N89 - 18379 S1-54 175230 8P

# LIVING AND WORKING IN SPACE

Linda Armstrong

> We can follow our dreams to distant stars, living and working in space for peaceful economic and scientific gain. 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 Message
> January 5, 1984

With these words, President Reagan officially began NASA's most difficult venture yet. NASA had been working on plans for the Space Station for several years before this announcement was made. However, the President's message was of great importance because it clearly told the world that the Space Station was a top priority of the United States government and that NASA would receive the funds necessary to undertake such a huge project.

Johnson Space Center in Houston, Texas, was chosen to lead the development of the Station, though all NASA facilities will be involved in the great amount of research that has to be done. It was estimated that the entire project will cost approximately eight billion dollars. Under the leadership of Phillip Culbertson and John Hodge, the Office of Space Station, at NASA Headquarters in Washington, D.C., has announced the basic plans for the station which is scheduled to be operational by the mid-1990s.

At this time NASA is planning to have a zero gravity environment in the Space Station. Though some scientists still argue that the Station should be rotated to create artificial gravity, there is no real need to create gravity. In fact, the major reason that the Station will be used for scientific work and commercial materials-processing is that it is a microgravity environment. NASA scientists continue to study the effects that living in zero gravity has on the cardiovascular system, body-posture, and spatial orientation to confirm that this environment will not be harmful to the astronauts.

The Station will fly at an altitude of 370 to 580 kilometers in low Earth orbit. This is the upper range of the Space Shuttle's average orbital altitude. The Station will lie in a low-inclination orbit at 28.5 degrees to the Earth's equator. It will be placed at an altitude and inclination which will allow it to avoid meteoroids, space debris, and radiation which are particular dangers for the crew.

The living and working areas of the Space Station will consist of a cluster of similar cylindrical modules each the size of a mobile home. Computerized climate control will keep the interior temperature comfortable, and a normal Earth atmosphere of mixed nitrogen and oxygen will be maintained so that the astronauts will need no special life support gear. Since all parts of the Station will be carried up inside the payload bay of the Space Shuttle, the size of the modules are limited by the dimensions of the payload compartment. The modules will be approximately 7.3 meters (24 ft) long and 4.25 meters (14 ft) in diameter to fit into the payload bay which has a length of 18.3 meters (60 ft) and a diameter of 4.27 meters (14 ft).

This size is significantly smaller than Skylab which had a diameter of 6.5 meters (21 ft), and was therefore a less confining environment for astronauts. Each Space Station module will have a volume of about 105 cubic meters (3,700 cubic ft). NASA hopes to avoid the serious problems that these dimensional constraints can cause in the decrease of human performance over extended periods of time. This concern becomes more important as crew sizes and mission durations increase. The weight of the initial Space Station will be approximately 36 metric tons. Though the weight will be meaningless in space, it is important in terms of how much the Shuttle will be able to carry in each launch.

Each module will have a certain function. The habitation modules will house the crew and contain individual sleeping compartments, a kitchen and dining area, exercise equipment, and a personal hygiene facility. One laboratory module will focus on the study of life sciences and the other on materials processing. Many companies are eager to rent space in this processing module to experiment with building electronic components and creating crystals and metal alloys in a zero gravity environment.

The logistics module will contain a 90-day supply of food, water, and clothing, and the entire module will be able to be removed and replaced. Each time the Shuttle visits the Station, it will bring a fully loaded logistics module in its payload bay to replace the depleted module. This will be done on the same flights that bring up the replacement crews. Research is still being done to determine if it will be possible to recycle water and to launder clothing in the Station, thus decreasing the need for new supplies. The ultimate goal of this research is to create a bioregenerative life support system in which plants will revitalize the air, process wastes, and grow food for the astronauts.

The end of each module will have a round end cap which can be removed to connect the module with a tunnel called a multiple docking adaptor. An adaptor connects two modules and can also serve as a temporary connection between the Station and the Shuttle, when it docks periodically.

To decide the exact arrangement of the modules NASA officials have met at various conferences in the past years. The original arrangement, called Phase A--CDG-1 (see figure 1), was chosen by the Space Concept Development Group which met from May 1, 1983, to May 1, 1984, in Washington, D.C. This early idea was later changed to a "racetrack" circulation-loop pattern, the Phase B Reference Configuration (see figure 2), by the "Skunkworks" conference at Johnson Space Center from May to July 1984. Debate continues over the final arrangement of the modules.

Instead of having one centralized command module from which all control of the Station would be done, the command and control system will be distributed throughout the modules. In each module there will be a basic command and communications console from which all major functions of the Space Station can be monitored and controlled. The Station Commander will be able to move freely about the station to perform tasks, but he or she will never be more than twenty feet from a command console.

The Station will not require continual human monitoring, because it will be highly automated. Machines will perform repetitive, boring, and dangerous tasks and will also provide automatic fault detection and recovery. The crew will supervise the machines, handle emergencies, make repairs, and conduct experiments. The Station will basically fly itself, and human intervention will only be needed if an emergency occurs.

In addition to the distributed command consoles, there will be one or two proximity-operations work stations. These window consoles which provide views of space will be used for any functions which require direct visual observation, such as docking with the Shuttle and extravehicular activity (space walking).

Emergency provisions for the Space Station will be distributed throughout the modules so that each module will contain a "safe haven," an emergency supply of food, water, clothing, life support systems, and waste management systems. This standard pack of supplies will be built into each module. The contents of one pack will be able to support the entire Space Station crew of eight for a period of 21 days until rescue by the Shuttle is possible.

In addition to the cluster of pressurized modules, there will be many other parts of the Space Station. The primary source of energy will be photovoltaic arrays of solar cells which total about 2,000 square meters in area. The arrays will be attached to a metal truss structure (see figure 3) and will generate about 75 kilowatts of electrical power, sufficient to meet the initial needs of the Station. They will be programmed to move to face the Sun in order to receive the maximum amount of light. The use of solar power has been chosen over the option of using nuclear power, because of the potential crew danger of having a nuclear reactor on-board the Station. Array panels similar to the solar ones will contain radiators to dissipate excess heat which is generated from Station operations.

Two free-flying platforms will orbit near the Station. One will fly in the same 28.5 degree orbit as the Space Station. It will carry scientific and commercial research experiments which will need only occasional attention from the Station crew. The other platform, flying in a 98 degree Sun-synchronous polar orbit, will be used to observe the Earth. Scientific experiments which depend on stabilized and accurately po inted instruments need to be mounted on these free-flying platforms. The distance protects them from destabilizing forces caused by the movement of the Station.

An unpressurized module connected to the Space Station will serve as a servicing station for satellites. Repair and maintenance of scientific and commercial satellites will be done in this module. Its equipment will include a large mechanical arm which will move structures in and out of the servicing module. The arm will be an advanced version of the Remote Manipulator System developed for the Space Shuttle by Canada.

The crew of the initial Space Station will be six to eight people, but the crew size is expected to increase to twelve to sixteen people by the year 2000. The astronauts will have a wide variety of backgrounds and talents. A typical crew will consist of two pilot-astronauts, two or three mission specialists, and three or four payload specialists who are scientists or researchers from private industries. The crews will train extensively together before their missions, though payload specialists will probably not receive as much training as the other crew members. Part of each crew's training might include working as mission ground controllers for other crews.

NASA has decided upon certain capabilities that the Space Station should have. It should be capable of functioning for 90 days in orbit without a Shuttle visit for resupply or rotation of the crew. In the event of an emergency situation, the crew should be able to live for 21 days in a survival mode using the "safe haven" supplies. This period of 21 days was chosen because 19 days are necessary to put the Shuttle back into orbit to carry out a rescue.

The Station should be able to go for five days without routine ground support, such as instructions and information, from Mission Control. This capability requires that the Station have an extensive database about Station construction, maintenance, and operations. But in the case that vital information is not available in the Station database sometime during this five day period, Mission Control will leave a continuously open channel for the crew for emergency calls. Mission Control will be capable of providing the astronauts with expert consultation by a scientist on the problem within four hours.

There must also be a large data storage base so that the Station will be capable of storing all of the data that it collects over a 24 hour period. This is necessary because NASA officials have specified that the Station must be able to spend one day in orbit with no communication from Mission Control, including sending down data to be stored. A final goal of NASA is to reduce the large staff that will originally be necessary at Mission Control. Eventually, there will only be a small staff working two to five days a week, eight hours a day, providing routine-operations support to the Station. This will lead to a reduction in overall operating costs for the program and will shift much of the decision-making responsibility from the ground crew to the astronauts in orbit.

For the future, NASA is looking at the possibility of adding a second Space Station in a polar orbit to allow for more areas of research to be conducted. The initial Station is expected to last for 20 to 30 years before it will have to be replaced. By that time, further engineering developments will allow NASA to build a new Space Station with incredible new features and capabilities.

## REFERENCES


Anderton, David A.: Space Station. U.S. Government Printing Office (Washington, D.C.), 1984.

Clearwater, Yvonne: "A Human Place in Outer Space," Psychology Today. July 1985.

Cohen, Marc M.: Human Factors in Space Station Architecture I. NASA Scientific and Technical Information Branch (Springfield, Virginia), 1985.

Froehlich, Walter: Space Station--The Next Logical Step. U.S. Government Printing Office (Washington, D.C.), 1984.

Stuster, Jack W.: Space Station Habitability Recommendations Based on a Systematic Comparative Analysis of Analogous Conditions. Anacapa Sciences, Inc. (Santa Barbara, California), 1984.

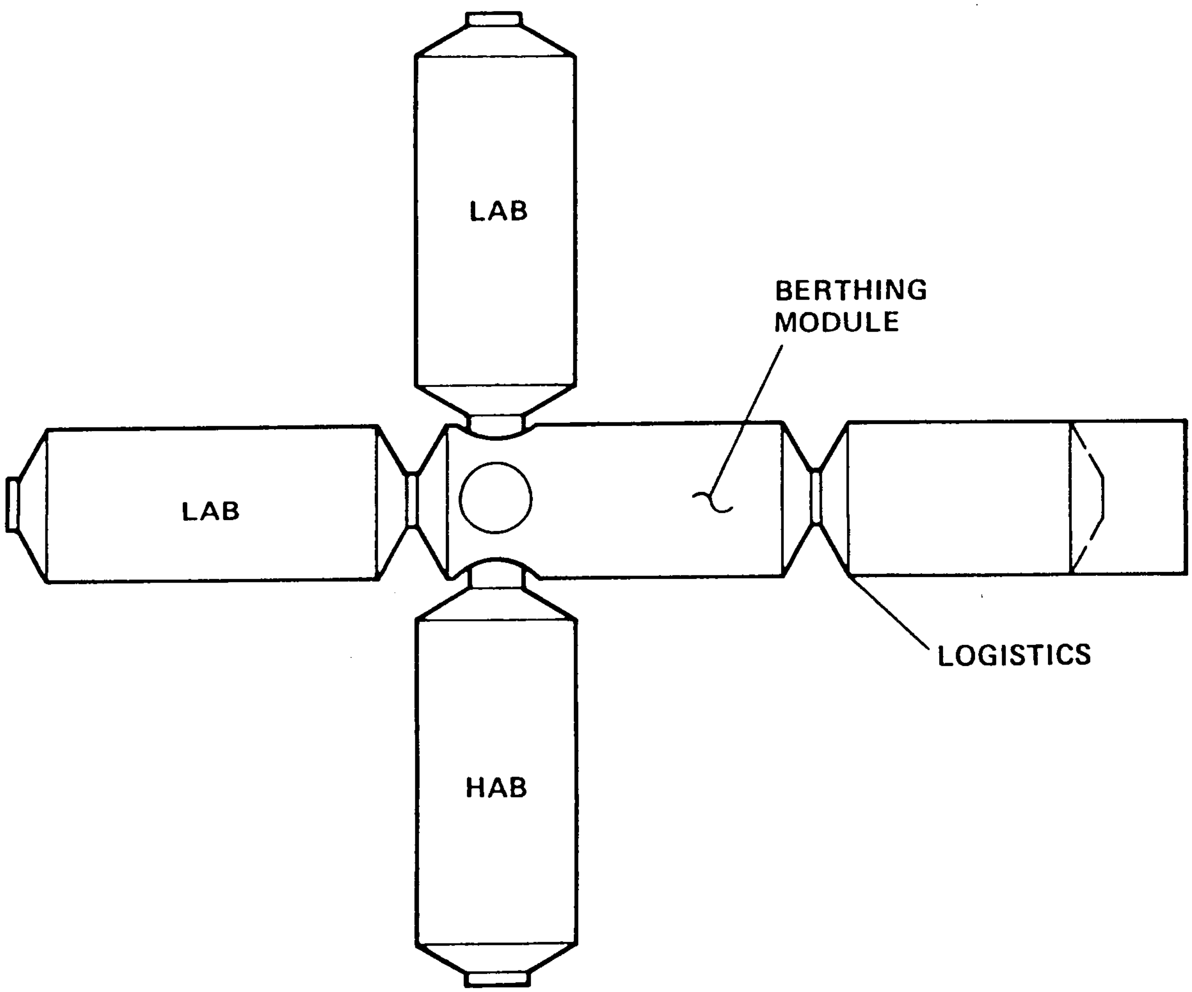


Figure 1.- "Phase A -- CDG-1" Baseline configuration module connection pattern.

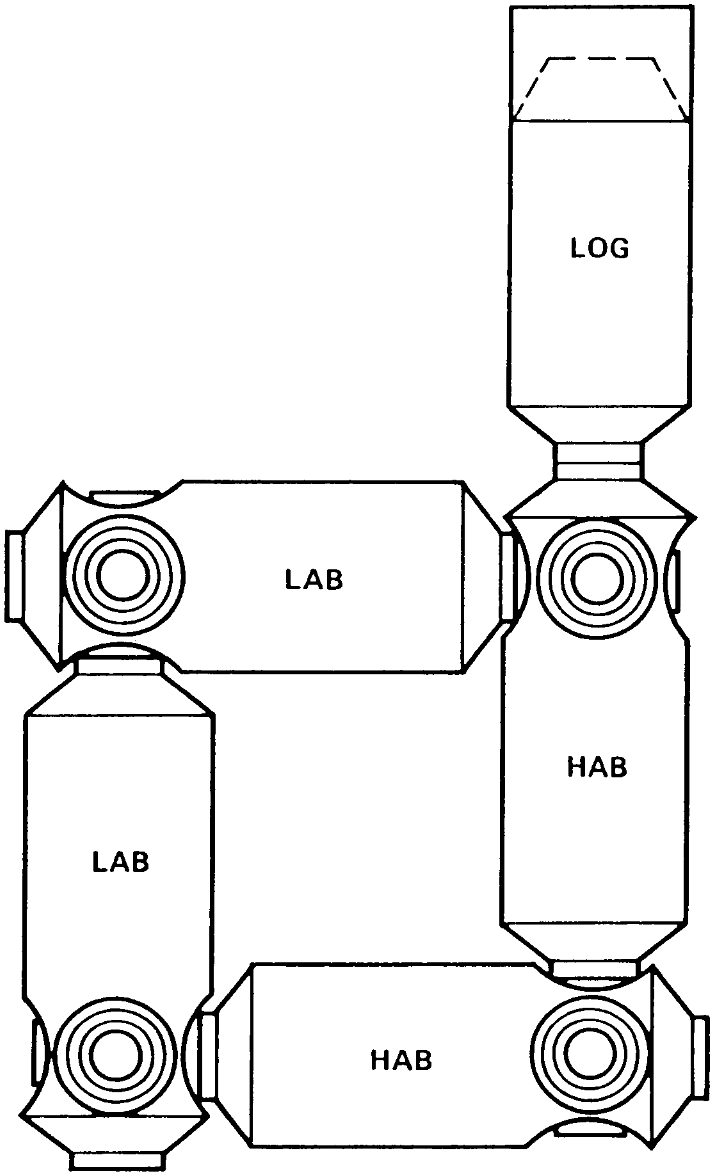


Figure 2.- "Phase B" reference configuration module connection pattern.

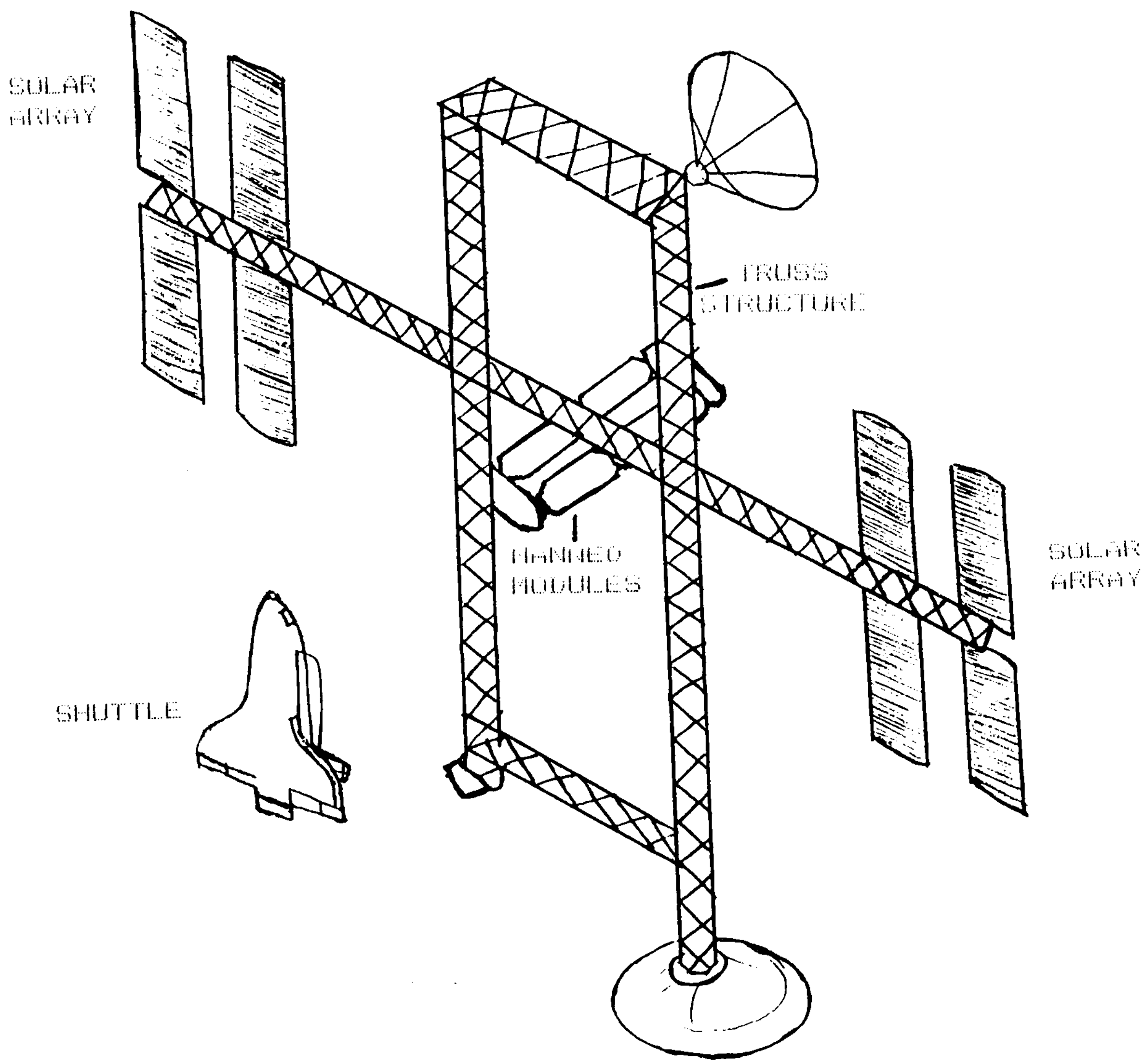


Figure 3.- Features of the Space Station.

**ORIGINAL PAGE IS OF POOR QUALITY**