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3. OVERVIEW OF SPACE STATION

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This overview is primarily aimed at those workshop participants who may not be fully familiar with the Space Station program. I do not plan to discuss some issues that have appeared in the media lately relating to things like potential program organization changes, potential work package changes, center role responsibility changes, and impacts that may result to the program from the Shuttle redesign activities after the Shuttle Challenger accident. The major topics I would like to cover today will be the overall program guidelines that we laid out when we put the program together, a little about the international involvement, what our baseline configuration is today, and our plans as we proceed into the development phase this next fiscal year.

Over the last few decades, NASA has conducted numerous studies on space stations. There were even some serious attempts at initiating development. We have, in fact, flown the nation's first space station, which was Skylab. The current Space Station program officially began with the President's 1984 State of the Union address, in which he directed NASA to develop a permanently manned Space Station within a decade. This commitment has been reaffirmed in two succeeding addresses, in 1985 and again this past year, which I think is a rare occurrence for most NASA programs.

Earlier studies focused on a space station design that was singular in its function, such as a laboratory in space or an operations base. Out of the current planning came the desire that the Space Station (Figure 1) be a multipurpose facility, capable of the following functions: It should provide a laboratory in which we can conduct research and technology development in a pressurized environment, primarily in materials processing and similar sciences. It should also be a permanent observation post for both Earth and celestial observations. We are looking at it also as a servicing facility that would have the capability to extend satellite lifetimes as well as upgrade existing

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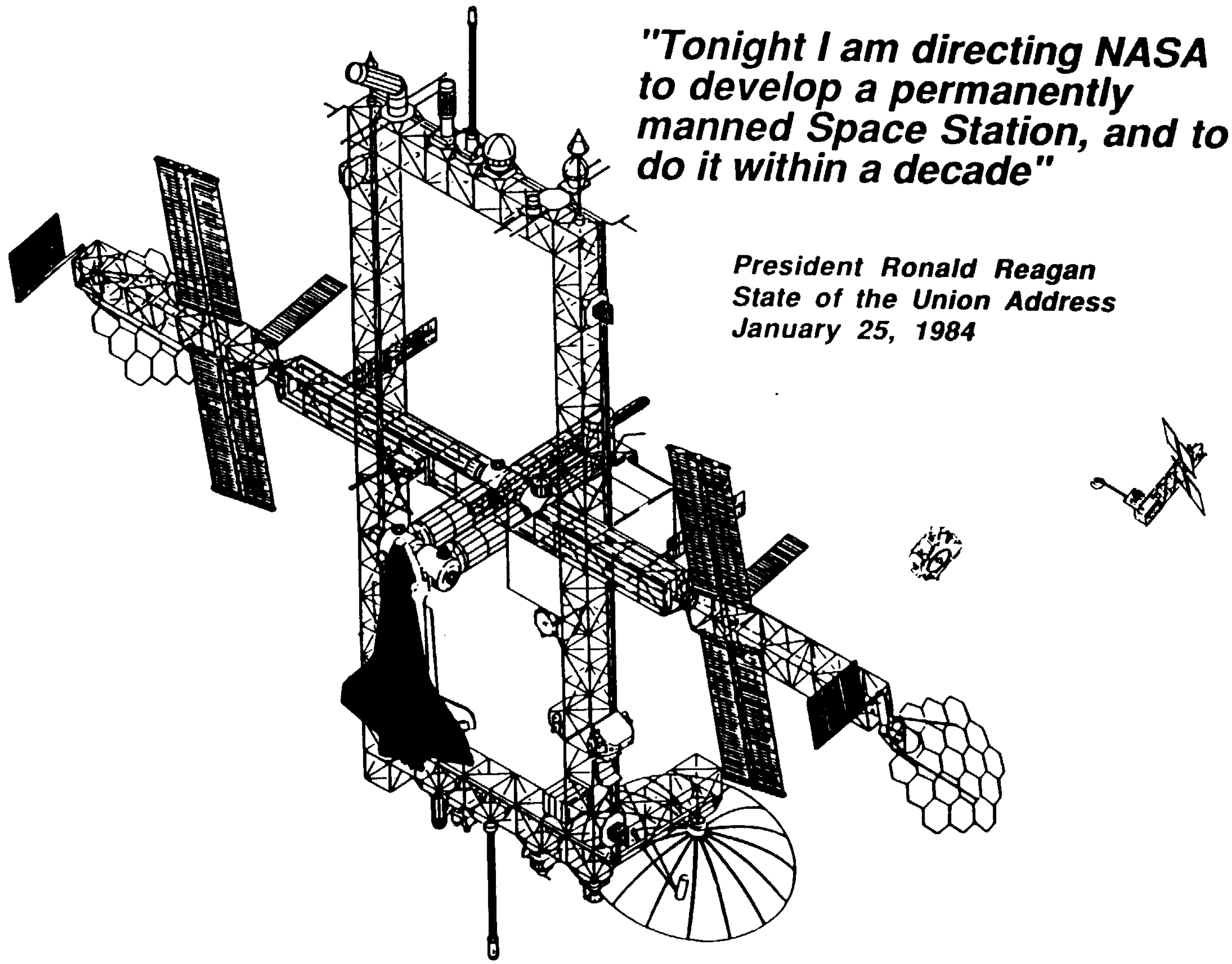

"Tonight I am directing NASA
to develop a permanently
manned Space Station, and to
do it within a decade"
President Ronald Reagan
State of the Union Address
January 25, 1984

FIGURE 1.

space systems. This service and repair function has been designated a number one priority by NASA's Office of Space Science and Applications. We are also looking at it as a transportation node for delivering payloads to other near-Earth orbits, to geostationary orbits, or to interplanetary trajectories. It would also allow payloads too heavy to be launched on the Space Shuttle to be brought up separately, assembled at the Space Station, fueled, checked out, and launched to their destination. This would increase the payload size for future space missions.

The development of these capabilities, plus some others, as shown in Figure 2, made it difficult to avoid the conclusion that the Space Station should be evolutionary in its development, because we couldn't provide all of these functions at the outset. This evolutionary growth became an underlying theme in the Space Station planning. Early in the program there was a set of planning guidelines that were adopted for this definition process; it is interesting to note that during the past three years these guidelines have essentially remained unchanged. The guidelines, shown in Figure 3, are management-related and engineering-related. With respect to the engineering-related guidelines, we plan the Space Station to be continuously habitable to meet the President's direction of a permanent manned space station. It also will be dependent on the shuttle for launch and assembly, as well as for crew rotation. It will be consistent with the desires of the user community.

The Space Station will consist of both manned and unmanned elements; in fact, there will be a manned base as well as unmanned platforms. The program has been heavily focused on the Space Station users and their requirements to ensure that the facility to be developed will be customer- or user-friendly. The management-related guidelines show a three-year definition program; we are currently in the third year. We had planned to spend between 5 and 10% of the expected total cost of the Space Station, estimated at $8 billion in fiscal year 1984 dollars, for the definition phase so that it would put us in a sound position as we go into the development phase. This program has NASA-wide participation: all of the NASA space centers are involved. During Phase B, the

SPACE STATION

- a laboratory in space
- a permanent observatory
- a servicing facility
- a transportation node
- an assembly facility
- a manufacturing facility
- a storage depot
- a staging base

A space station is a multi-purpose facility

FIGURE 2.

SPACE STATION PLANNING BASELINE GUIDELINES

MANAGEMENT RELATED

- Three year detailed definition
- NASA-wide participation
- Manage SE&I in-house
- Development funding in FY 1987
- IOC: "within a decade"
- Cost of initial capability: $8.0B
- Extensive user involvement
  - Science and applications
  - Technology
  - Commercial
- International participation

ENGINEERING RELATED

- Continuously habitable
- Shuttle dependent
- Manned and unmanned elements
- Evolutionary
- Maintainable/restorable
- Operationally semi-autonomous
- Customer friendly
- Technology transparent
- Man-tended approach
- Automation and robotics focus

FIGURE 3.

system engineering and integration is being accomplished in-house. Consistent with the directive to complete the Space Station in a decade, we plan to have development funding beginning in the next fiscal year.

International participation has also been a fundamental requirement of the program, as directed by the President. When the President gave the direction to develop a permanently manned station, he also invited our friends and allies to participate (Figure 4). A year ago last spring, NASA signed bilateral MOUs (Memoranda of Understanding) with Canada, the European Space Agency, and Japan, and, in parallel with us, they are in the preliminary design phase. Canada is focusing on the Mobile Servicing Center (MSC), which provides support to attached payloads, as well as to the initial assembly of the Space Station. The European Space Agency is focusing primarily on a pressurized laboratory module as well as unmanned platforms. Japan is focusing on a Japanese experiment module that consists of a pressurized laboratory, with a pallet-like structure attached to the laboratory. So, the Space Station is going to be an international endeavor.

The result of these planning guidelines is a Space Station complex as depicted in Figure 5. The Station will be in a low-inclination orbit at 28.5°, in phase with unmanned co-orbiting platforms and supported by a maneuvering vehicle. The complex may also include an Earth observation platform in a polar orbit, supported by the Shuttle and also by a maneuvering vehicle. A manned base, a polar platform and co-orbiting platforms, are planned to be part of the IOC Space Station. The maneuvering vehicle, also called OMV, is being developed in a separate NASA program.

The major program phases are shown in Figure 6. Phase B, initiated a year ago last April, consists of two parts: a definition and a preliminary design. The definition part was concluded this past March with a systems requirements review. This led to a baseline configuration (Figure 7) in May of this year. Phase B is scheduled to be completed in January 1987. The design and development phase, C/D, should

SPACE STATION PROGRAM

INTERNATIONAL COOPERATION

- When directing NASA to develop a permanently manned Space Station, President Reagan invited friends and allies of the United Sates to participate in the Space Station endeavor
- International cooperation has been a hallmark of many NASA programs
- In the spring of 1985, NASA signed bilateral Memoranda of Understanding (MOU) with Canada, European Space Agency, and Japan that provide a framework for cooperation on Space Station during Phase B (Definition and Preliminary Design)
- International elements are part of the Space Station baseline configuration. Under study in Phase B preliminary design:

  Canada — Mobile Servicing Center (MSC)
  European Space Agency — Pressurized laboratory module, polar platform, resource module
  Japan — Japanese Experiment Module (JEM)

- Negotiations on Space Station cooperation during Phase C/D and Operations begin in June, 1986

SPACE STATION IS AN INTERNATIONAL ENDEAVOR

FIGURE 4.

INITIAL SPACE STATION COMPLEX

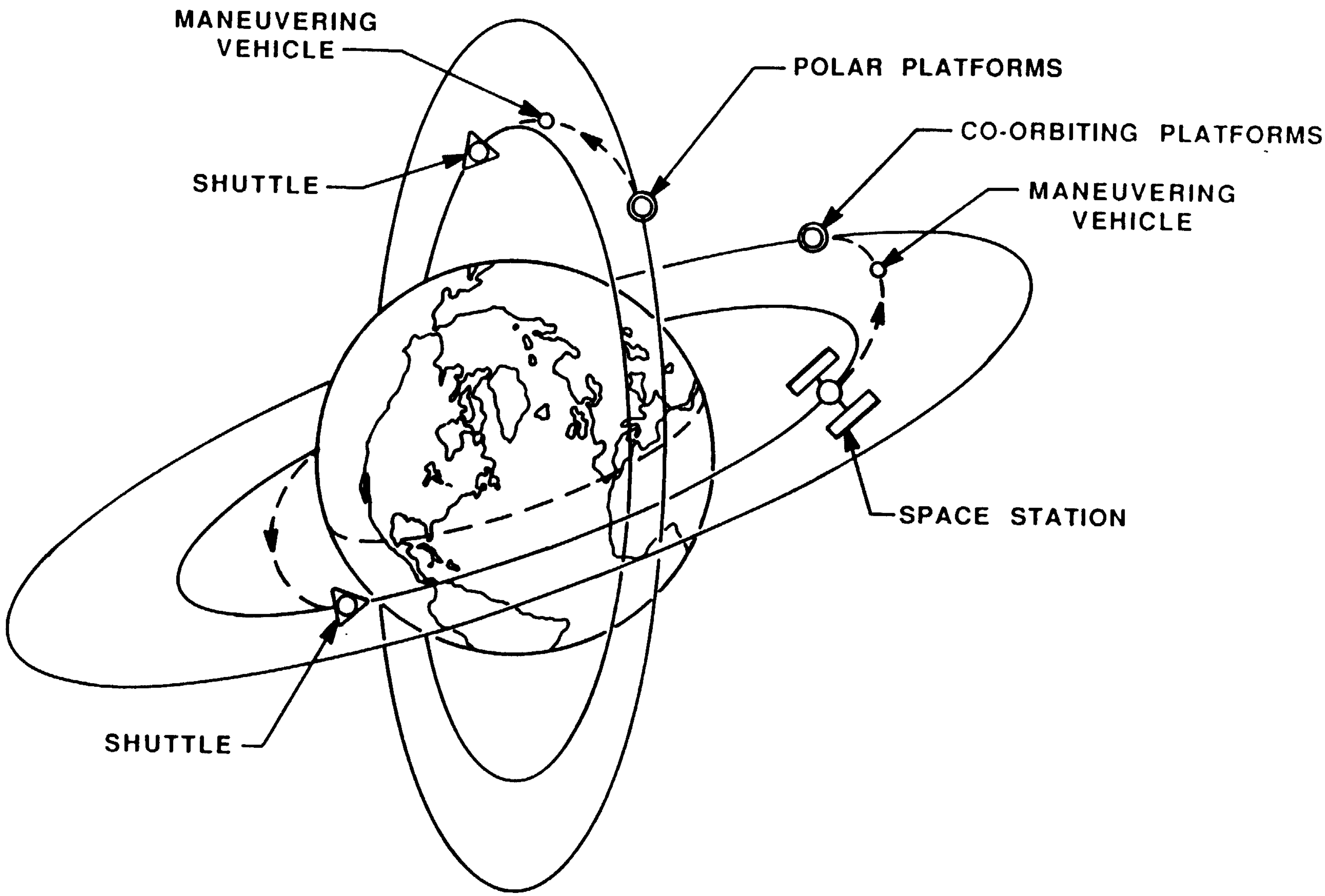


FIGURE 5.

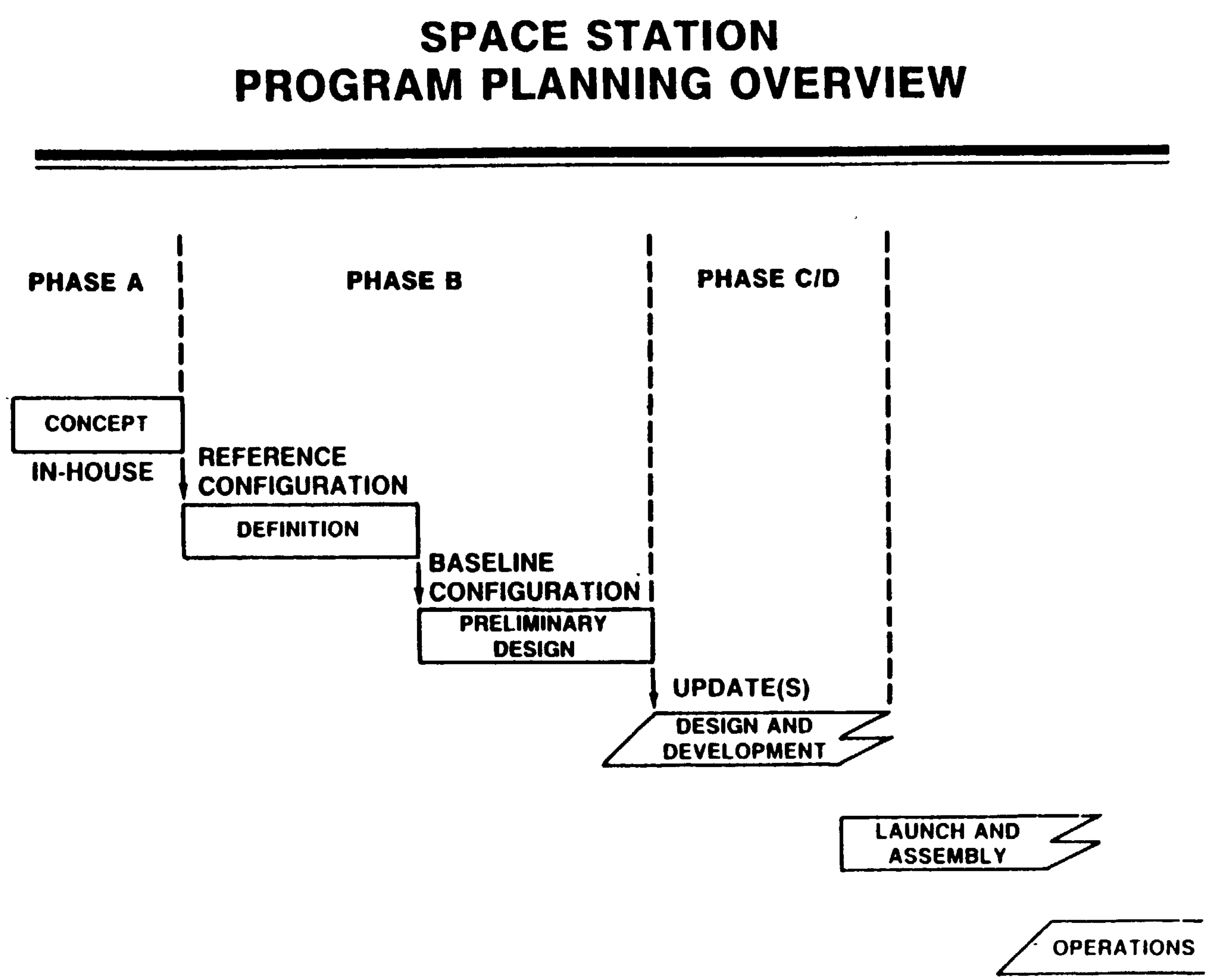

SPACE STATION
PROGRAM PLANNING OVERVIEW
PHASE A
PHASE B
PHASE C/D
CONCEPT
IN-HOUSE
REFERENCE
CONFIGURATION
DEFINITION
BASELINE
CONFIGURATION
PRELIMINARY
DESIGN
UPDATE(S)
DESIGN AND
DEVELOPMENT
LAUNCH AND
ASSEMBLY
OPERATIONS

FIGURE 6.

DUAL KEEL SPACE STATION BASELINE CONFIGURATION

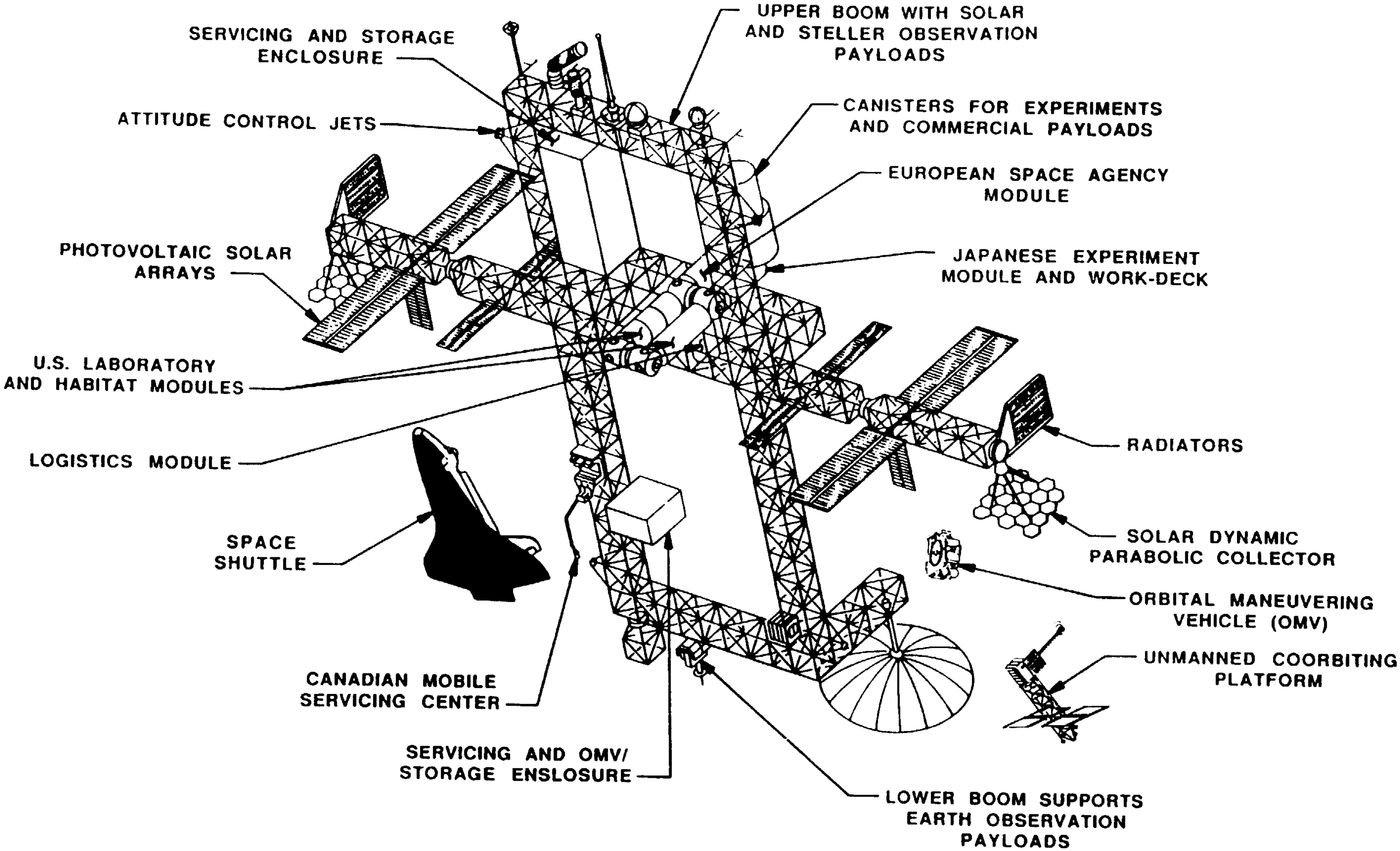


FIGURE 7.

be under contract by the middle of next year. This will lead, if we are successful, to a first-element launch in 1993, leading to the permanently manned capability about a year later, consistent with the President's directive.

There are four work packages in four NASA centers involved in the Phase B definition: Marshall Space Flight Center, Johnson Space Center, Goddard Space Flight Center, and Lewis Research Center. Most of the work on the manned base part of the Space Station is being done by Work Packages 1 and 2 and their contractors. Work Package 3 is primarily focused on the unmanned platforms and on the servicing and attached payload functions of the manned base. Work Package 4 is defining the power system for both the manned base and the platforms.

The baseline configuration that resulted from the definition phase, now under preliminary design, is shown in Figure 8. This configuration is called a dual-keel Space Station because of the two parallel vertical keels. The keels are about 360 ft long; the transverse boom, which runs from left to right on the figure, is about 500 ft long. The bases of these trusses are 5-m cubes. The Space Station will fly in an Earth-fixed attitude with the keels pointed toward the Earth. At the top of the keels are attached payloads, including instruments for stellar and solar observations.

The lower boom, attached to the two keels at the bottom, will support attached payloads observing the Earth. The transverse booms support the power systems at the ends, the thermal radiators, and the pressurized modules. The power system as planned today is a hybrid system of solar photovoltaic and solar dynamic design. The solar photovoltaic system will be put up initially to help support the base during assembly. When both of these power systems are in place, the total average power output will be 75 kW, with 50 kW being allocated to users and 25 kW for housekeeping or system support. There are servicing bays located between the keels, for servicing satellites and the OMV.

SPACE STATION

- ASSURE FREE WORLD LEADERSHIP IN SPACE DURING THE 1990's
- STIMULATE ADVANCED TECHNOLOGY
- PROMOTE INTERNATIONAL COOPERATION
- ENHANCE CAPABILITIES FOR SPACE SCIENCE AND APPLICATIONS
- DEVELOP FURTHER THE COMMERCIAL POTENTIAL OF SPACE
- CONTRIBUTE TO PRIDE AND PRESTIGE
- STIMULATE INTEREST IN SCIENCE AND ENGINEERING EDUCATION

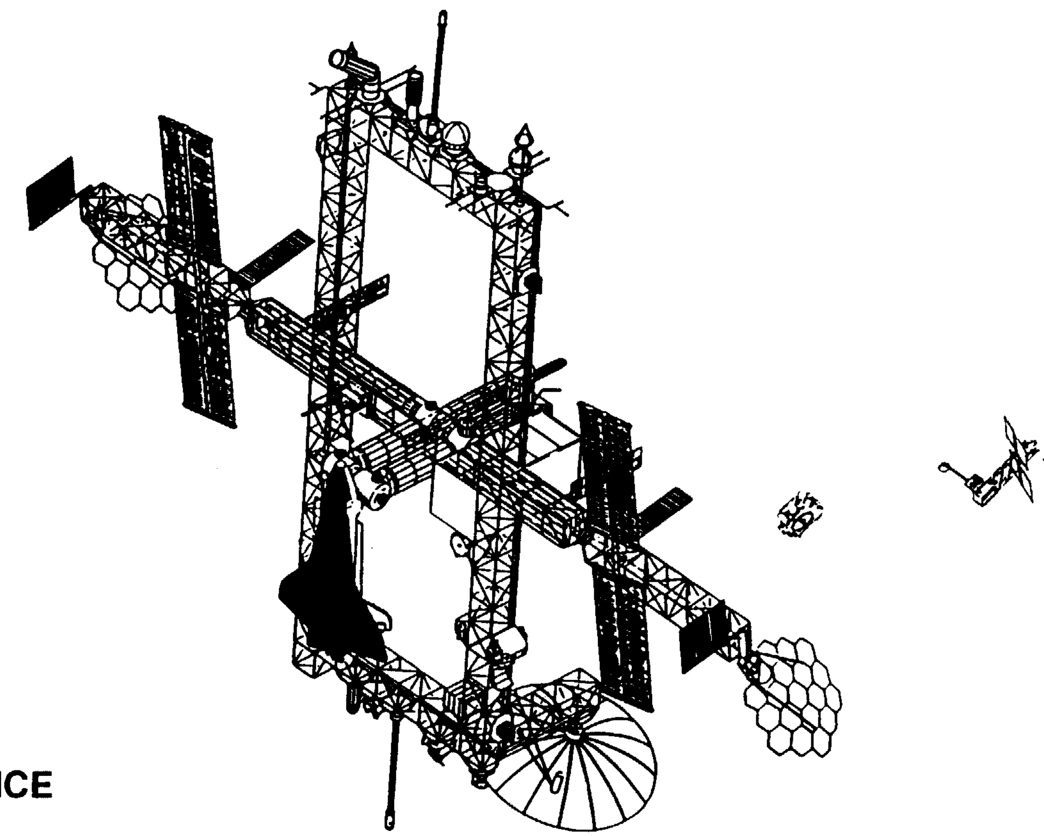


FIGURE 8.

The module assembly (Figure 9) consists of four major pressurized modules, two provided by the U.S., a habitation module and a lab, and one each provided by the European Space Agency and Japan. The length of the U.S. modules is on the order of 44 ft; the pressure level is the same as on Earth (14.7 psi). The environmental control system will be a closed-loop system with nitrogen resupply. The microgravity level that we want to achieve in the laboratory modules is on the order of 10E-5 g near the centerline of the U.S. Laboratory module. The Station will be assembled initially at an altitude of 220 n.mi. Later, it will be boosted up to its operating altitude of at least 250 n.mi. There are four major modules, all interconnected. Additionally, not shown in the figure, there is a logistics module and two airlocks. All the presurrized modules will incorporate a horizontal arrangement of floor, ceiling, and walls, much like Spacelab. A cross-section of a typical module is shown in Figure 10.

Four symmetrical longitudinal standoffs are used for utility runs down the module interior and also to support the racks that are mounted in the four quadrants of the modules. A utility interface will be provided between each two double racks that will provide power, data lines, and thermal ducts. Standard racks will be provided that can be replaced on orbit, either tilt-out or slide-out types. They will be interchangeable, with standard racks in all four modules. Both double and single racks will be provided; double rack width will be 42 inches, and two single racks will be capable of replacing one double rack. We are trying to maintain a minimum aisle space and a ceiling space of about 84 inches.

The U.S. and International modules currently have different module diameters, which will make the standard rack development more challenging. The U.S. module has about 166 inches internal diameter while the Japanese module is about 158 inches and the European module 157 inches in diameter.

SPACE STATION MODULE PATTERN

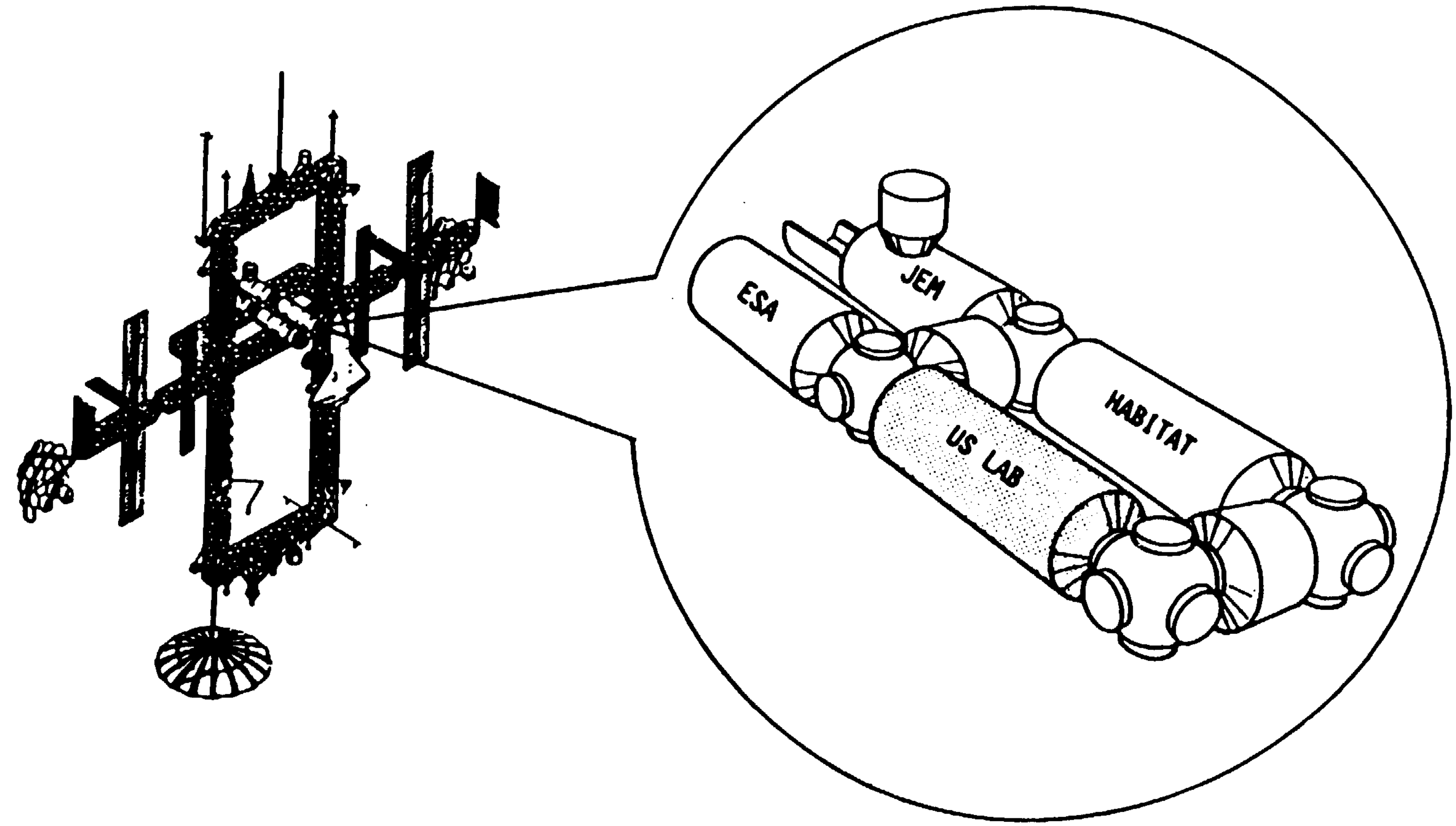


FIGURE 9.

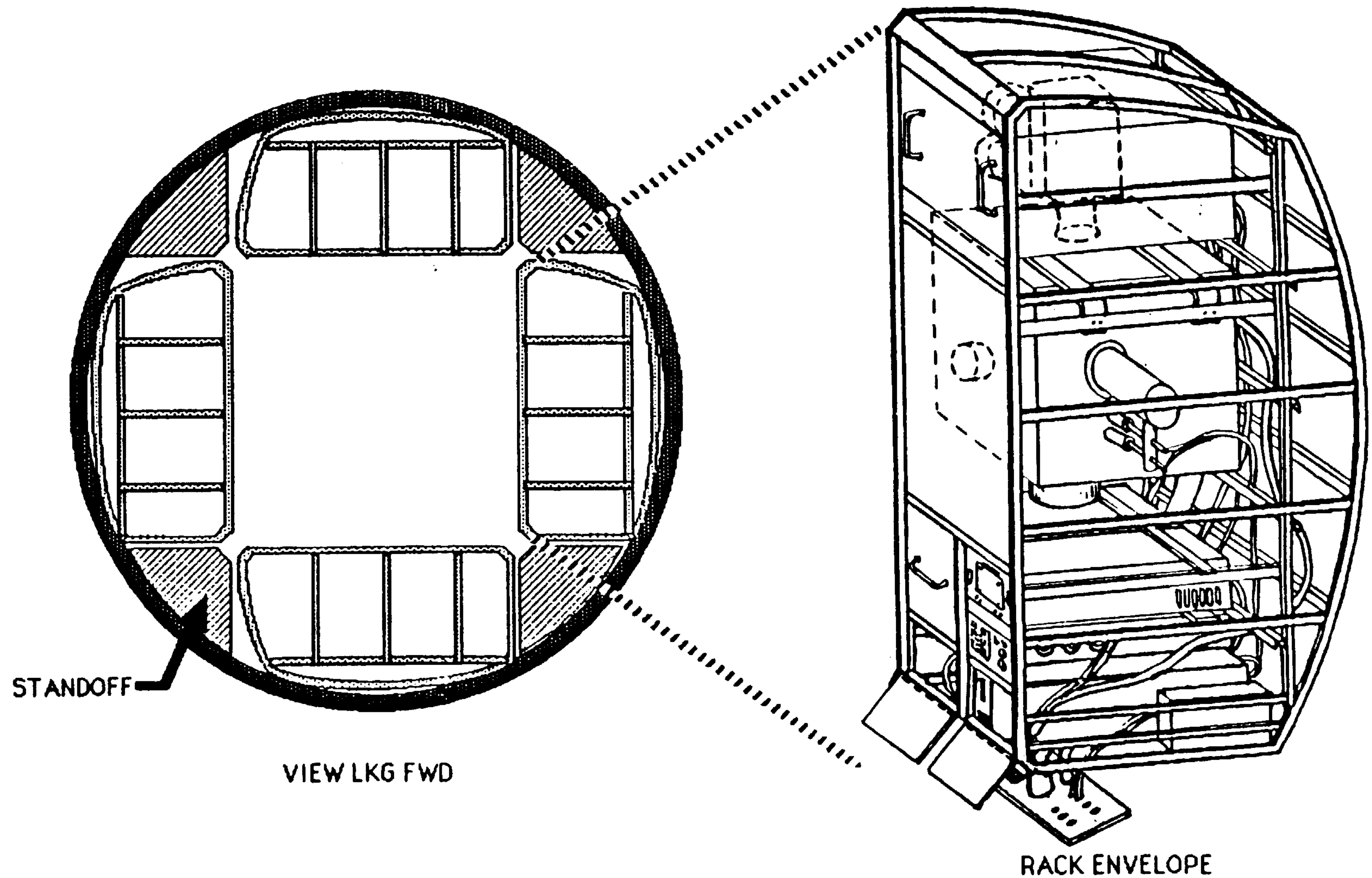


FIGURE 10.

The primary function that is going to be accommodated in the U.S. lab is materials reseach and development that would be most sensitive to acceleration environment.

There will also be control and monitoring space for user-provided pressurized modules that would be attached to the assembly. Such a module might be a production facility for commercial materials processing. The lab module will also be designed to accommodate life-sciences that would also require low acceleration levels. The life-sciences community has stated the need to have two centrifuges on board the space station. These will be variable-acceleration centrifuges to perform experiments on animals as well as humans. There will be a 1.8-meter-diameter centrifuge, to be available at the time of permanent man capability, which could be one year after the initial launch. There should also be a large centrifuge with 4-meter diameter about two years later. The 1.8-meter centrifuge can be rack mounted; it would have to be brought up in two double racks, and it would require some assembly on orbit. This centrifuge could be accommodated in either the U.S. lab or the European Space Agency Lab.

The 4-meter centrifuge will probably be carried up in a separate pressurized module and attached to the end of one of the laboratories. Such a module might be a derivative of a logistics module.

Figure 11 shows a typical floor plan of how the lab module might be laid out, with racks in the four quadrants, the ceiling, the floor, and the two walls. Floor and ceiling racks are primarily used for module subsystems as well as lab subsystems. The wall space is being reserved for user racks.

Figure 12 shows an artist's concept of one wall of the habitation module. Its primary function is for crew habitation. It will be designed to accommodate a crew of 8. The kinds of habitation facilities this module will include are shown on Figure 13 (galley, health maintenance, personal hygiene, crew quarters, ward room, workstations, and habitation storage). The hab module will also provide volume for the

U.S. LABORATORY
U.S. – PROVIDED MODULE

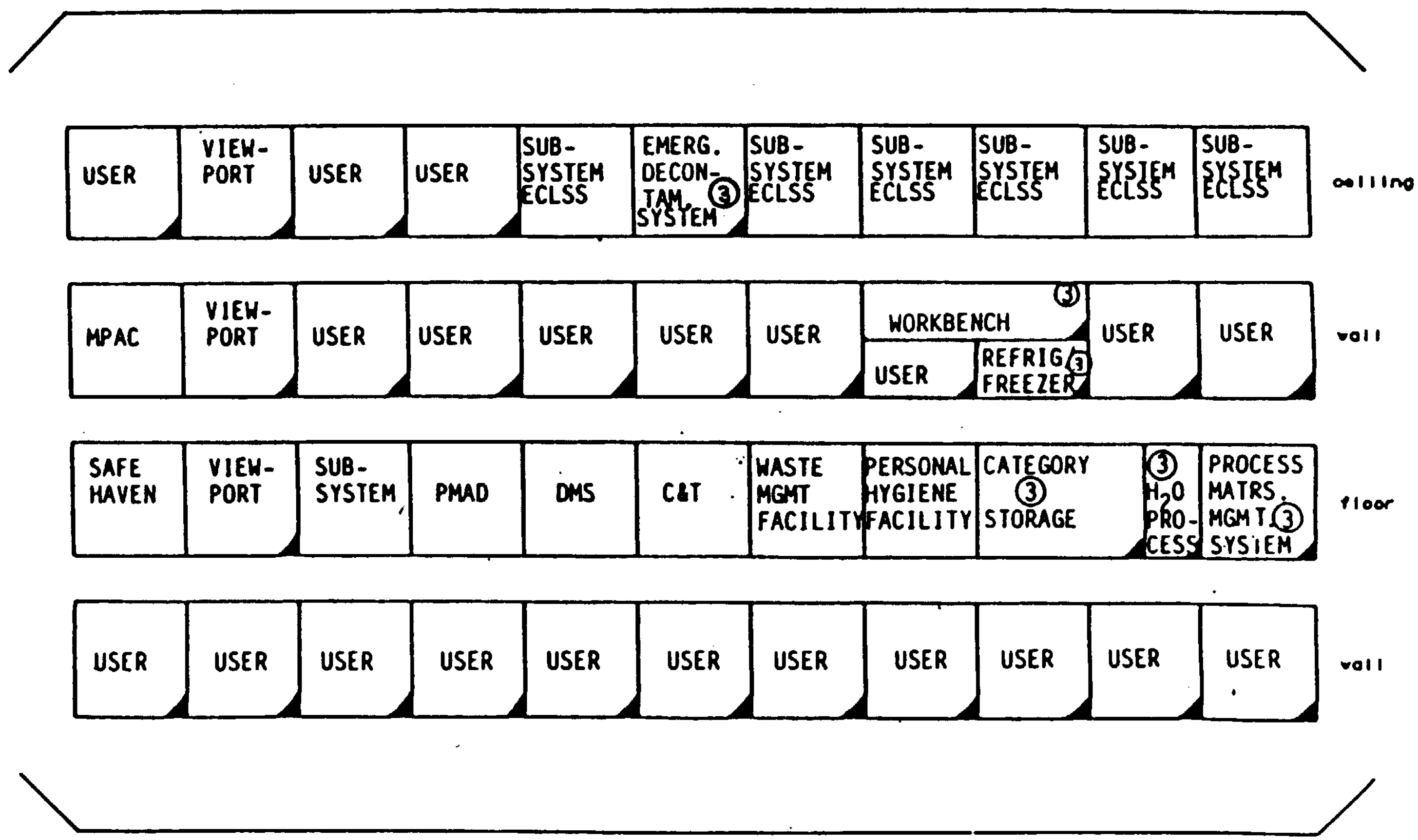


FIGURE 11.

STARBOARD WALL

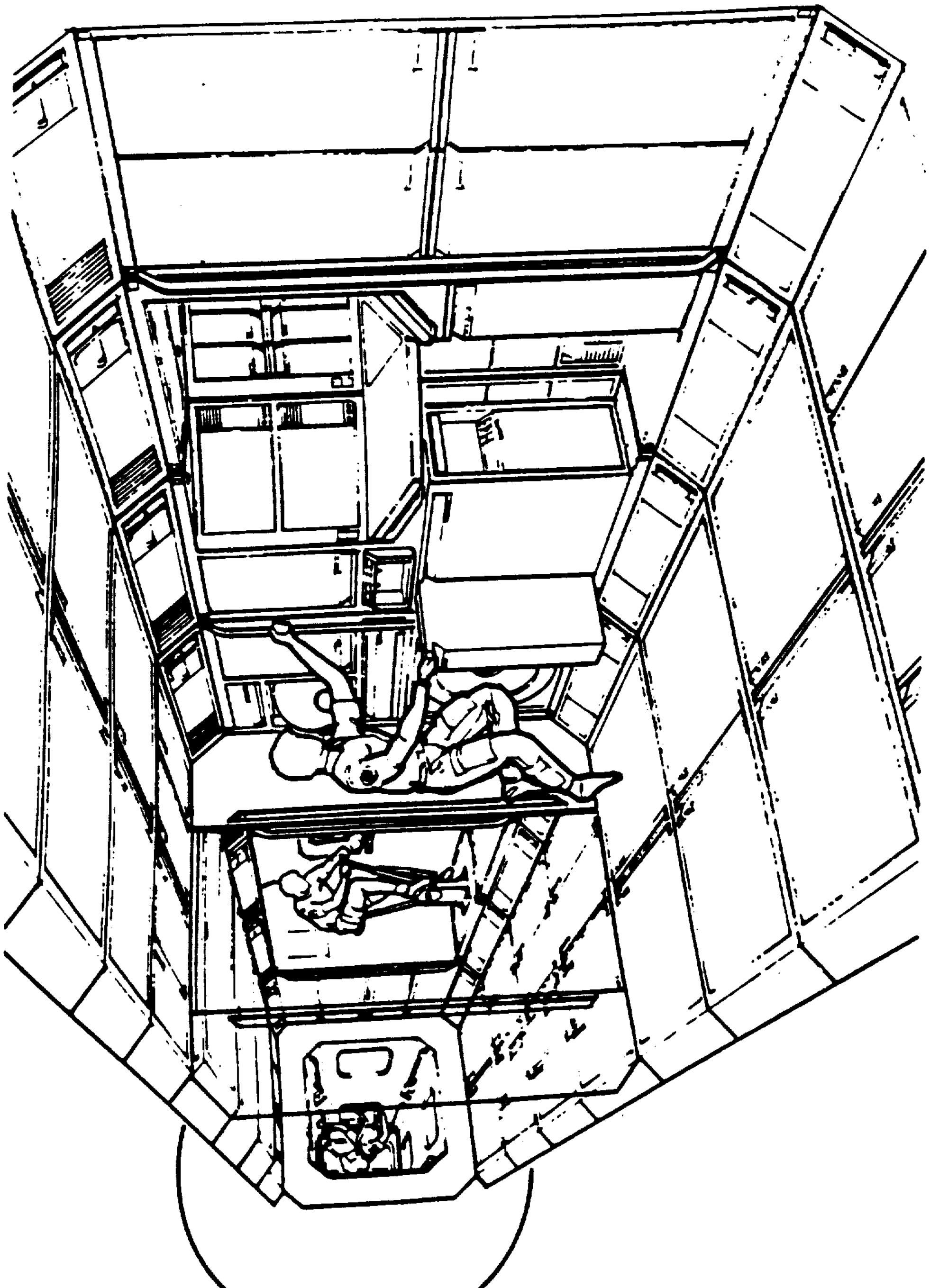


FIGURE 12.

HABITATION MODULE
U.S. – PROVIDED MODULE

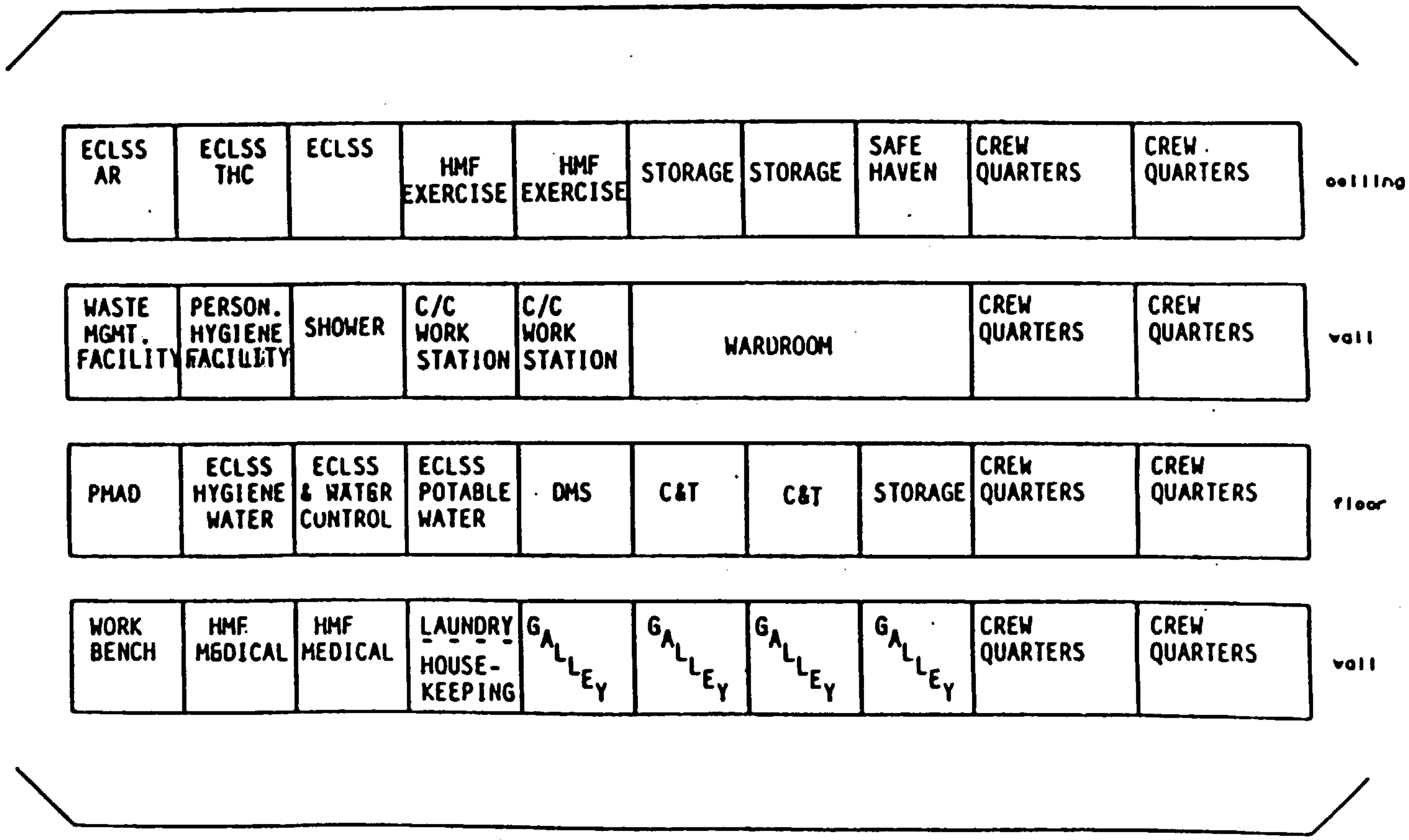


FIGURE 13.

equivalent of 44 double racks. The crew quarters, as shown here, are located at one end of the module complex for isolation. As in the lab module, the primary module subsystems are located in the ceiling and floor.

The Japanese experiment module (Figure 14) consists of a pressurized module, an experiment logistics module, exposed facilities, a local manipulator, and an equipment airlock so things can be moved in and out of the pressurized module. Activities planned in the Japanese experiment module include general science and technology R&D. The experiment logistics module is for the storage of experiment materials and equipment as well as fluids and gases. The experiment logistics module will also be used as a transportation device to get equipment up; currently, the experiment logistics module is planned to be changed out twice a year.

The exposed facility, a pallet-like structure, will serve for science observations and technology development, and also for some materials processing that may be too hazardous to be done in the pressurized modules. The airlock will be needed to transfer equipment between the pressurized module and the exposed facilities. Figure 15 shows a typical floor plan. The module has 24 racks; the Japanese module is shorter than the U.S. module. The wall space is again filled with user racks. The upper and lower boom-attached payload controls may also be located in this module as well as the control station for the Canadian Manipulator. Again, the floor and ceiling space is used for subsystems and storage. There may also be some overflow storage from the U.S. habitation module located in the Japanese module.

Figure 16 shows the European Columbus module; Figure 17 represents the floor plan arrangements for the Columbus laboratories. The European Space Agency is basing its design currently on a four-segment long spacelab module. The module would have a capability for 40 double racks; about one double rack less in length than the U.S. lab. Ten of the double racks in the module would carry overflow storage from the

SPACE STATION PROGRAM
REFERENCE CONFIGURATION
JAPANESE EXPERIMENT MODULE (JEM)

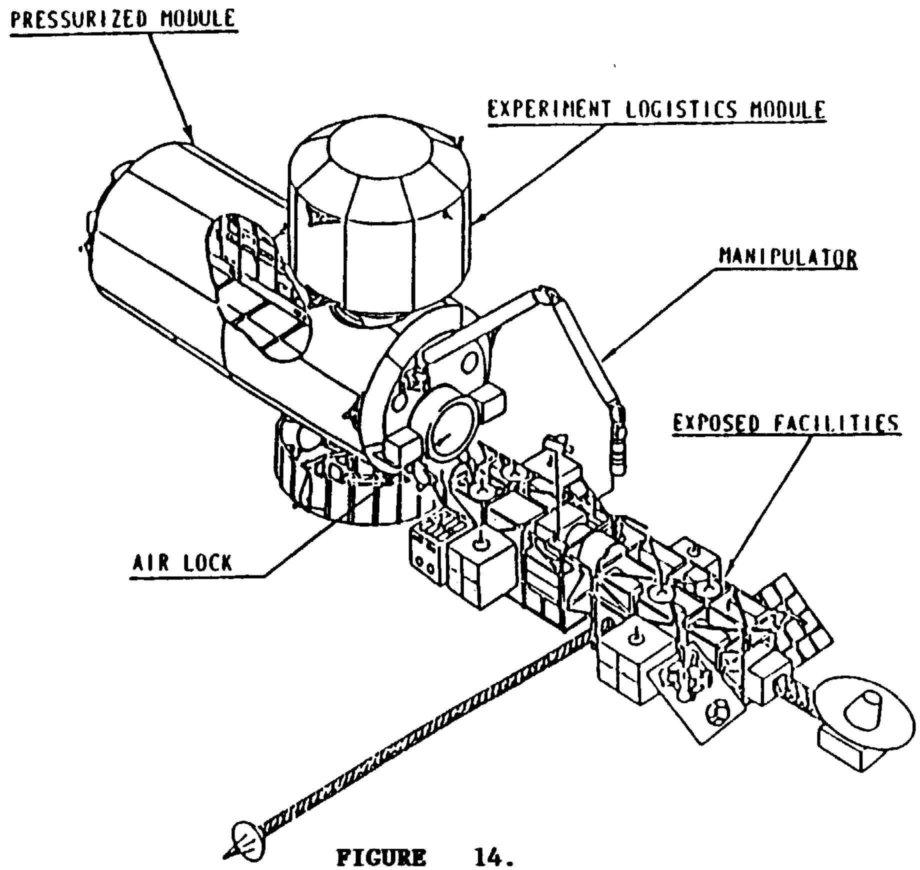


FIGURE 14.

JAPANESE EXPERIMENT MODULE (JEM)
JAPAN – PROVIDED MODULE

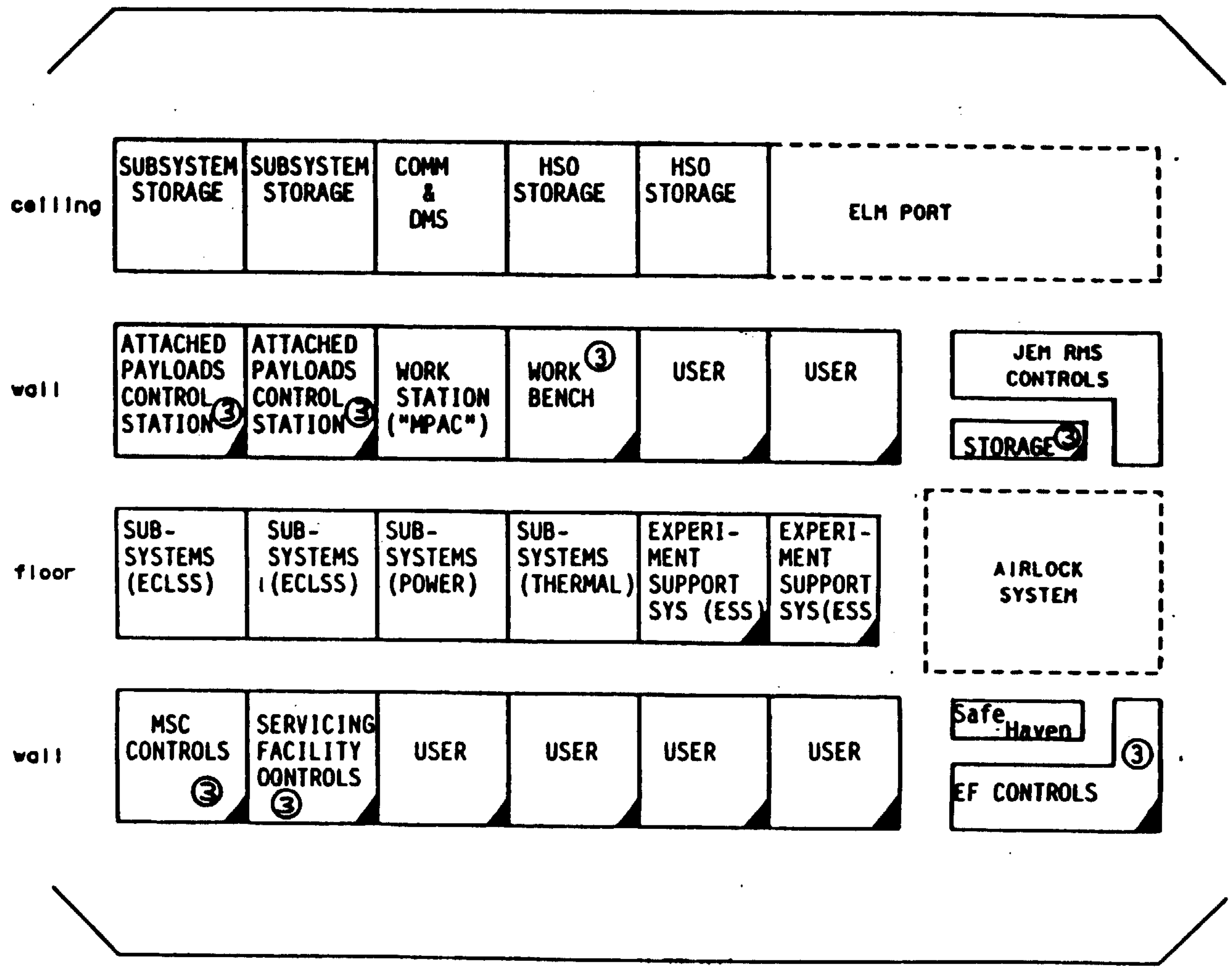
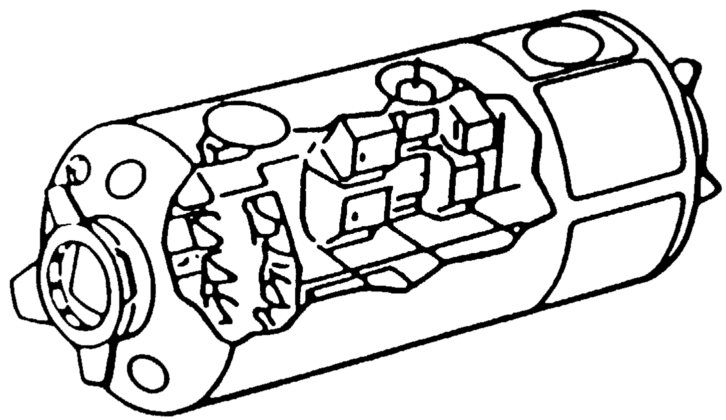


FIGURE 15.



PRESSURIZED MODULE

ATTRIBUTES/REQUIREMENTS

- MULTIDISCIPLINE LABORATORY
  - LIFE SCIENCES
  - MATERIALS PROCESSING
  - GENERAL SCIENCE
- POWER REQUIRED 30 kW
  - HOUSEKEEPING (6 kW)
  - PAYLOADS (24 kW)
- CREW ACCOMMODATION 3
  - REQUIREMENT (5)

FIGURE 16.

COLUMBUS LABORATORY
ESA – PROVIDED MODULE

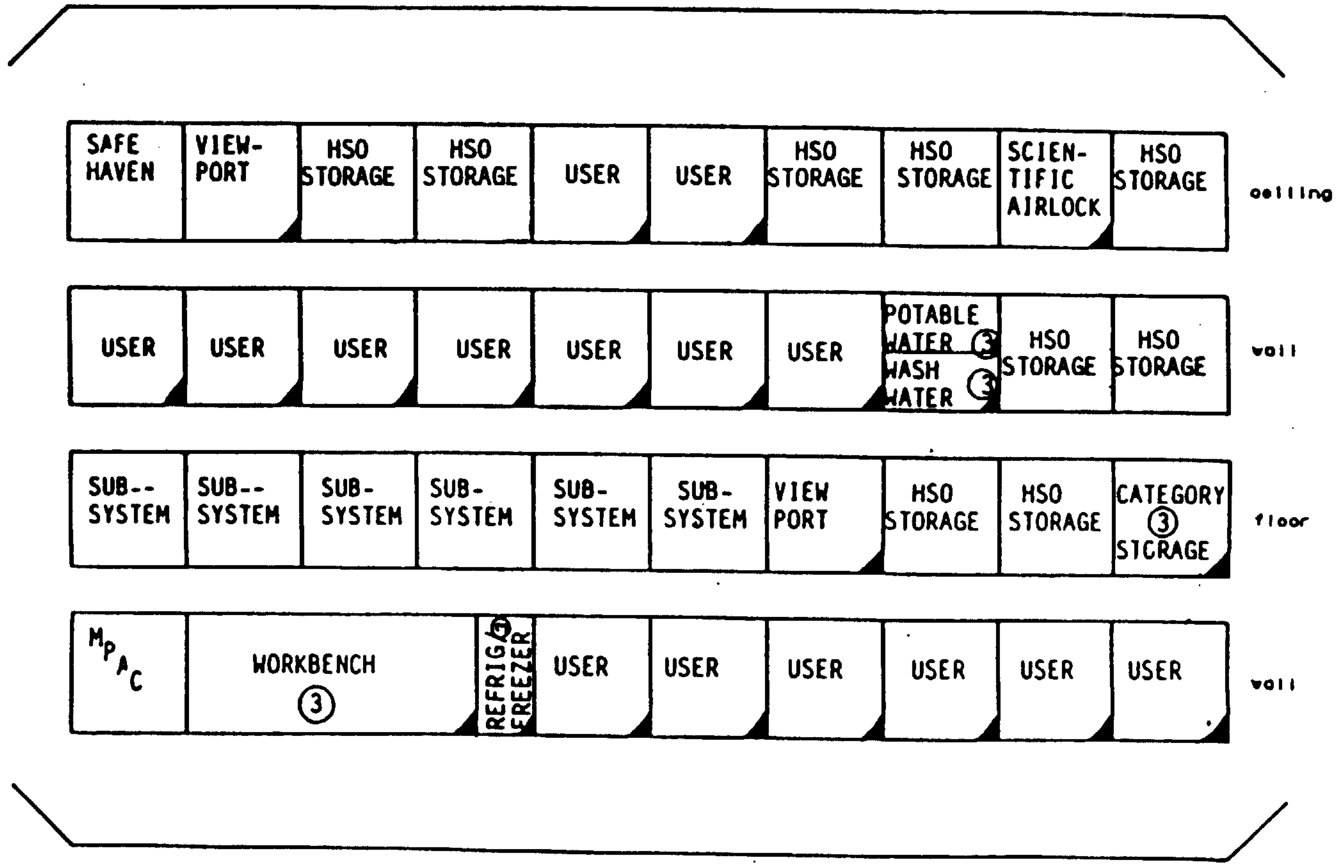


FIGURE 17.

U.S. Habitation Module. The Columbus module may support both life-sciences and materials processing, as well as general science. Again, the wall space is primarily used for user racks, and the floor and ceiling for subsystems and storage.

In addition to the U.S. Logistics pressurized module, there will be unpressurized elements such as fluid and gas containers and other materials that do not require pressurizing. It is currently planned to bring up a replacement logistics module about once every 90 days.

As a concluding remark, I would like to address the question: Why do we need a Space Station? I think a year ago we might have said that we needed a space station to maintain our leadership in space. I think today we would probably say that we need a space station to help us regain that leadership.

Question: What was the gravity level we want to maintain?

Priest: The current program requirement is that the acceleration level should not be higher than 10^{-5} g at the centerline of the U.S. Laboratory module.

Question: Will there be a safe haven?

Priest: The U.S. modules, both the hab and the lab module, are the only modules that have the total environmental control life-support systems. These modules will provide the basic safe haven capability. The race track configuration for the modules will allow crew escape to one of the two U.S. modules should there be a problem in a module that would necessitate that module being closed off.