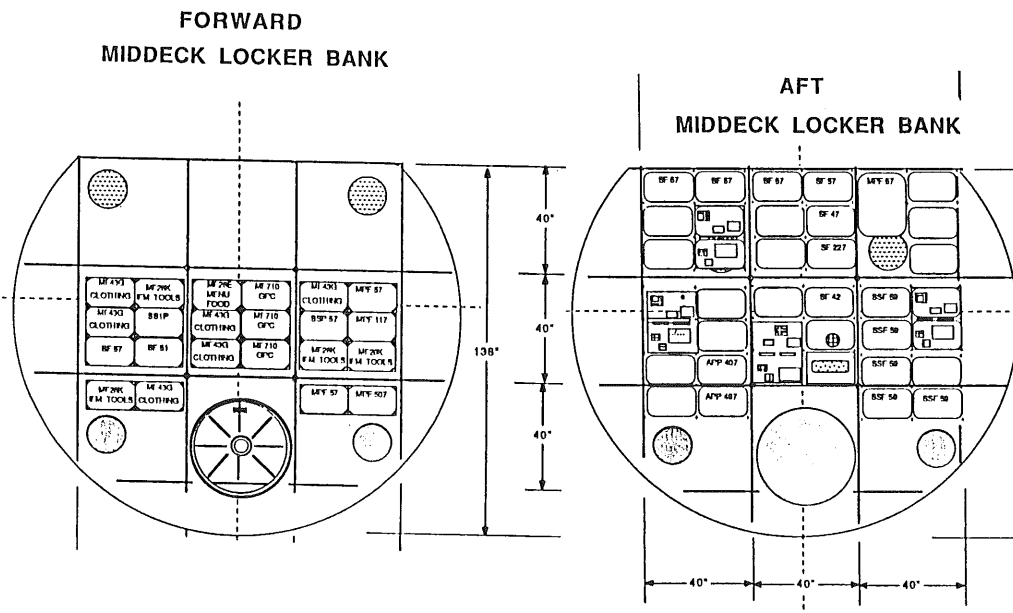


Figure 7 Basic Spacehab Module Middeck Interior Configuration

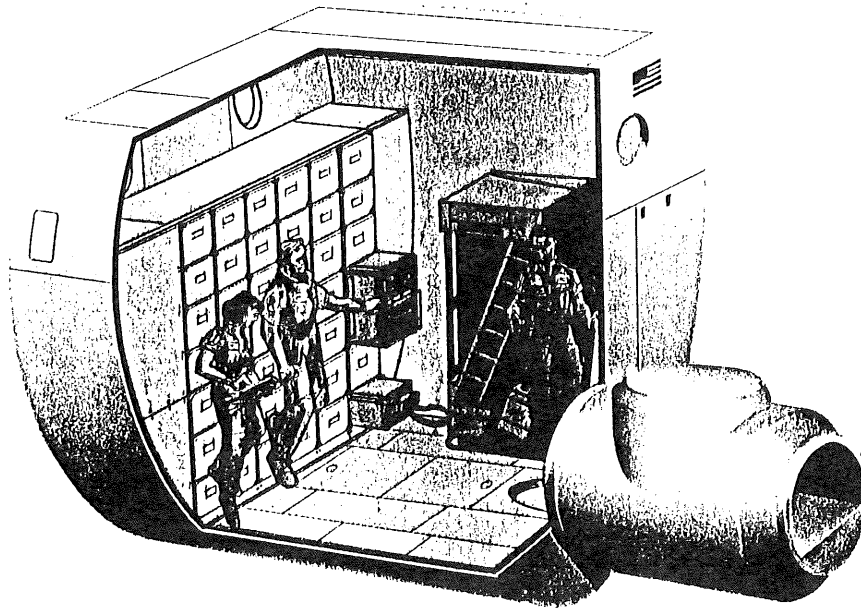


Figure 8 Spacehab Middeck Augmentation Module Cutaway

## YOUR DEVELOPMENT SEQUENCE WITH SPACEHAB

Space research is new to some organizations and the cost of space research is sometimes hard to sell to upper management. Spacehab is prepared to assist you and your firm with technical information, development models, full scale mock-ups and access to space on a continuing basis. The firm will respect the proprietary nature of your business and your research.

Middeck lockers offer an early starting point for orbital research and after ground based research. The orbiter has approximately 42 middeck lockers with about 7 available to non crew utilization on each launch. The basic Spacehab Module can accommodate approximately 60 middeck type lockers on the forward and aft bulkheads as shown in Figure 7. It also can provide additional volume for racks and other experiments as shown in Figure 8.

Most early microgravity research requires broad experiment parameters to isolate, through pathfinder research, the most productive research area for concentrated efforts. The Spacehab Module is ideal for the pathfinder research and can provide the support facilities and ground support for your research efforts. If your research is successful, then more sophisticated and focused research is warranted in racks in the advanced Spacehab Module shown in Figure 9. Once the research is ready for Space Station production, then flight testing in the Spacehab Space Station Simulation Module is a low cost scenario for flight testing the equipment prior to the commitment of full Space Station resources. After the commercial research is in production at Space Station, Spacehab can support the operation with supplemental logistics as required.

The Space Shuttle can accommodate, for short emergency periods, eleven crewmembers. The support gear and equipment for the station replacement crew is likely to be more than can fit into the normal middeck volume. Spacehab can provide an overflow storage transport volume on the launch and can eventually be attached at Space Station to provide temporary crews quarters and equipment storage volume on orbit. The ability to stow less critical middeck lockers in the Spacehab Module may increase the near term opportunities for late access middeck lockers in the orbiter middeck volume.

As a precursor to the full utilization of a Spacehab Module by an organization, SPACEHAB, Inc. has introduced a full scale mock-up to assist the experimenters and stimulate the funding within an organization. The mock-up helps focus the center of activity within the customer's organization rather than at some exterior integration facility controlled by others. The mock-up is furnished to dedicated Spacehab Module Users and the mock-up is a cost effective method of starting the cycle of experiment creation, flow and integration within an organization. Figures 10 and 11 depict a Spacehab Module Full Scale Mock-up recently delivered to NASA Ames Research Center.

The Spacehab Payloads Services Division can provide a variety of ground and data services to the customers. These payload services are available on an "As Required" basis. These payload services can be seen in Figure 12.

## THE DEPLOYABLE MODULE AT SPACE STATION

The Deployable Spacehab Module is expected to continue to exploit the low cost existing technology shell, but will not require truncation. It can continue to use the same hardware and organization created in the earlier module development.

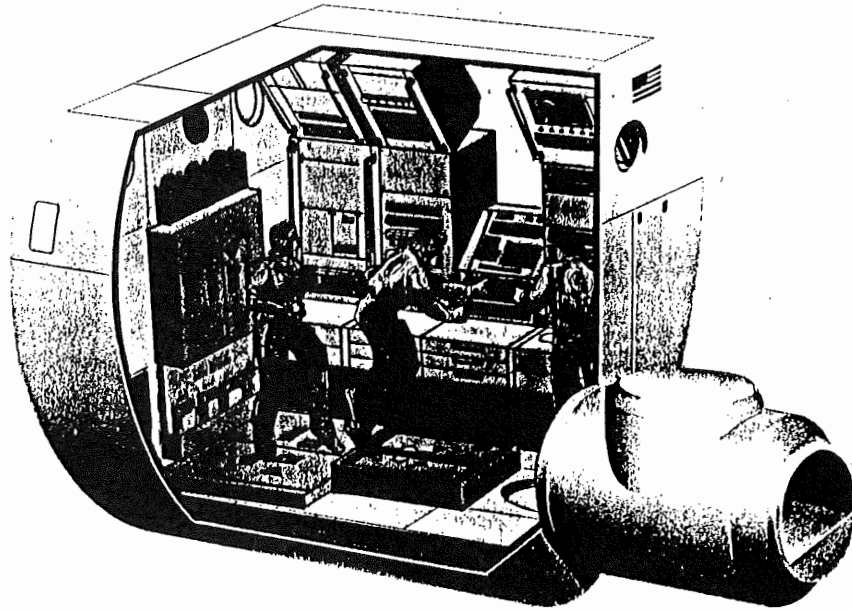


Figure 9 Spacehab "Advanced" Space Development Module

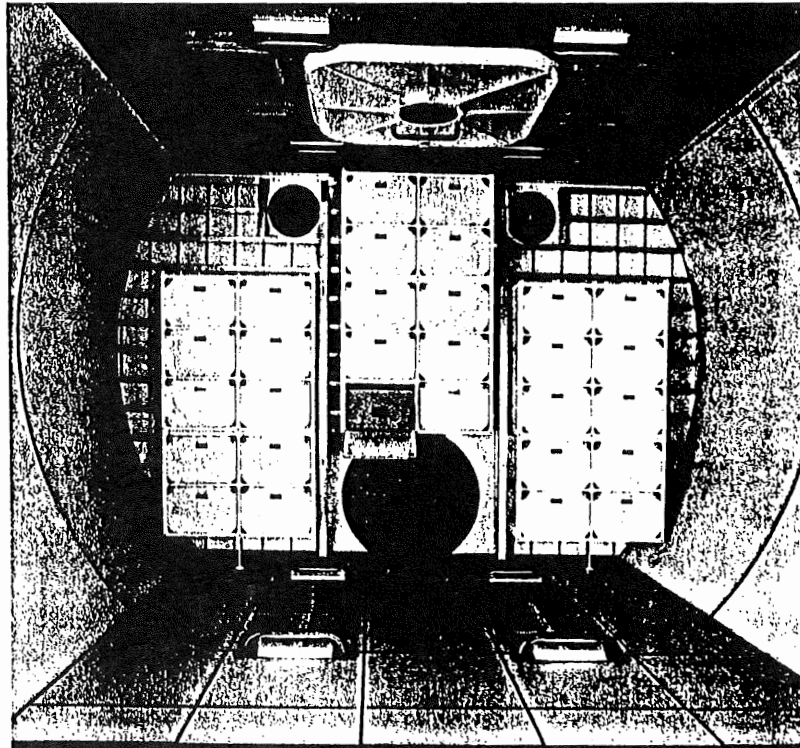


Figure 10 Spacehab Middeck Augmentation Module Mock Up

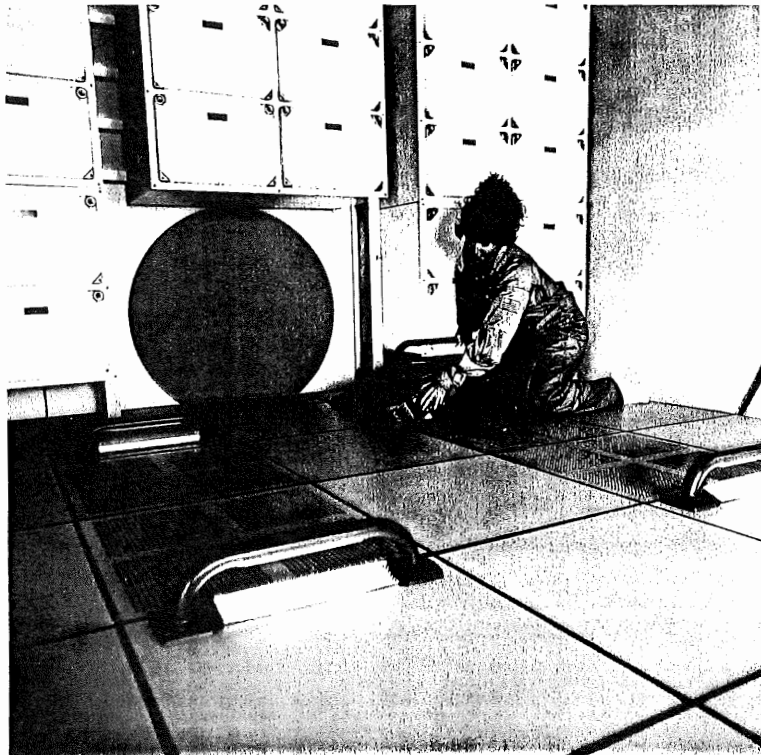


Figure 11 Mock Up Used as an Artificial Intelligence/Robotics Testbed

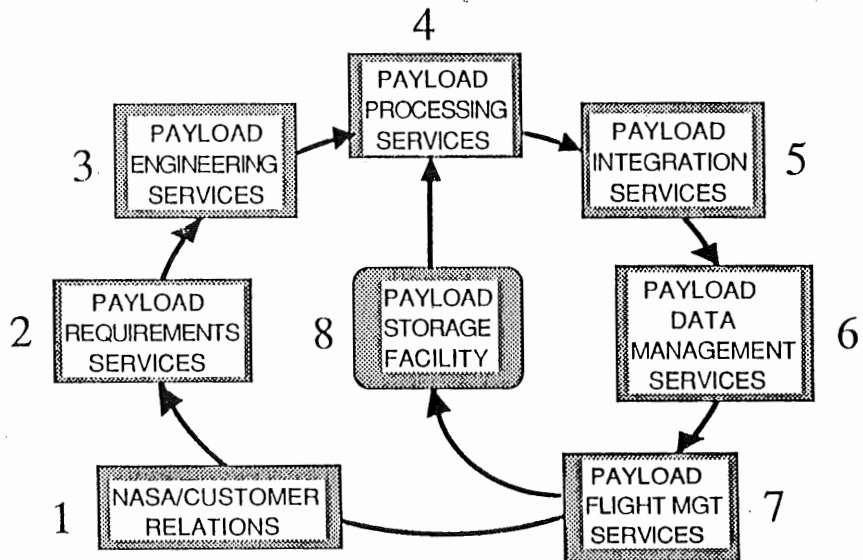


Figure 12 Spacehab Payload Services Flow Chart

As the Spacehab Module evolves into advanced versions, several methods of interface with the Space Station are possible. The major goal at Space Station with Spacehab is a commercial development and production volume. The Spacehab Module is anticipated to be attached to the Space Station and provide a commercial interface for space research and commercial production facilities. Several methods of attachment are possible. The truncated Spacehab Module is shown attached to a Spacehab Deployable (Non Truncated) Module in Figure 13. The Spacehab Module shown attached in the figure is the Space Station Simulation Module that is to be available for orbital research about five years before Space Station deployment.

The proprietary safeguard of trade secrets from other users including the NASA is important to the commercial customer. These same kinds of hardware safeguards can also provide the military a research volume at Space Station without the cost, security problems and political sensitivity associated with the placement of military racks in a civilian station. Figure 14 shows one method of attachment. The secure military research module facility at Space Station or other orbital military facility can be resupplied separately with classified items as shown in Figure 15.

Traditionally, the assembly of facilities in remote environments on the surface of earth or beneath the oceans have required extensive "Human Support" facilities; in the arctic it is expensive protective shelters and under the ocean it is a remote life support pressurized work volume system. In space something similar is expected for the "Erectable" Space Station and the Spacehab Module can assist by providing an EVA specific pressurized work volume designed to fill the requirements of an EVA "heavy" and tool intensive environment indicated from similar remote assembly history.

Each version of the Spacehab Module is expected to exploit the basic module low cost existing technology shell. The shuttle based modules will require truncation and the deployable version can use similar shell technology. It can continue to use the same subsystems, hardware and organization created in the earlier module development.

#### COST REDUCTION OPPORTUNITIES

The Spacehab Module Concept can offer the space commercialization industry a variety of significant cost reduction opportunities. The utilization of commercially developed hardware has the following advantages (Ref 11).

1. The development cost of the module is to be spread over the entire user base and providing each user with the benefit of lower cost. This means one user does not support the entire development cost of the modules.
2. The development risk and the up front funding is raised from private investors and eliminates some of the cost growth risk and new start funding normally associated with new hardware. This means the user does not require up front budgets to develop the module hardware. Private investors raise the funding in anticipation of profits later through the lease of the module.
3. The Spacehab Module is designed to minimize the length of payload bay required, therefore minimizing the launch charges to the customer. The Spacehab Module is expected to require approximately 10 feet of length in the payload bay plus the tunnel adapter from the Spacelab hardware and may fit within the forward quarter of the payload bay.
4. The flat end cap design of the module requires a shorter length in the payload bay and also provides two more useful interior flat wall surfaces for cost effective interior experiment

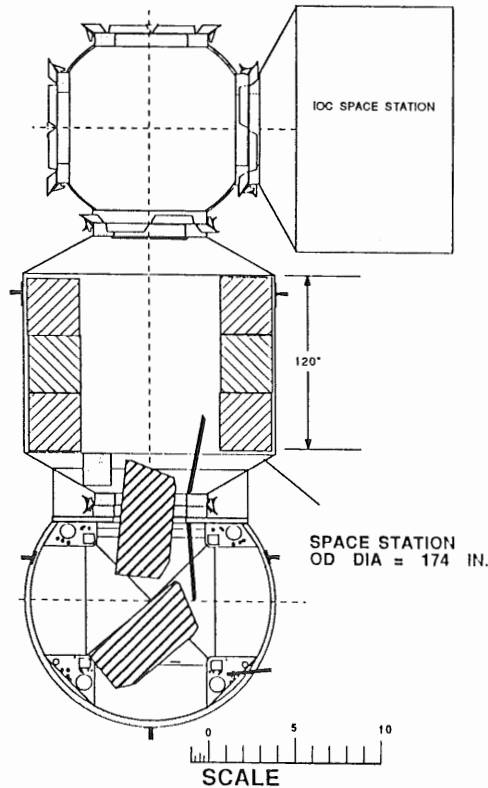


Figure 13 Early Basic Module Transferring to Attached Spacehab Module at Space Station

layouts. The forward and aft flat bulkheads are of similar design to reduce tooling costs. The interior then has four useful walls to fasten racks, middeck lockers and other experiments. The top panel adds an additional location to attach payloads.

5. Unlike other pressurized modules, Spacehab allows other payloads to fill the remaining 3/4's of the payload bay. The total launch cost is shared with other payloads. This also means many combinations are possible. For example, classified man-tended payloads can be mixed with unclassified payloads in the payload bay to cost effectively utilize the full shuttle capabilities. This means a totally dedicated DoD STS launch is not required for some portion as a classified pressurized module mission.

6. Spacehab is expected to provide a wide range of payload services beyond the launch of a leased module. These services require a fixed overhead and a cost component based on the magnitude of services provided. The fixed overhead is shared by all the customers and the savings are available to all.

7. The frequent launches of the Spacehab Modules will provide frequent flight opportunities. The frequency of a service provided permits the distribution of the fixed costs of an operation to be shared by more customers and permits lower costs. It also permits the Spacehab Module business to emulate the commercial airline-type approach.

8. The ability of the module to evolve into advanced versions and deployable versions provides a cost reduction capability by continuing to utilize the originally developed hardware as a base for future enhanced modules. When one thinks about it, almost all rocket development programs grow in launch capability and payload provisions. Spacehab combines

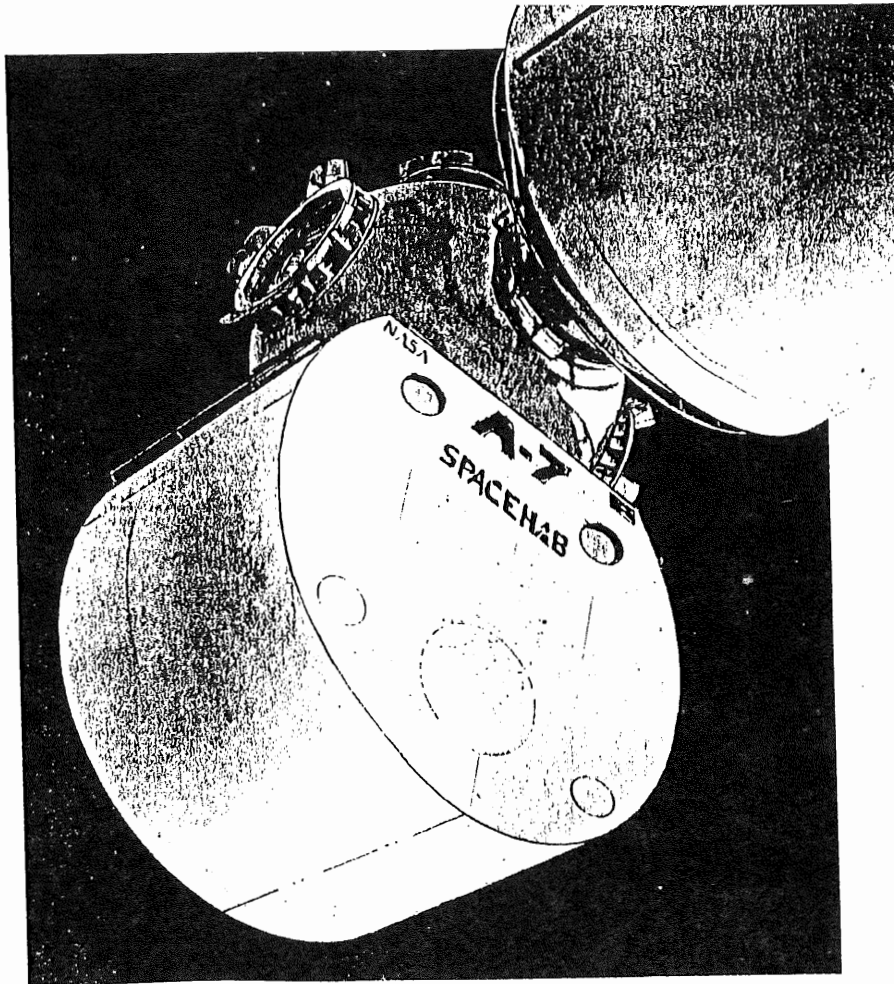


Figure 14 Secure Military Research Module

this growth of hardware capability with the fact that the hardware is reusable instead of being destroyed with each launch.

9. A major component of the total cost of space research is the integration. It can approach a cost equal to the launch cost of the payload. Spacehab offers several ways for the customer to control this cost. First, The Payload Services Division can provide cost effective commercial integration services. Second, the entire module can be integrated in the customer's facility where the customer controls the cost and the customer's staff isn't on expensive temporary duty. Third, portions of the payload can be partially integrated in remote/classified locations. This includes racks and the top panel.

The space commercialization industry can maximize the cost reduction opportunities of this and other commercial hardware by not only using it when it is available, but also contributing to the development of the user requirements documents, staying aware of the commercial development and assisting the commercial organizations in the development with suggestions and improvements permitting the industry to more effectively utilize the hardware.



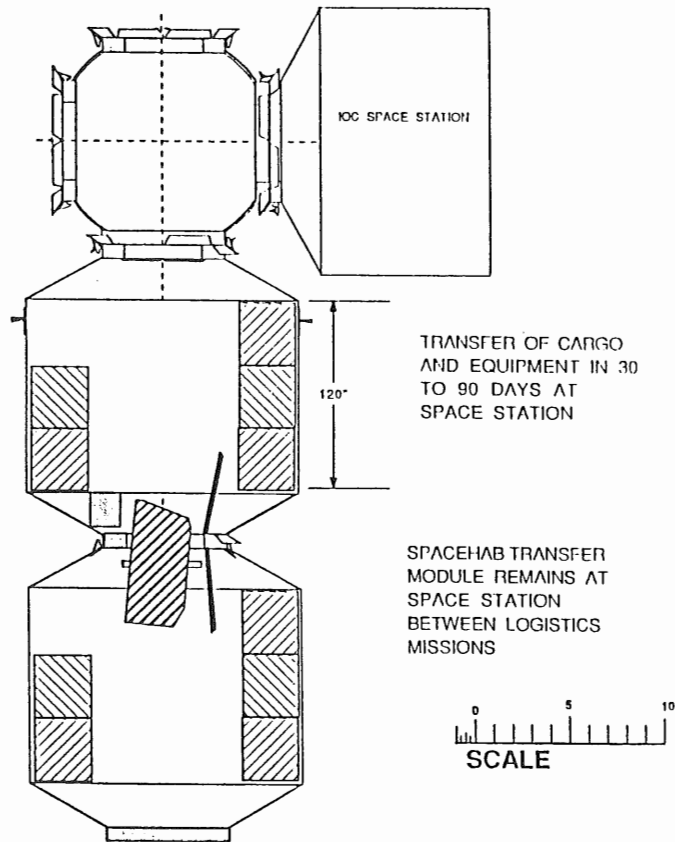


Figure 15 Deployable Spacehab Module Resupply

#### PRIVATE FINANCING OF THE SPACEHAB MODULE

To be truly cost effective, aerospace hardware must evolve and become more productive at less cost. The Basic Spacehab Module Business Plan is based on a middeck locker and early rack experiment market. The anticipated cost to lease the module for a flight is expected to be in the range of \$ 15 million per launch, plus flight charges. An individual middeck locker is anticipated to cost \$ 400k per launch including the launch and moderate integration charges as required. The basic Spacehab Module design is scarred for upgrade to advanced versions. A later version of the Spacehab Module will be designed to attach to the Space Station to provide an evolutionary research capability in orbit able to change as the industry changes and provide cost effective service.

## CURRENT STATUS

Spacehab is currently in Phase B development, an MOU has been signed with NASA and a Form 100 has been submitted for a flight after the shuttle is operational again (Ref 12, 13). A 1990 first launch is requested and possible with a high priority payload. An SSDA and Launch Services Agreement are under discussion (Ref 14). A Launch Services Agreement for the first five flights is expected to be signed with NASA within a short time. The Phase B Design studies are continuing (Ref. 15) and continue to discuss future launches with perspective customers (Ref. 16). The first day of accepting Form 101's, Spacehab's Request for Flight Assignment, resulted in 23 middeck locker and 5 Spacelab type rack flight requests. A planned Spacehab User's Seminar for 25 potential users at the IAF Congress in Innsbruck, Austria resulted in over 100 participants each receiving the 250 page Users' Manual. (Ref. 17) A new version is being printed. Approximately, 800 other users worldwide have requested the manual and the new revision will be mailed in approximately several weeks. McDonnell Douglas is performing the Phase B study scheduled to complete approximately May 86. Richard K. Jacobson, former vice president of McDonnell Douglas Astronautics Company, has recently become the CEO of SPACEHAB, Inc. Figure 16 depicts the facilities being setup worldwide. Over two million dollars of private financing have been raised toward a total of the \$ 65 million development funds required for the first three modules.

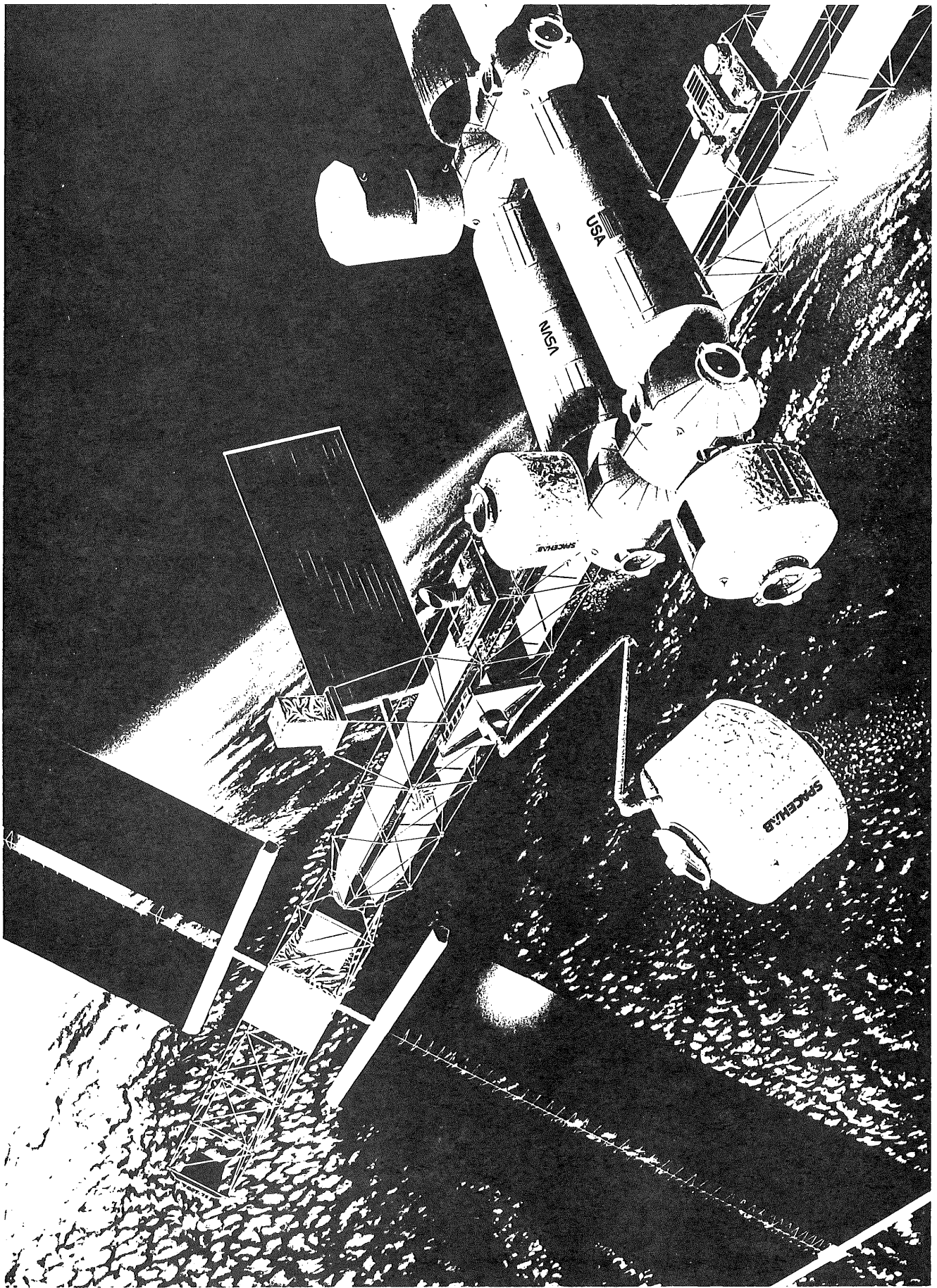
## CONCLUSIONS

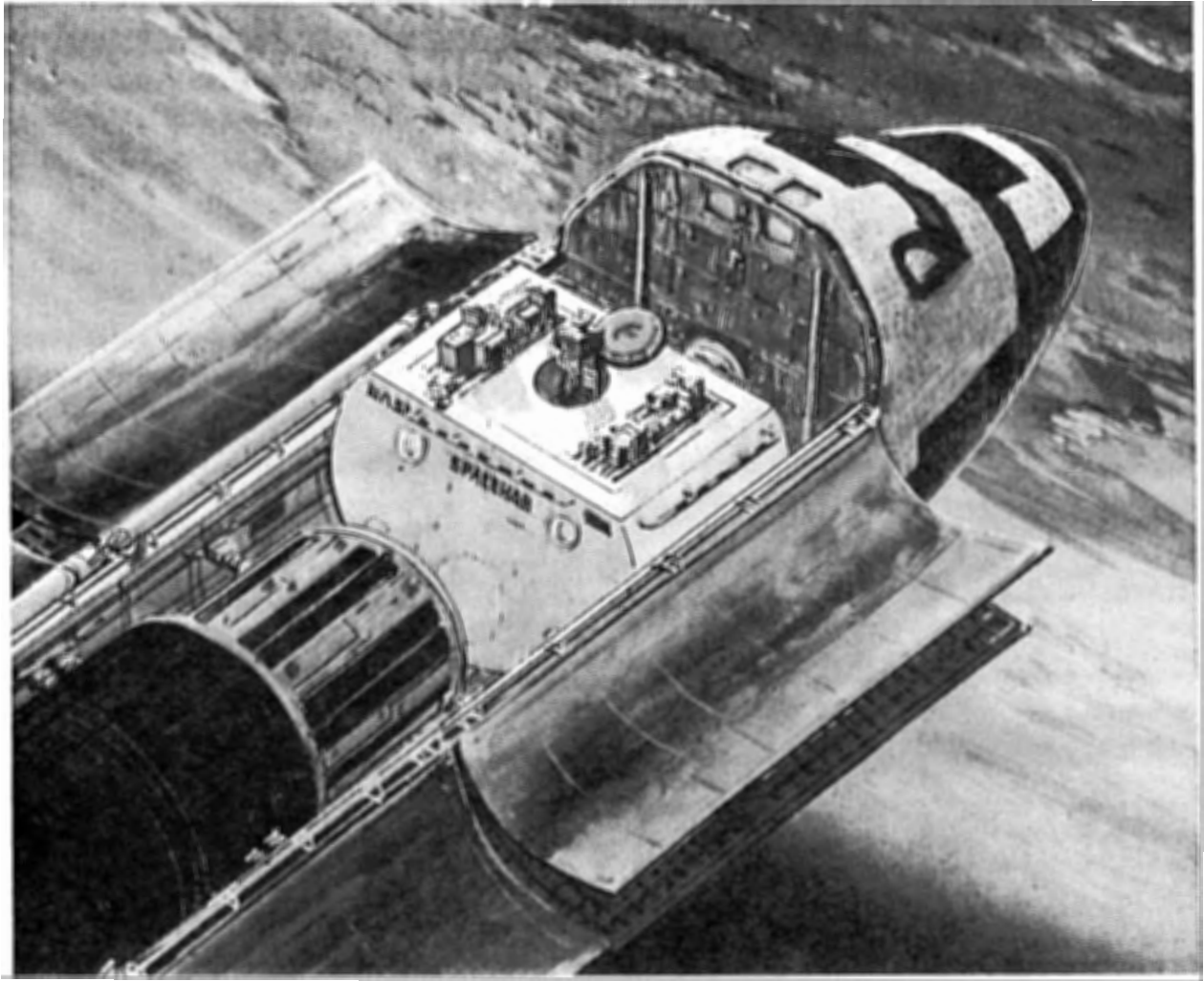
SPACEHAB, Inc. has committed private money to the Space Station and is actively pursuing a low cost scenario in support of the Space Commercialization industry. Cost reduction opportunities exist within the Spacehab Concept for the space commercialization industry at Space Station. To gain all the benefit from the commercial development of the hardware, the customers must provide specialized user requirements for the Spacehab Phase B studies. Spacehab actively solicits those comments from all that are interested. If you are not on our mailing list, please let us know.

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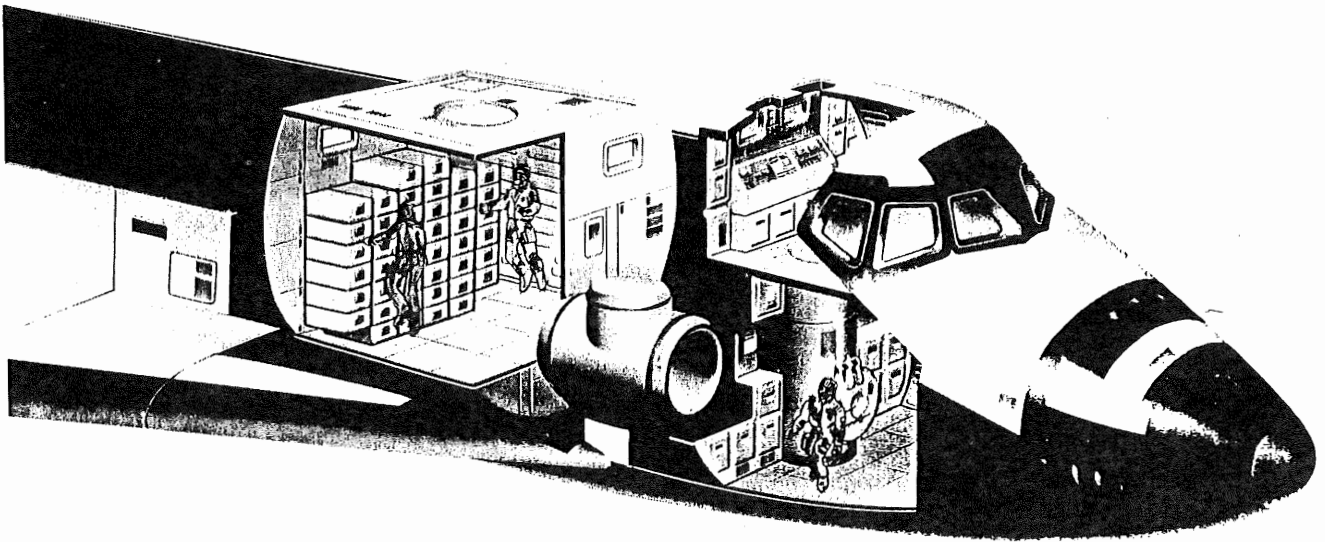
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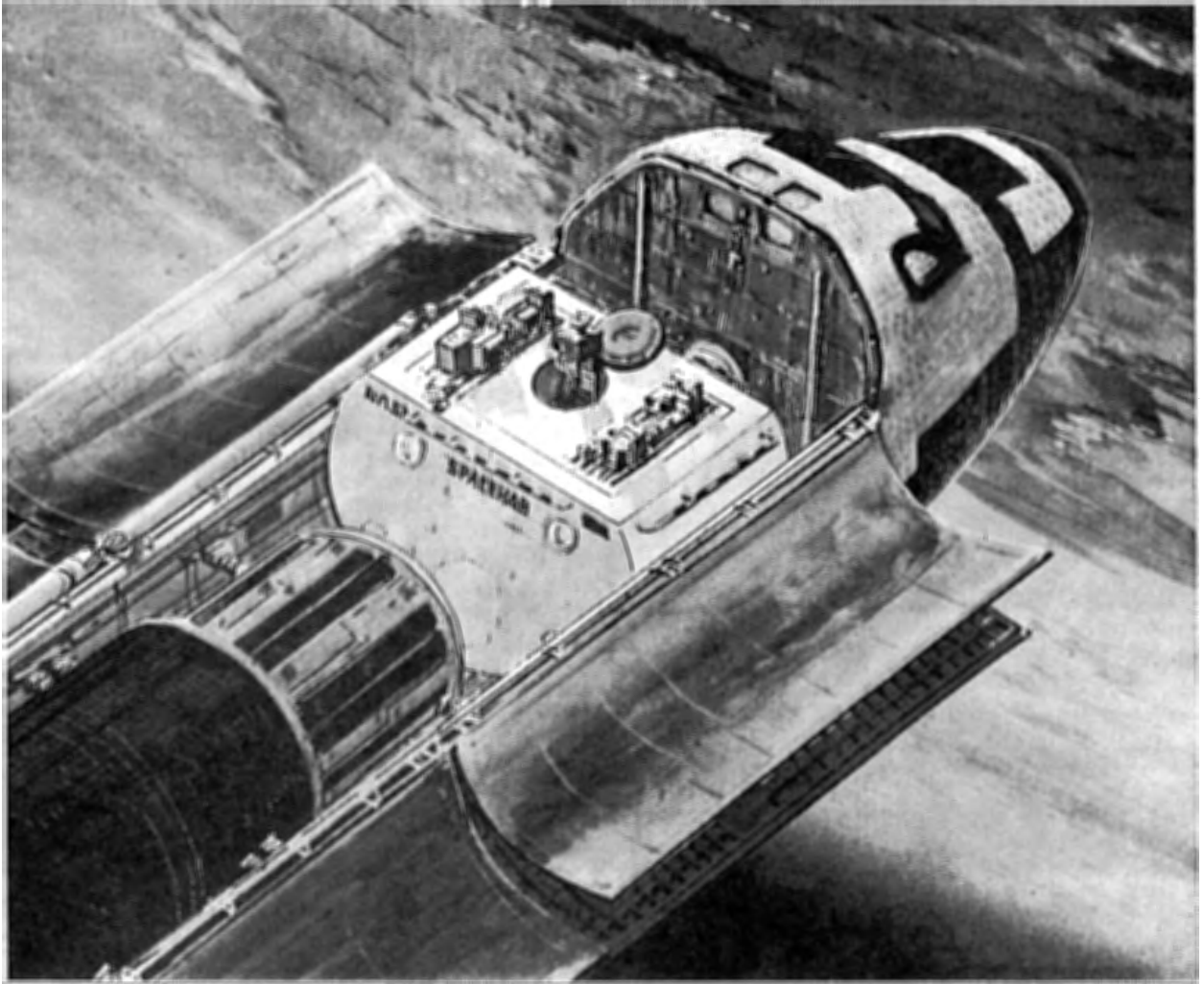




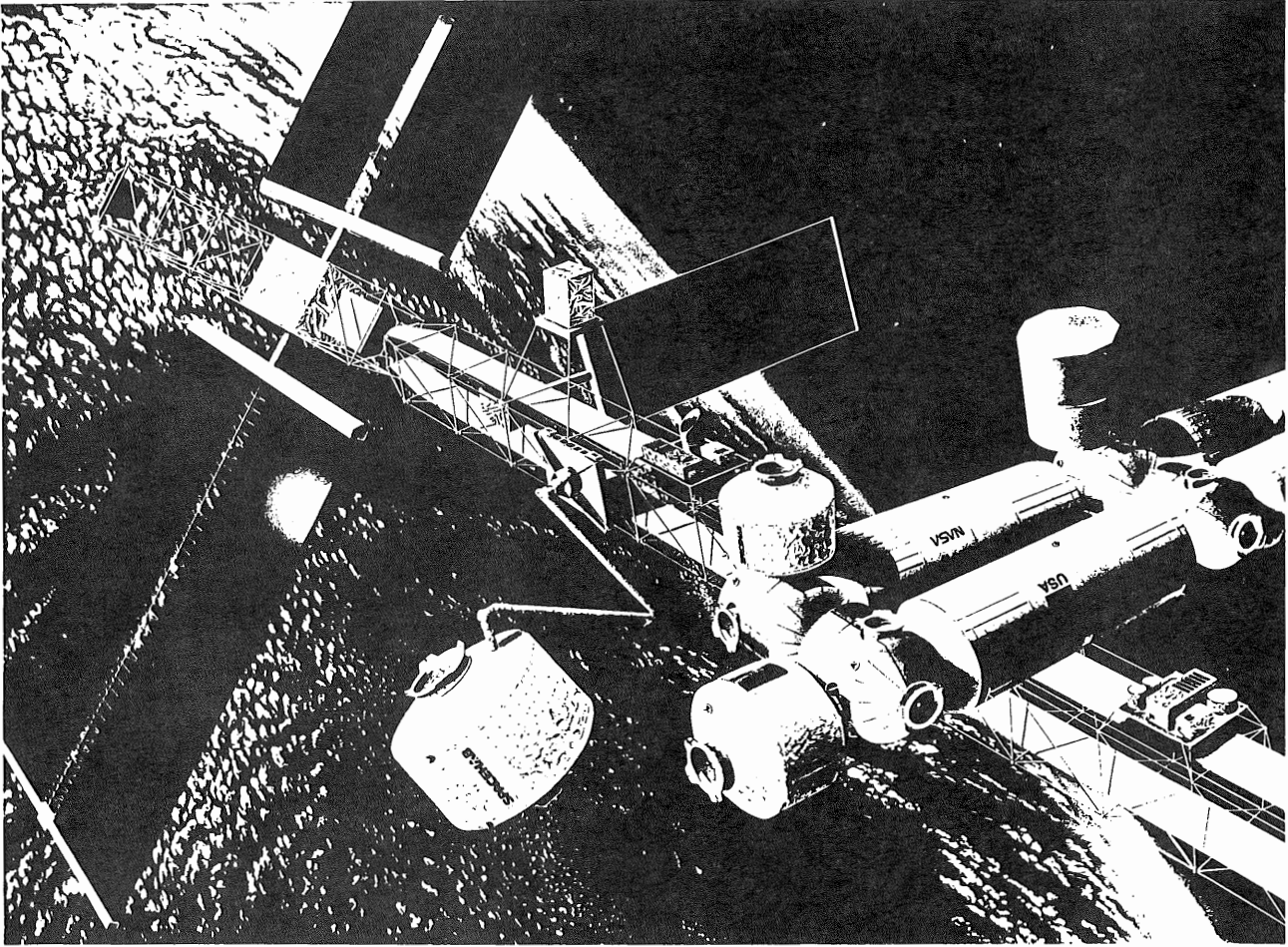
SPACEHAB MODULE SHOWN IN  
ORBITER PAYLOAD BAY



SPACEHAB MIDDECK AUGMENTATION MODULE  
IN ORBITER PAYLOAD BAY

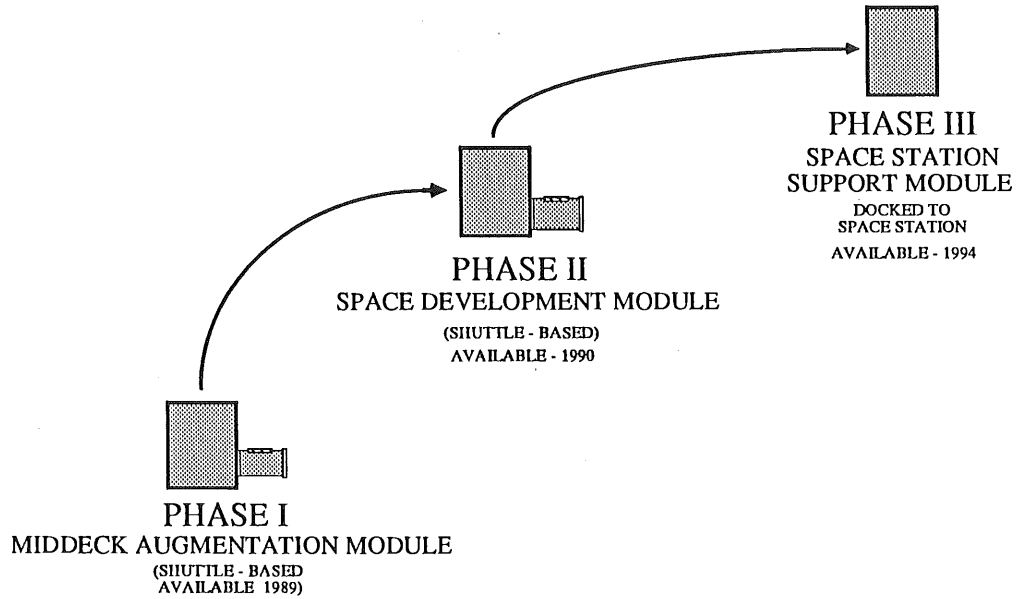


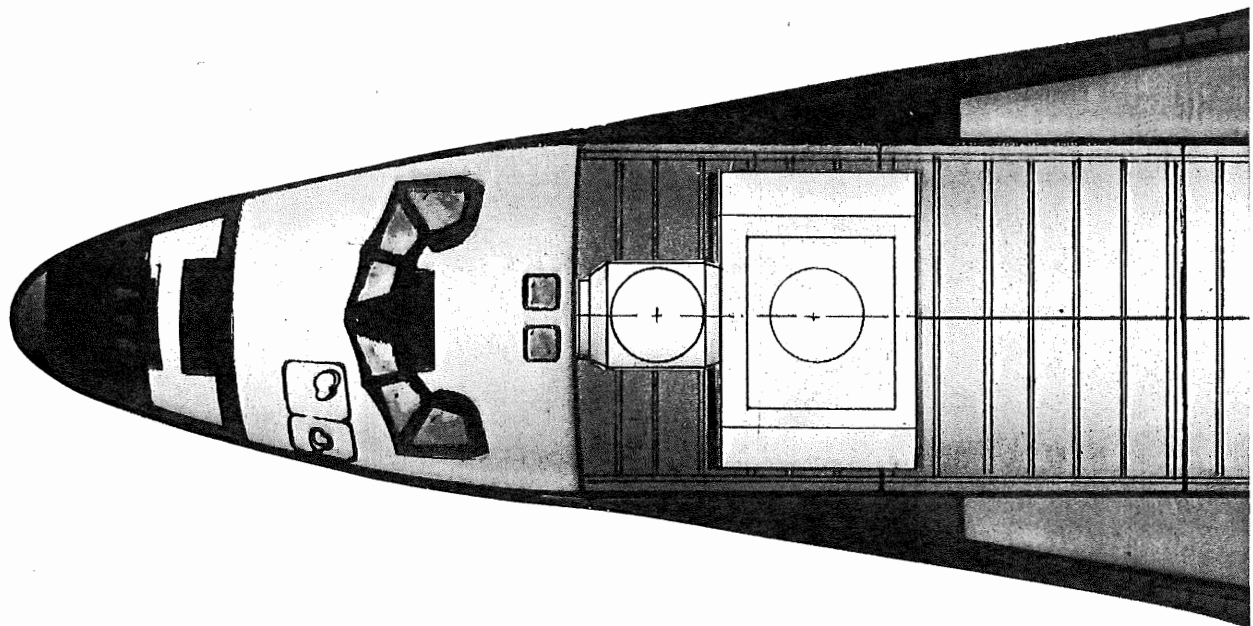
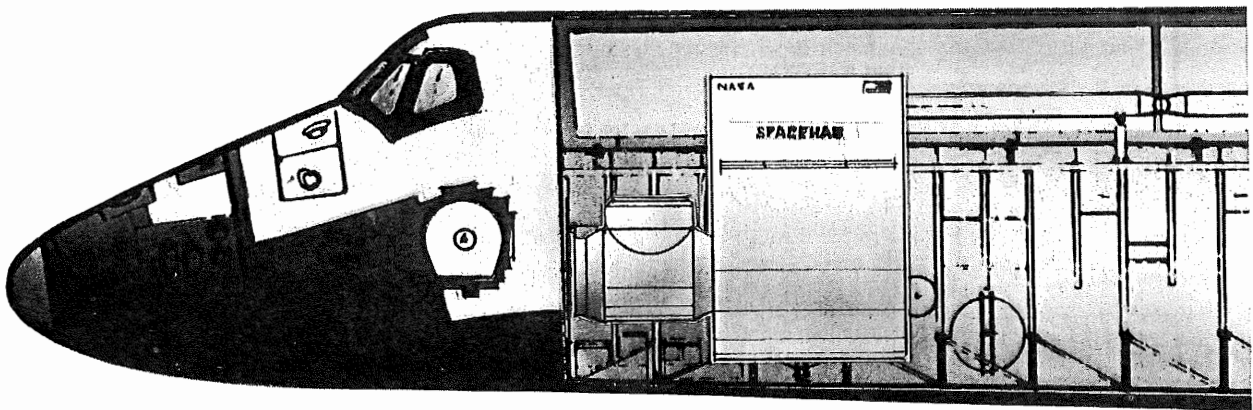
SPACEHAB MODULE SHOWN IN  
ORBITER PAYLOAD BAY



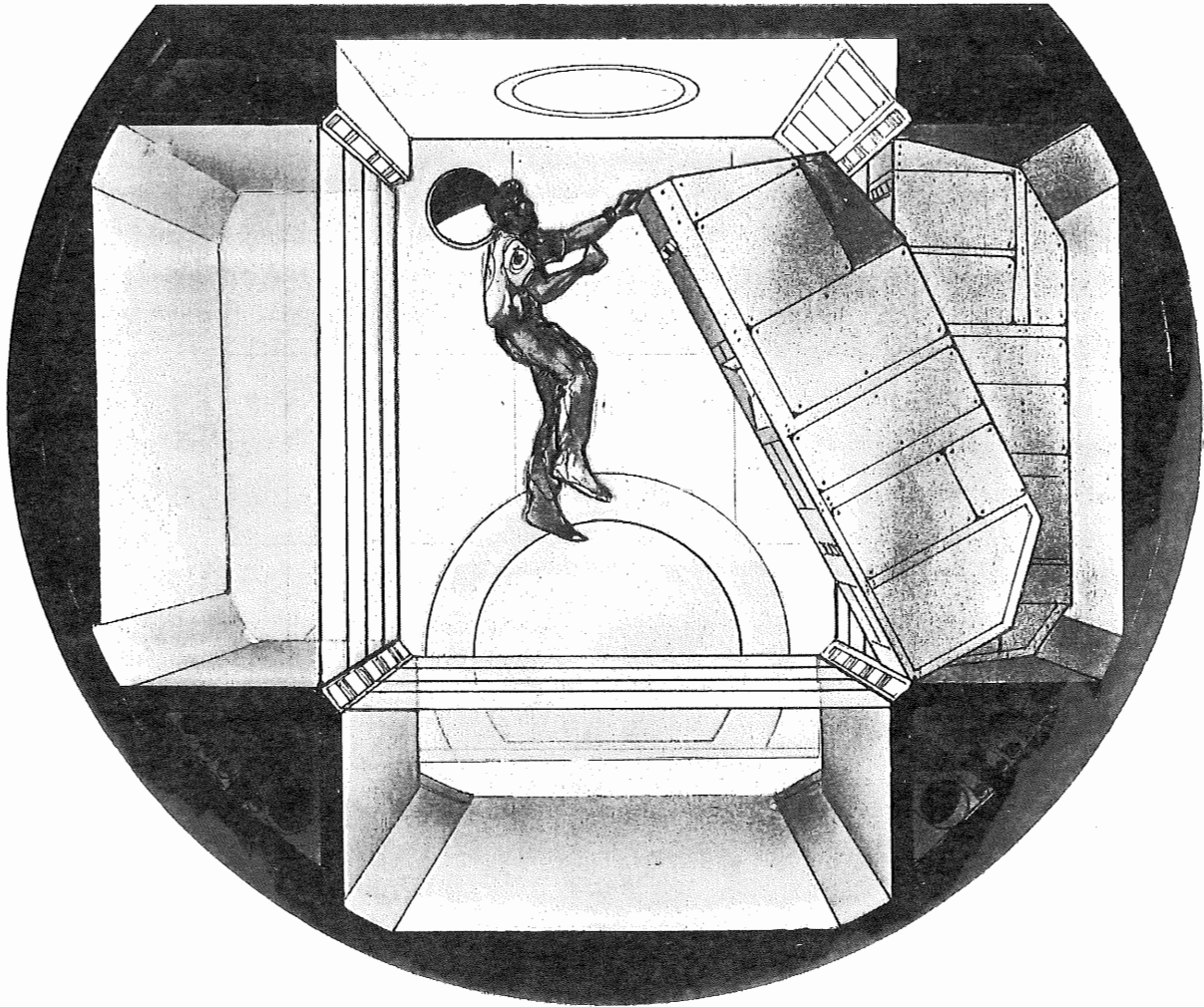


# SPACEHAB MODULE GROWTH SCENARIO

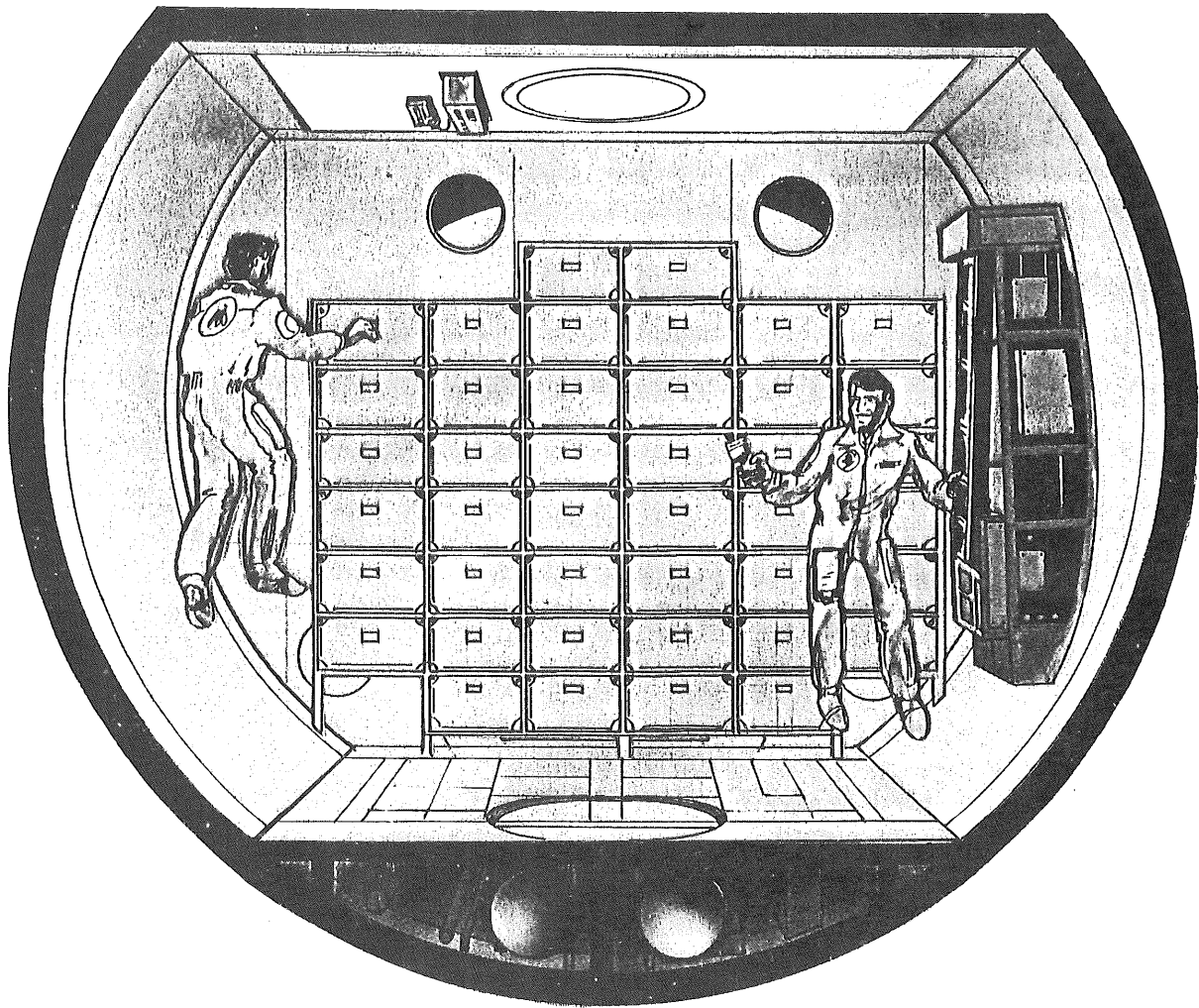




SPACEHAB MODULE SHOWING POSITION  
IN ORBITER PAYLOAD BAY



SPACEHAB SPACE DEVELOPMENT MODULE  
SPACE STATION SIMULATION VOLUME

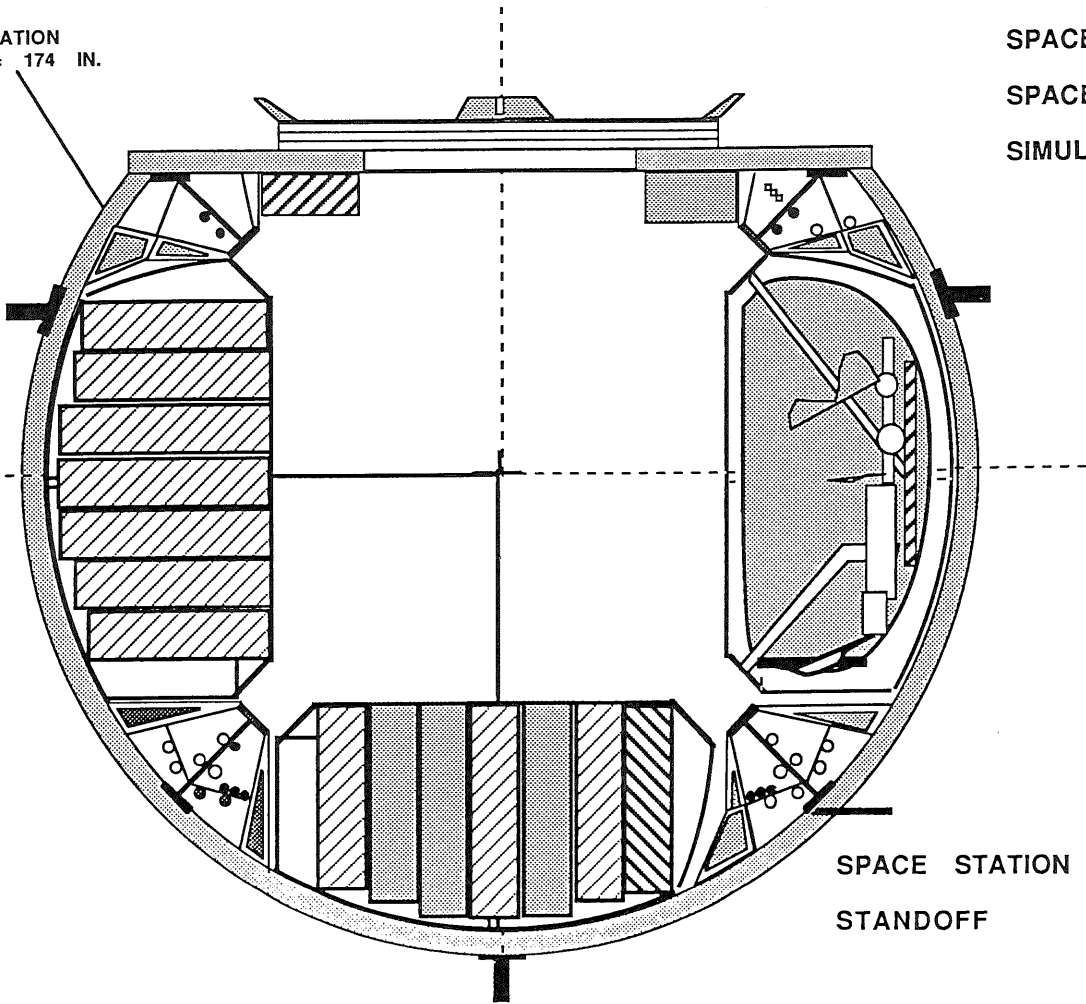


SPACEHAB MIDDECK AUGMENTATION MODULE  
CUTAWAY VIEW TOWARD REAR

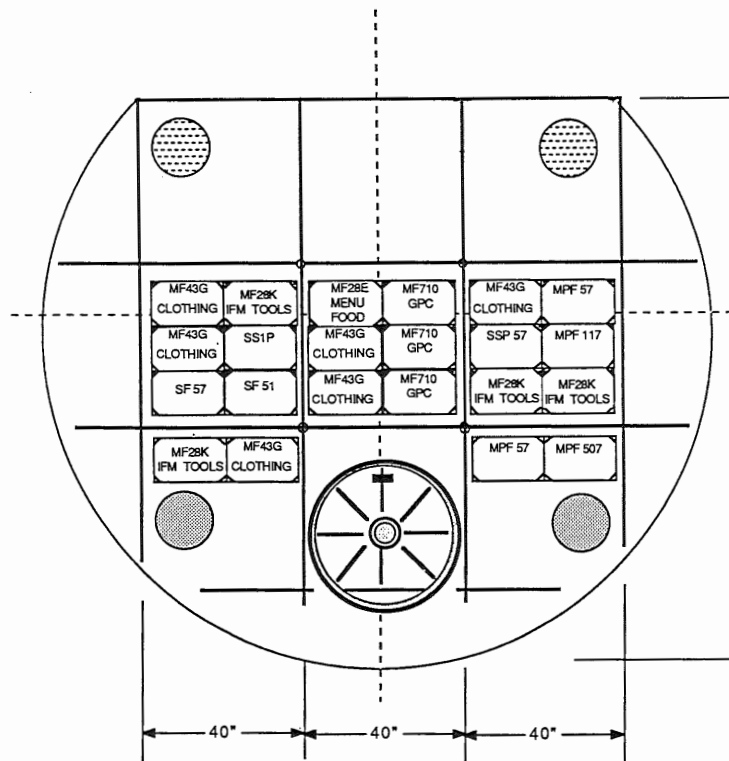
# Spacehab Space Station Simulation Module

SPACE STATION  
OD DIA = 174 IN.

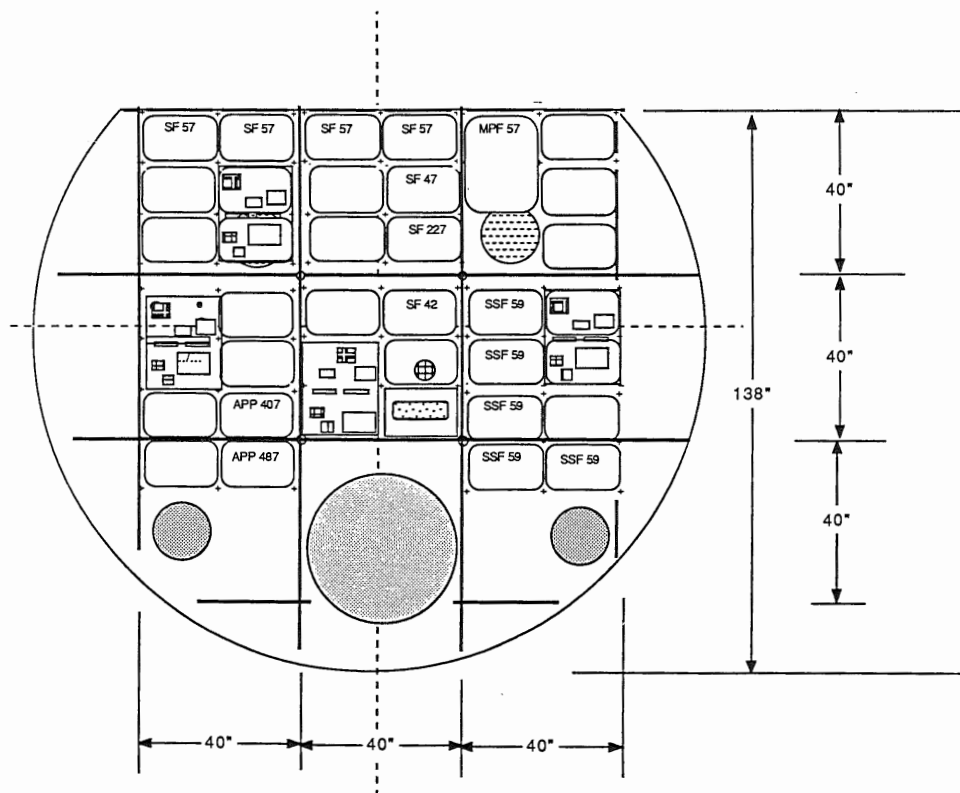
SPACEHAB DERIVED  
SPACE STATION  
SIMULATION MODULE

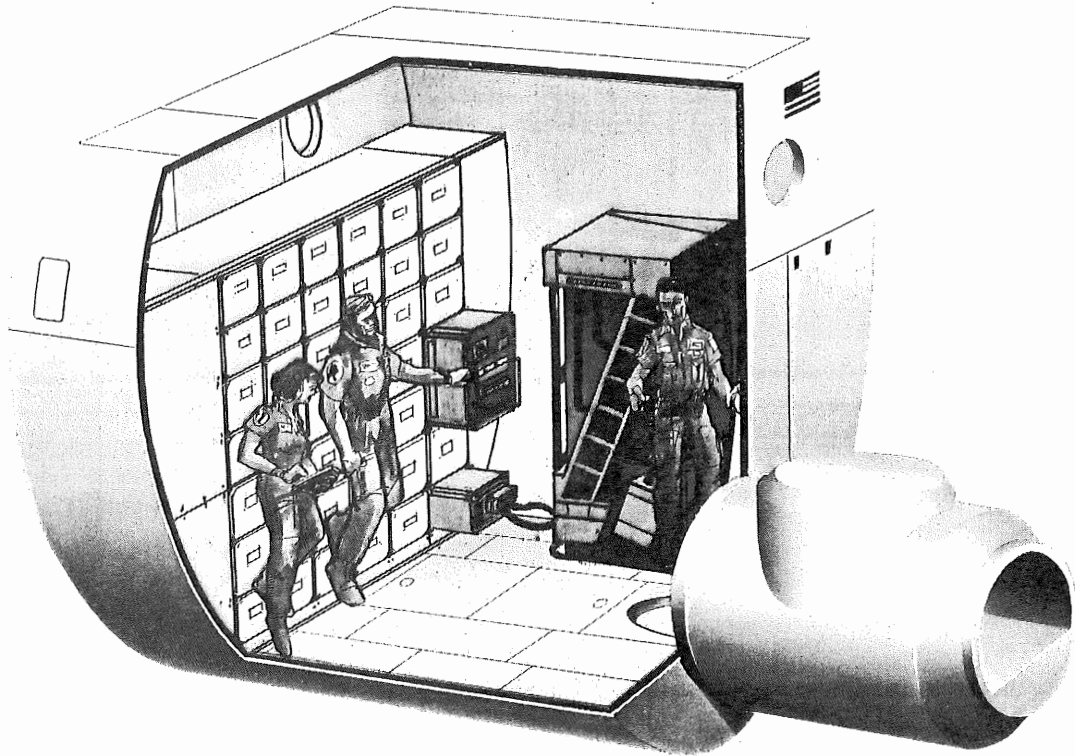


### FORWARD MIDDECK LOCKER BANK



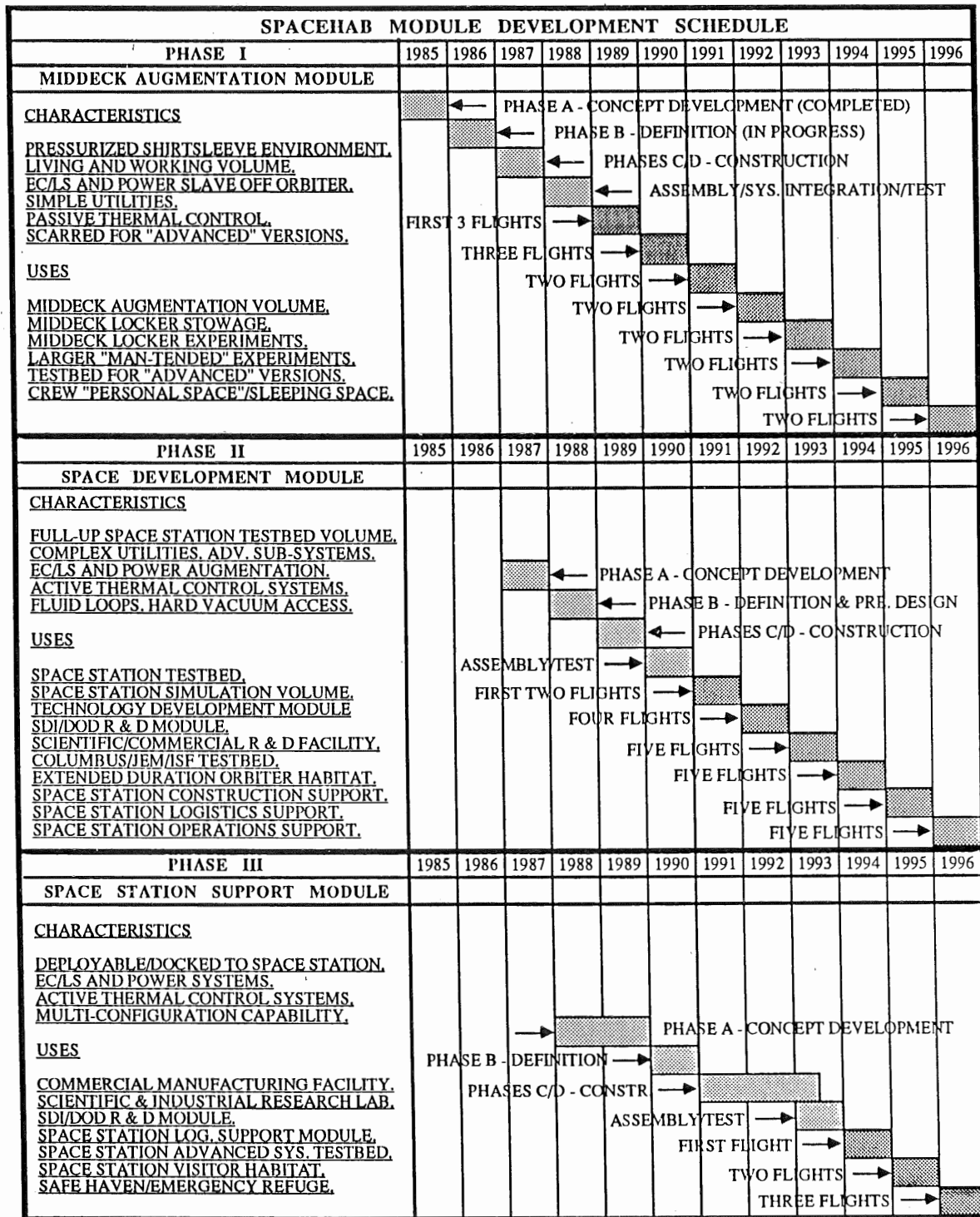
### AFT MIDDECK LOCKER BANK



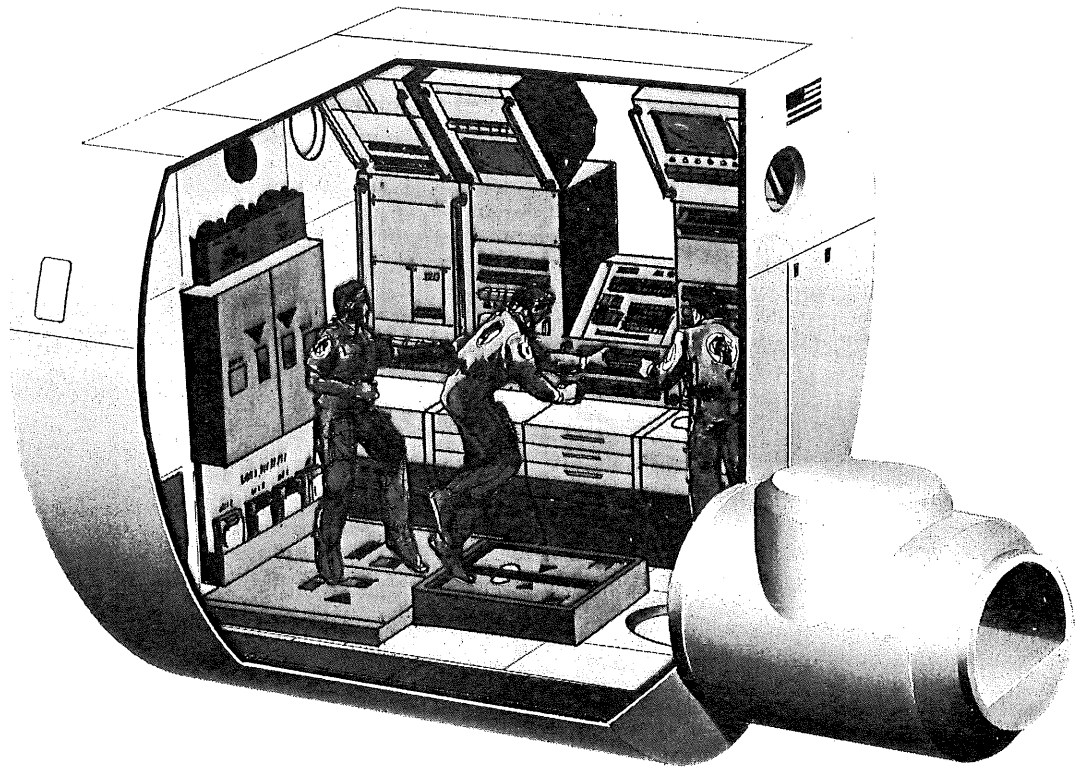


SPACEHAB MIDDECK AUGMENTATION MODULE  
CUTAWAY VIEW TOWARD REAR

## SPACEHAB MODULES THREE PHASE DEVELOPMENT SCHEDULE



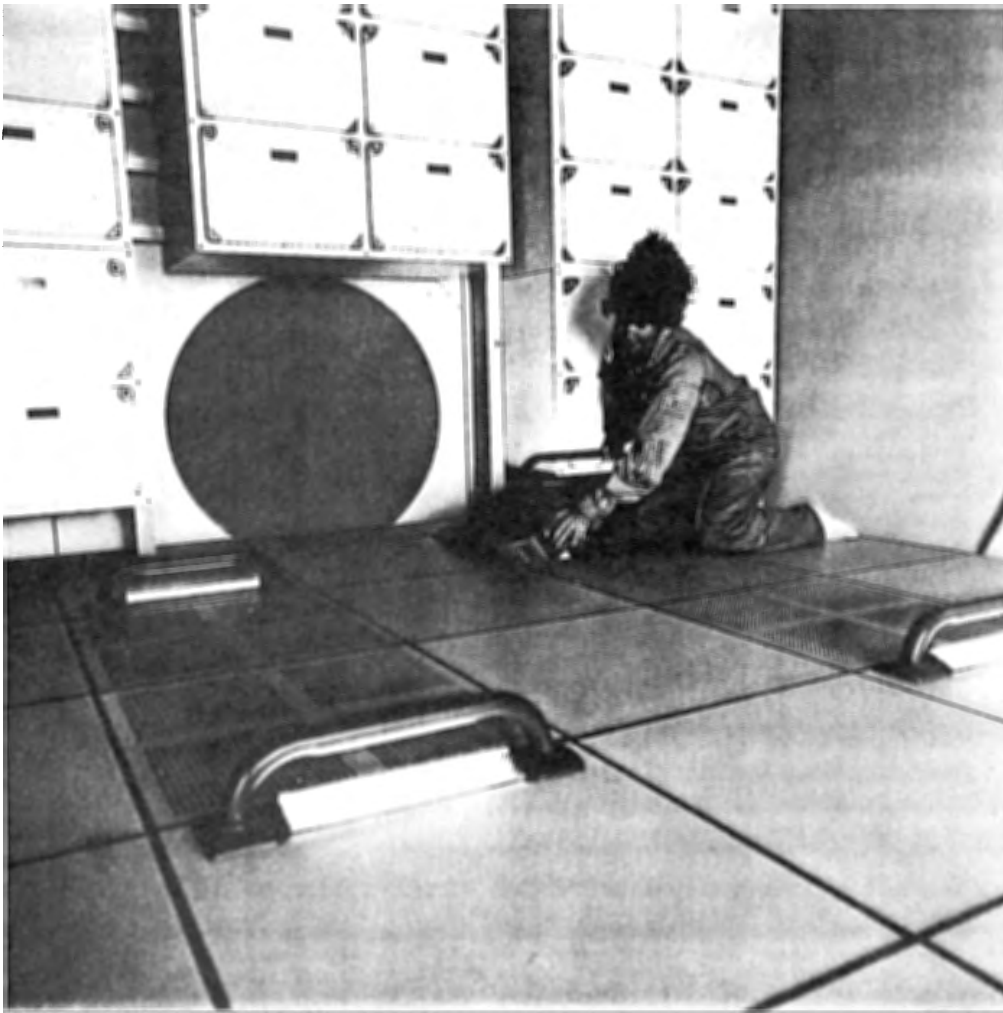




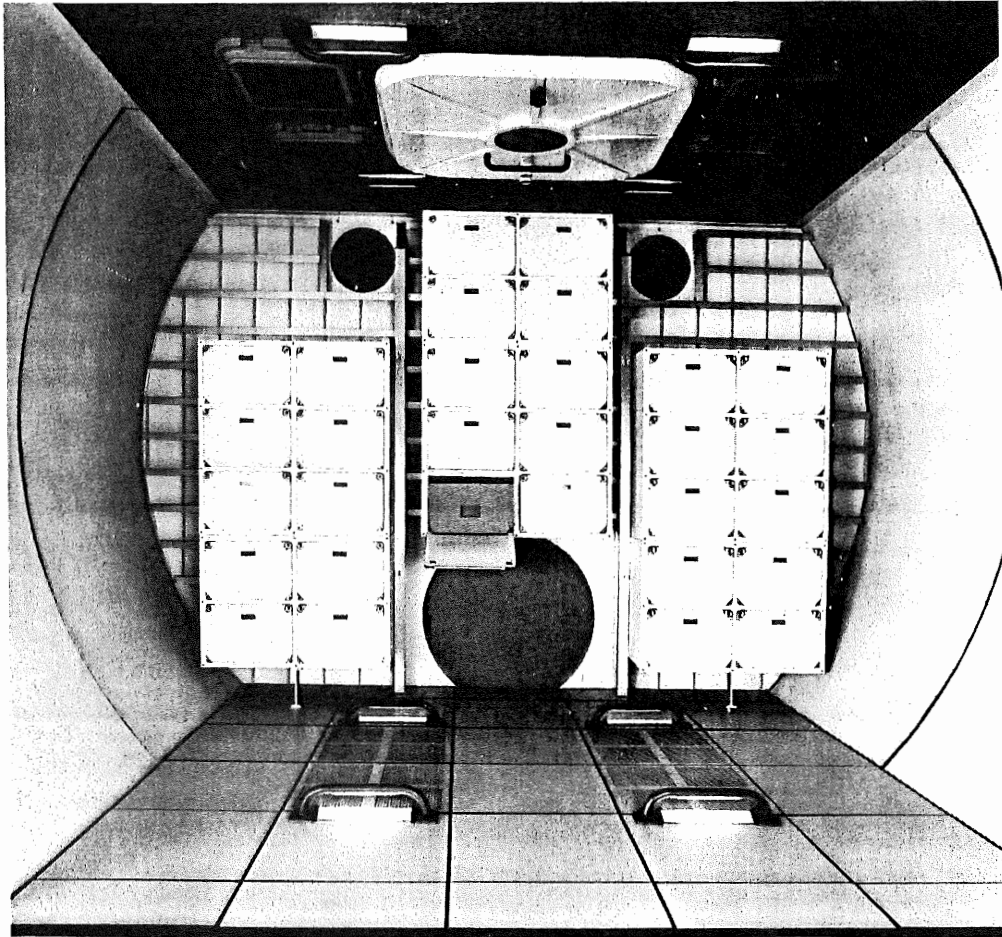
SPACEHAB "ADVANCED" SPACE DEVELOPMENT MODULE  
SPACE STATION R & D TESTBED

<b>SPACEHAB MODULE</b> <b>SPACE STATION UTILIZATION</b>
<b>COMMERCIAL CUSTOMER DEVELOPMENT MODULE</b>
<ul style="list-style-type: none"> <li>• COMMERCIAL MANUFACTURING HARDWARE PROTOTYPE DEVELOPMENT FACILITY</li> <li>• COMMERCIAL PRODUCTION PROOF-TESTING FACILITY</li> <li>• FULL- UP SPACE STATION SECTION SIMULATION VOLUME</li> <li>• ADVANCED FACILITIES RESEARCH &amp; DEVELOPMENT MODULE</li> <li>• SPACE STATION VISITOR HABITAT</li> <li>• SPACE STATION MANUFACTURING FACILITY (DEPLOYABLE TO CO-ORBIT WITH SPACE STATION)</li> </ul>

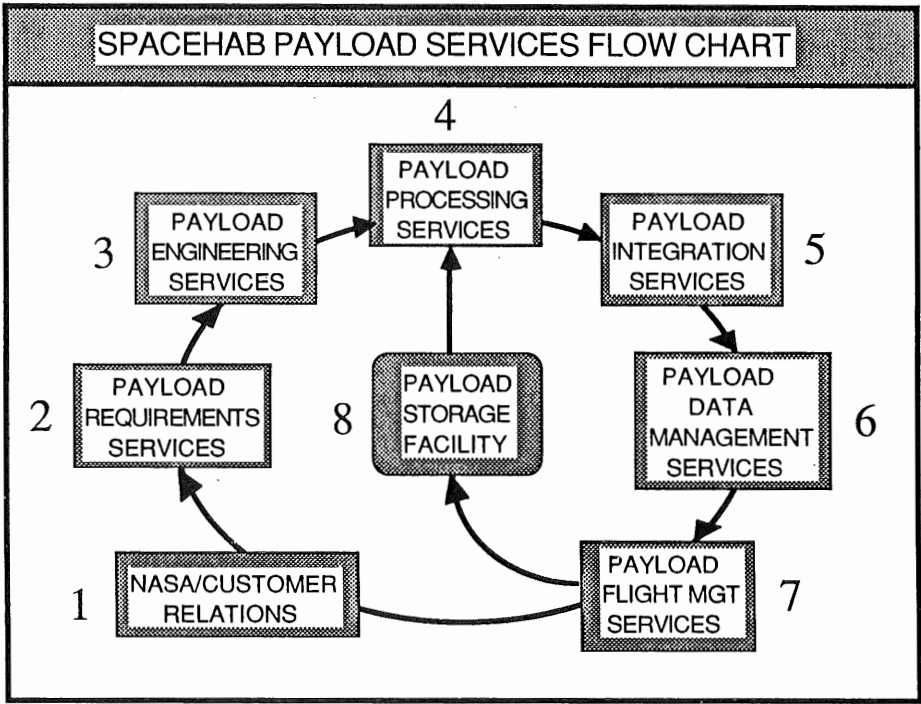
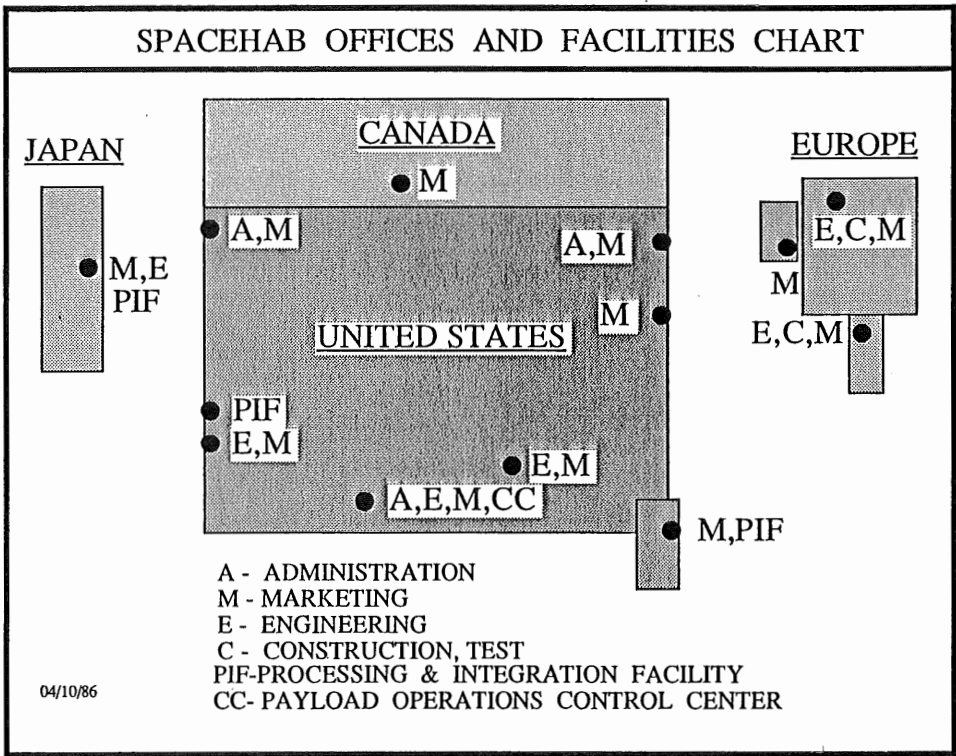
<b>SPACEHAB MODULE</b> <b>SPACE STATION UTILIZATION</b>
<b>PRESSURIZED TRANSFER MODULE</b>
<ul style="list-style-type: none"> <li>• PORTABLE AIRLOCK/INTERCONNECT SEGMENT</li> <li>• IMMOBILIZED ASTRONAUT TRANSFER CONTAINER</li> <li>• ANIMAL TRANSFER CONTAINER</li> <li>• ORBITER/STATION TRANSFER VEHICLE DOCKING ADAPTER FOR NON-MATCHED GASEOUS ENVIRONMENTS</li> <li>• EMERGENCY CREW HOLD-AND-RETURN MODULE</li> <li>• PRESSURIZED CARGO-ON-DEMAND MODULE</li> </ul>

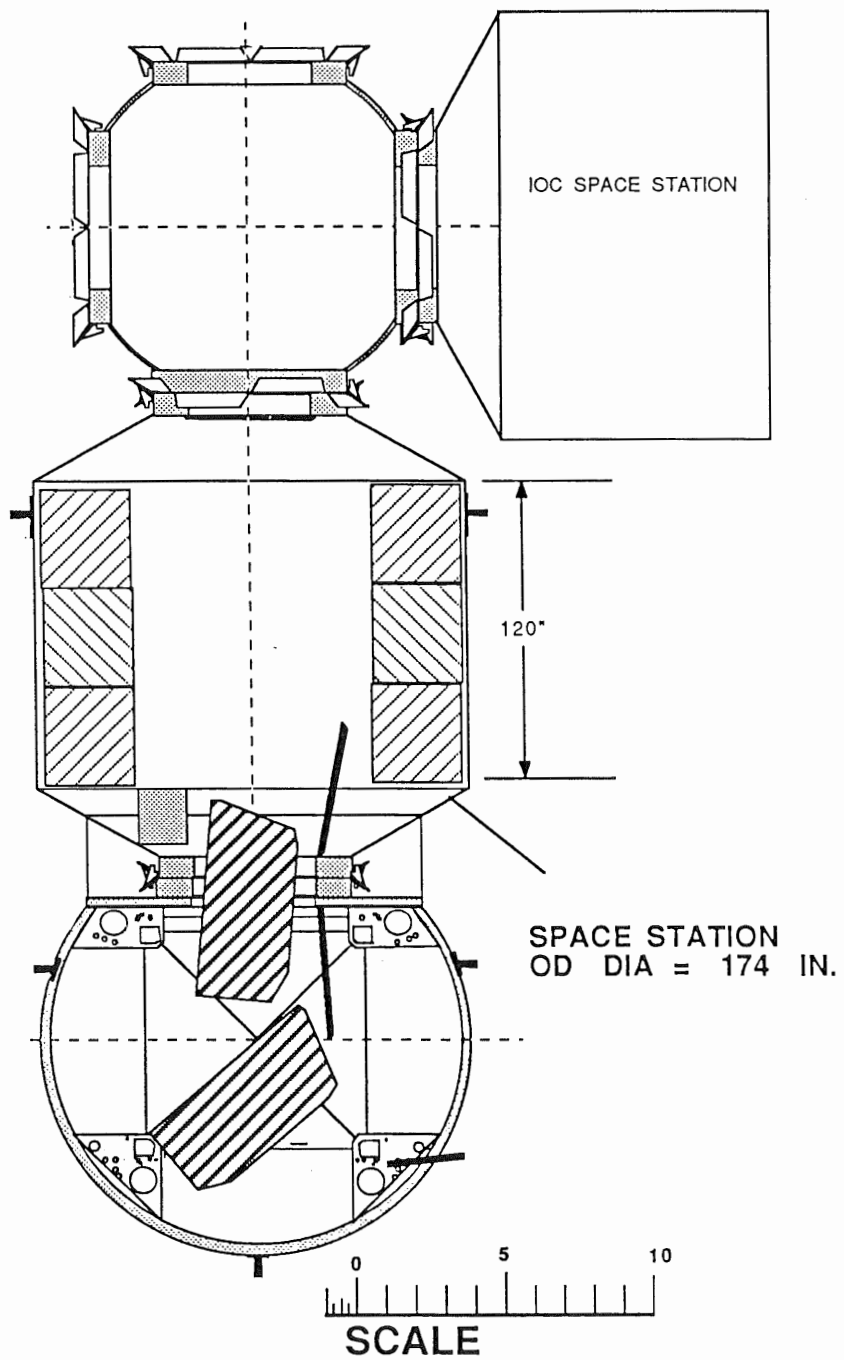


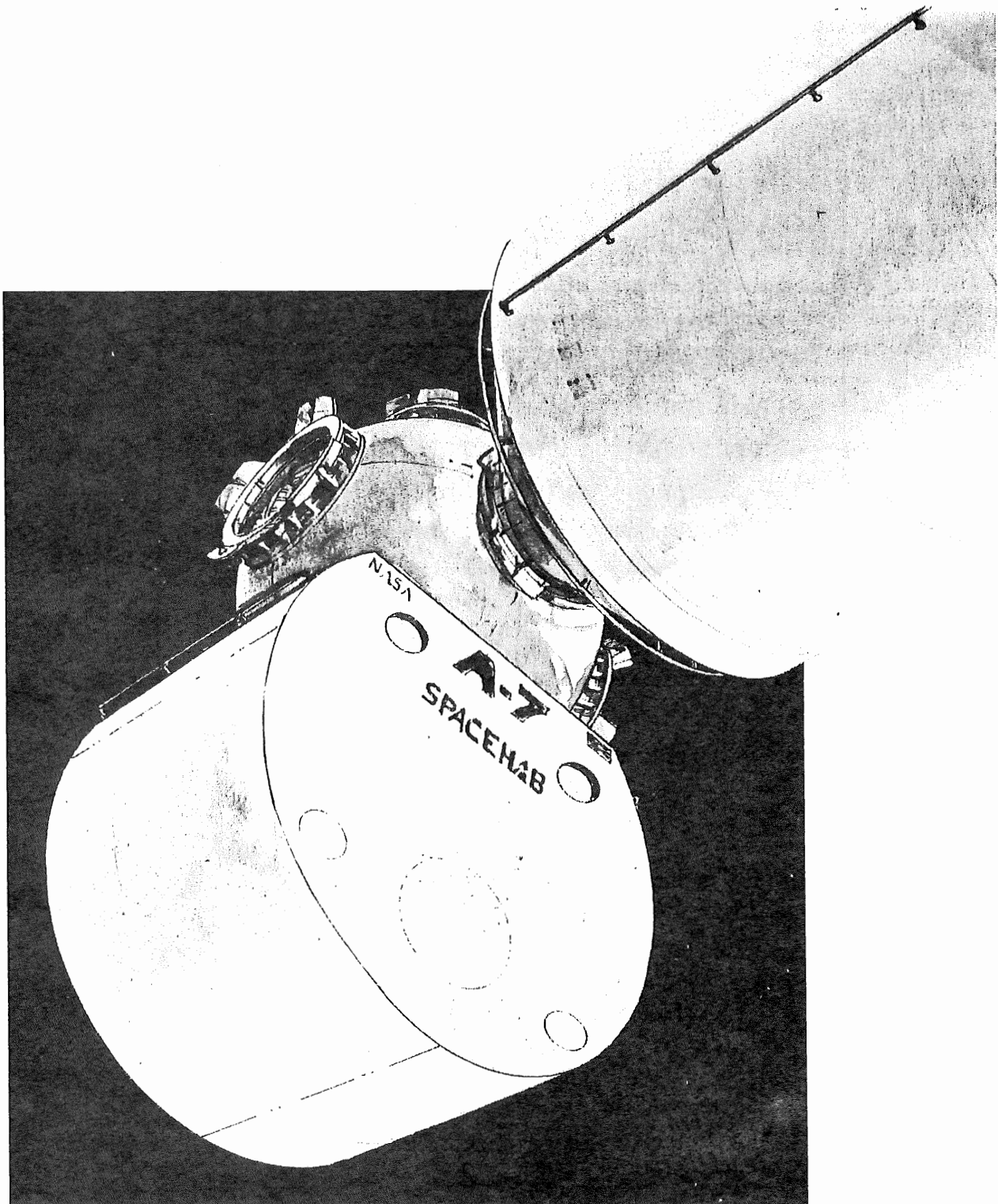
**THE NASA AMES RESEARCH CENTER  
SPACEHAB MODULE MOCKUP WILL BE USED AS  
AN ARTIFICIAL INTELLIGENCE/ROBOTICS TESTBED  
FOR THE INTERNATIONAL SPACE STATION**



**SPACHAB MIDDECK AUGMENTATION MODULE  
FULL-SCALE MOCKUP  
BUILT FOR THE NASA AMES RESEARCH CENTER  
MOFFET FIELD, CALIFORNIA**







SPACEHAB SPACE STATION SUPPORT MODULE  
DOCKED TO SPACE STATION NODE

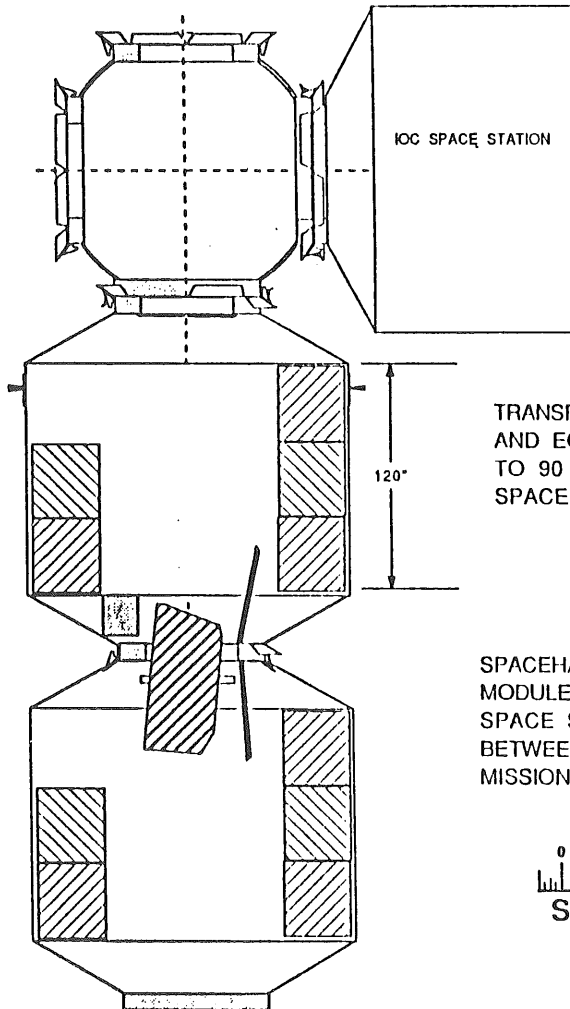
SPACEHAB MODULE

SPACE STATION UTILIZATION

RESEARCH AND DEVELOPMENT MODULE

- SPACE STATION HARDWARE TESTBED
- SPACE STATION BIOMEDICAL RESEARCH LABORATORY
- SPACE STATION TECHNOLOGY DEVELOPMENT MODULE
- SPACE STATION FULL-UP SECTION SIMULATION VOLUME
- SPACE STATION MAN/MACHINE INTERFACE TEST MODULE
- SPACE STATION HUMAN PRODUCTIVITY RESEARCH FACILITY
- SPACE STATION SCIENCE & APPLICATIONS TECHNOLOGY DEVELOPMENT FACILITY
- SPACE STATION ADVANCED SYSTEMS R & D FACILITY
- SPACE STATION CONSTRUCTION SHACK
- SPACE STATION LOGISTICS MODULE





IOC SPACE STATION

TRANSFER OF CARGO  
AND EQUIPMENT IN 30  
TO 90 DAYS AT  
SPACE STATION

120°

SPACEHAB TRANSFER  
MODULE REMAINS AT  
SPACE STATION  
BETWEEN LOGISTICS  
MISSIONS

