N87-24496

SPACE STATION: A PROGRAM OVERVIEW

Judith H. Ambrus
Office of Space Station
National Aeronautics and Space Administration
Washington, D.C.

INITIAL SPACE STATION COMPLEX*

Mankind is at the threshold of a new age. Before the end of this century we will have taken the next logical step in space exploration: we will have established man's permanent presence in space. We will have a facility in low Earth orbit consisting of a manned base with working and living facilities for a crew of eight and several unmanned platforms carrying experiments, tended and serviced by the Station or the Shuttle crew (Figure 1). The Shuttle will be a regular visitor delivering new crews, supplies, new experiments or spacecraft for launch into different orbit and returning with completed experiments, crews that have finished their tour of duty, waste material, and perhaps items to be repaired on the ground. An orbital maneuvering vehicle, a robotic space tug, will assist in hauling in spacecraft for servicing or possibly logistics modules delivered by expendable launch vehicles. This is the vision, but the hard facts must be considered.

The idea of a Space Station is not new to anyone engaged in the business of space. Even while the Apollo project was still on the drawing boards, future plans which included various concepts of space stations were being drawn up. Over the years, as we gained more experience, the concepts changed. For instance, we now know that artificial gravity is not necessary for men to survive and not suffer irreversible damage to their health, after living in space for a period of a few weeks or months. We also know what our transportation system to space is, its strength and its limitations. These and other data are enabling us now to realistically plan, design and develop the next logical step.

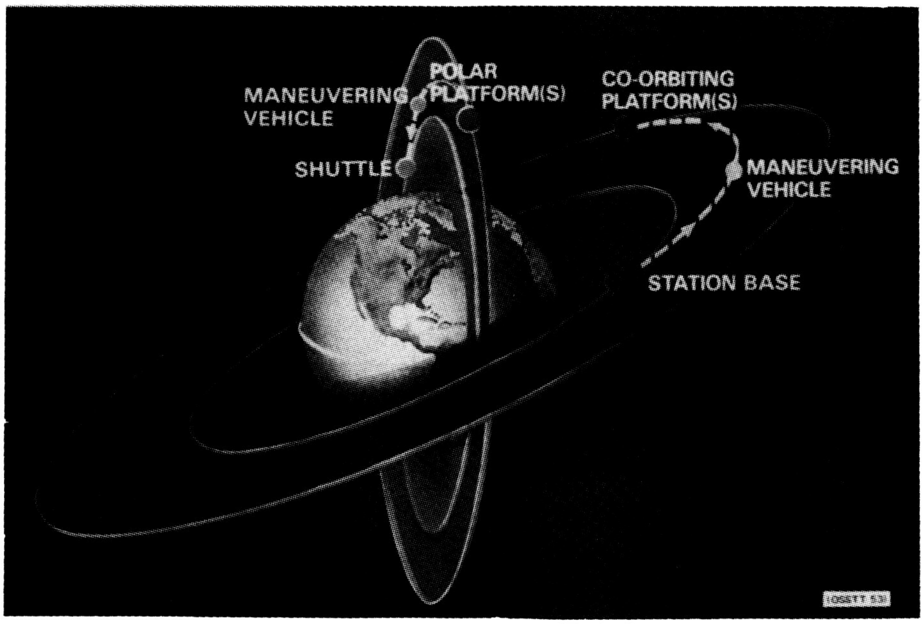

Figure 1

*Original figures not available at time of publication.

SPACE STATION GOALS

When the President directed NASA in January, 1984 (in his State of the Union Address) to develop a Space Station, he set very important goals for this program (Figure 2).

The preliminary design of the facility (Figure 2) might contribute to the accomplishement of all of these goals. It is a multi-purpose facility, serving as a microgravity laboratory in space where basic research and technology development experiments will be performed in a "shirt sleeve" environment. Some of these will lead to enhanced knowledge about human physiology in the weightless environment; others might lead to materials processes which, once automated, will develop into commercial ventures. Scientific instruments will be mounted on the upper and lower booms for the observational sciences. These instruments will be serviced or changed by either crew members via EVA*, or by a mobile telerobotic servicer. Spacecraft, such as the Gamma Ray Observatory and the Hubble Space Telescope, will be serviced in the servicing bay. It will also be possible to assemble spacecraft to be launched into other orbits or toward outer space. Finally, several elements will be contributed by the European Space Agency, Japan, and Canada -- our international partners in this endeavor.

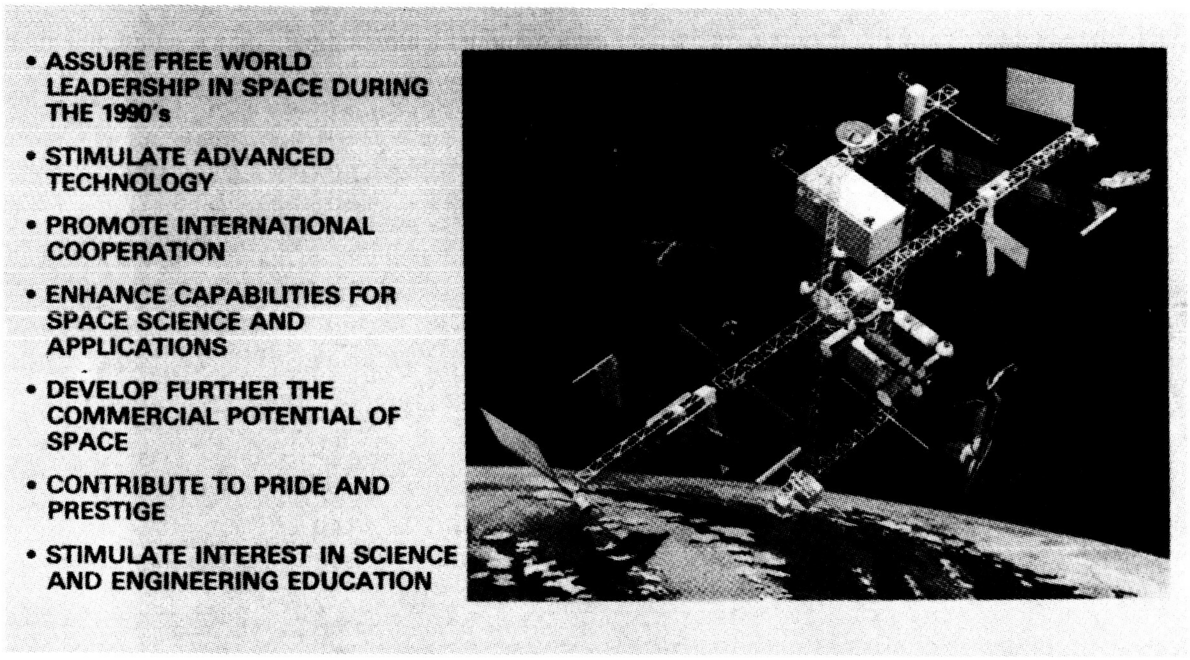

Figure 2

---

*EVA (extravehicular activity).

SPACE STATION PROGRAM OBJECTIVES

The key program objectives that have been set to meet these goals (Figure 3) take into consideration the environment in which we have to attain our goals. We are committed by Presidential directive to have a permanently manned facility in 1994; we also have limited resources. The facility has to provide more than useful capabilities. These capabilities will have to be affordable. We are not yet sure what the most useful aspects of the Station might be; therefore, we will have to build a Station which is capable of evolution. Man in space is very expensive; therefore,we have to design a facility with a judicious mix of manned and unmanned elements. We also have to make sure that those expensive man-hours are not used up trying to keep the Station afloat; thus, development of automation and robotics technologies is imperative for long-term affordability of the capabilities. Finally, we have to secure international cooperation in both building and using the Station.

It is obvious that this is the most challenging program ever undertaken by NASA. The challenges are both technical and managerial.

o We have to design for "permanence," which means both easy maintainability and design for evolution

o We have to build to cost and schedule, meeting both the presidentially mandated milestone for permanent manned presence in 1994 and the budget constraints placed upon us by Congress

o We have to design within a realistic transportation environment, which is currently undergoing redefinition

o We have to manage systems engineering and integration for a program far bigger and more complex then any in our experience

o We have to learn to efficiently communicate without drowning in paper

o We have to incorporate new technologies, balancing cost, schedule, and risk; trading off the potential of long-term, operational cost savings versus the risk of having a new technology develop unexpected flaws

o We have to try to design operations during the hardware design stage, so as to design to the operational environment. This will mean hard choices involving possibly an as yet unknown user versus a problem here and now, which might delay a launch schedule

o We have to learn new techniques, such as assembly and checkout on orbit, potentially while parts of the Station are already operational o Finally, we have to orchestrate the international dimensions of the program, which involves meshing not only schedules and costs not under our control but also dealing with unfamiliar technical and management practices

SPACE STATION PROGRAM OBJECTIVES

- **Develop a permanently manned Space Station by 1994**
- **Provide useful and affordable capabilities**
- **Enhance space science and applications**
- **Stay within $8 billion cost envelope***
- **Secure international cooperation**
- **Design for evolution**
- **Push automation and robotics technologies**
- **Incorporate potential for man-tended concept in baseline program**
- **Blend manned and unmanned systems and capabilities**

FY 1984 Dollars

Figure 3

SPACE STATION PROGRAM SCHEDULE

Because of its complexity, the program has been planned in different phases (Figure 4). The official program start of 1984 drew heavily on planning and concept development work accomplished over the years by NASA and its contractors. Thus it was possible to convene an in-house Concept Development Group, which in the span of a year (Phase A) developed the so-called reference concept, which became the basis of the RFP for Phase B of the program, the Concept Development and Preliminary Design Phase. To manage this phase the work was divided into four "work packages," each managed by a different NASA Center and involving two contractors per work package doing parallel work. System integration was accomplished in-house in the Program Office established at the Johnson Space Center.

During this phase the reference configuration was critically examined from aspects of user capability, development cost, technical risk, maintainability, and other factors to evolve into the baseline configuration. The most obvious changes were the manned base configuration change from the "power tower" to the "dual keel." This provides a stiffer structure, allows for placement of the modules in the most favorable microgravity environment and has considerably more space for attaching payloads. The module pattern was changed from the "racetrack" configuration which included internal airlocks to a simpler design consisting of modules with nodes and tunnels to interconnect. This allowed for easier traffic patterns as well as providing more volume.

It was also during this process that technologies for the various subsytems were selected. For example the decision was made to have a "hybrid" power system consisting of both solar array/battery modules and solar dynamic modules. The much smaller area of the solar collectors reduces drag and saves operating costs and thus has more growth capability. The technical risk of not having fight experience with a solar dynamic system was outweighed by the operational considerations and high near-term power demands. It was also decided to close the Environmental Control and Life Support System to the point where only nitrogen would be resupplied to the pressurized atmosphere (the oxygen being regenerated). Recycling water would allow only food to be supplied and solid waste to be returned. Again, the long-term savings in logistic resupply costs were considered worth the higher development costs of such a system.

SPACE STATION PROGRAM SCHEDULE

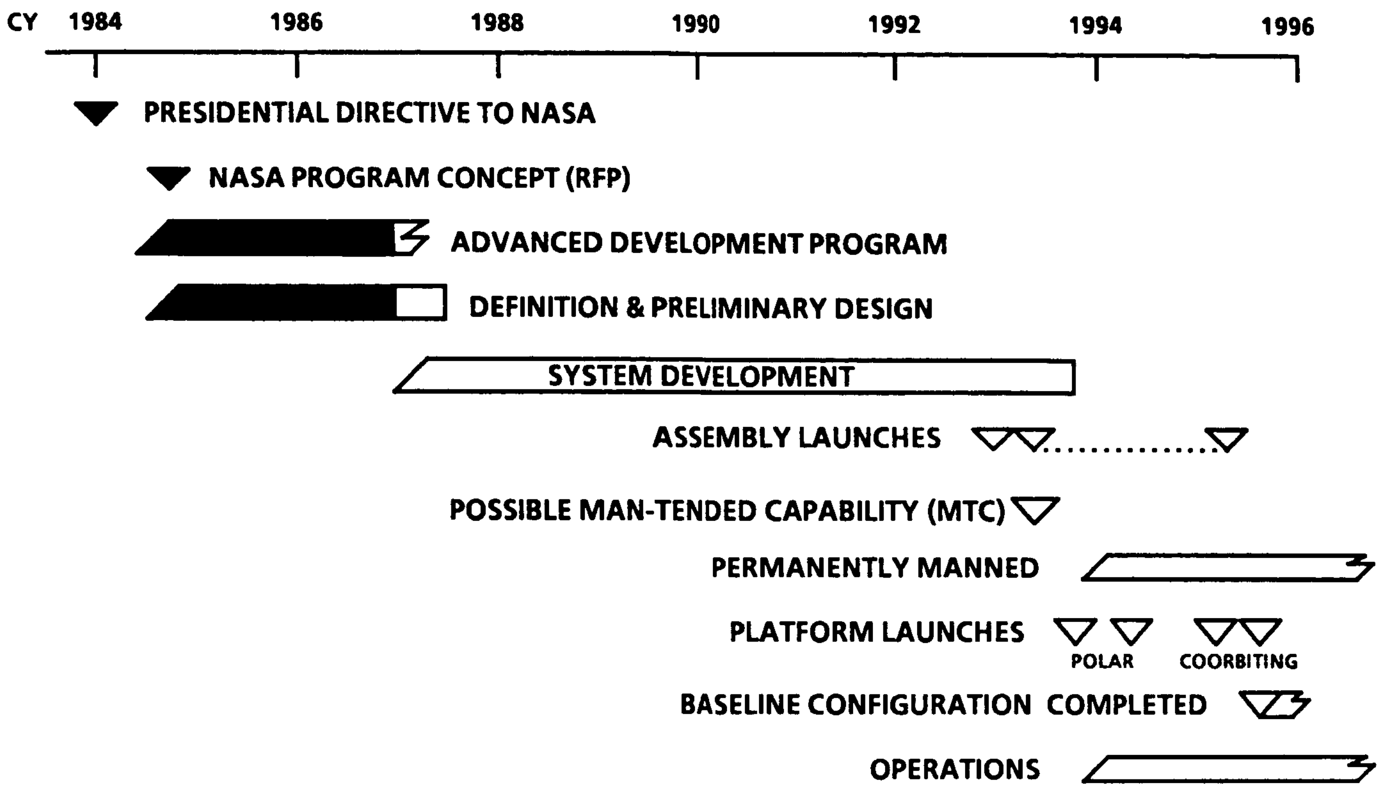

Figure 4

ADVANCED DEVELOPMENT PROGRAM

These choices were greatly aided by the results from the Advanced Development Program that was conducted parallel to the Phase B effort (Figure 5). During the early planning process it had become apparent that there were several promising technologies in NASA's generic technology base program which, if focused towards the Space Station application, would have high pay-off in operational cost savings.

The program was designed for a three year effort in thirteen different areas. After the first year some technologies were selected for prototype development and testing. This program was also used to establish test beds, which are being used for prototype testing now, but will be retained for use in test bed verification of flight hardware as well as serve the evolutionary technologies. Several decisive flight experiments were also conducted.

It was the advanced development program that lowered the risks to an acceptable level and enabled the choices mentioned above in power and ECLSS*. Other examples include the choice of the high efficiency, two-phase thermal management system (outside the pressurized volumes), the hydrogen/oxygen propulsion system, the erectable instead of deployable structure, the sea level pressure in the pressurized volumes, and others.

As the second phase of the Space Station Program neared completion, the Baseline Configuration underwent another hard scrutiny. This had been necessitated by the changed environment following the loss of the Challenger, which includes the change in the availability (and possibly mode) of transportation, the heightened awareness of crew safety, the concern over early uses of the Space Station and the cost of the baseline configuration raised by Congress and the management concerns highlighted by the Roger's Commission. The Administrator, therefore, ordered a comprehensive technical, cost, and management review of the program.

---

*Environmental Control and Life Support Systems.

ADVANCED DEVELOPMENT PROGRAM

- **Current technology is, in some areas, inadequate for desired Space Station capabilities**

- **Purpose of Advanced Development Program is to provide advanced technology options that are reliable and cost effective**

- **Five key program elements:**

Focused Technology -	provides proper application focus to the generic R&T base program and continues technology development through demonstration at the breadboard level
Prototype Hardware -	provides for development of protypical hardware that embodies the advanced technologies
Test Beds -	provides for proper testing of the new technologies at the brassboard or prototype level
Flight Experiments -	provides in-space demonstrations of advanced technologies using the Shuttle
Subsystem Studies -	provides for additional studies of technical options resulting from advanced development efforts

Figure 5

CRITICAL EVALUATION TASK FORCE REFERENCE CONFIGURATION

The configuration resulting from this review (Figure 6) has the following features:

o It combines the nodes and interconnecting tunnels into "resource nodes." This results in more useable pressurized volume, thus enabling the inside accommodation and servicing of instruments, which previously required EVA

o It increased the initial deployed power to allow for early user operations

o It adjusted the assembly sequence to achieve permanent habitability in 1994, and user operations during assembly to allow for the limited transportation capabilities

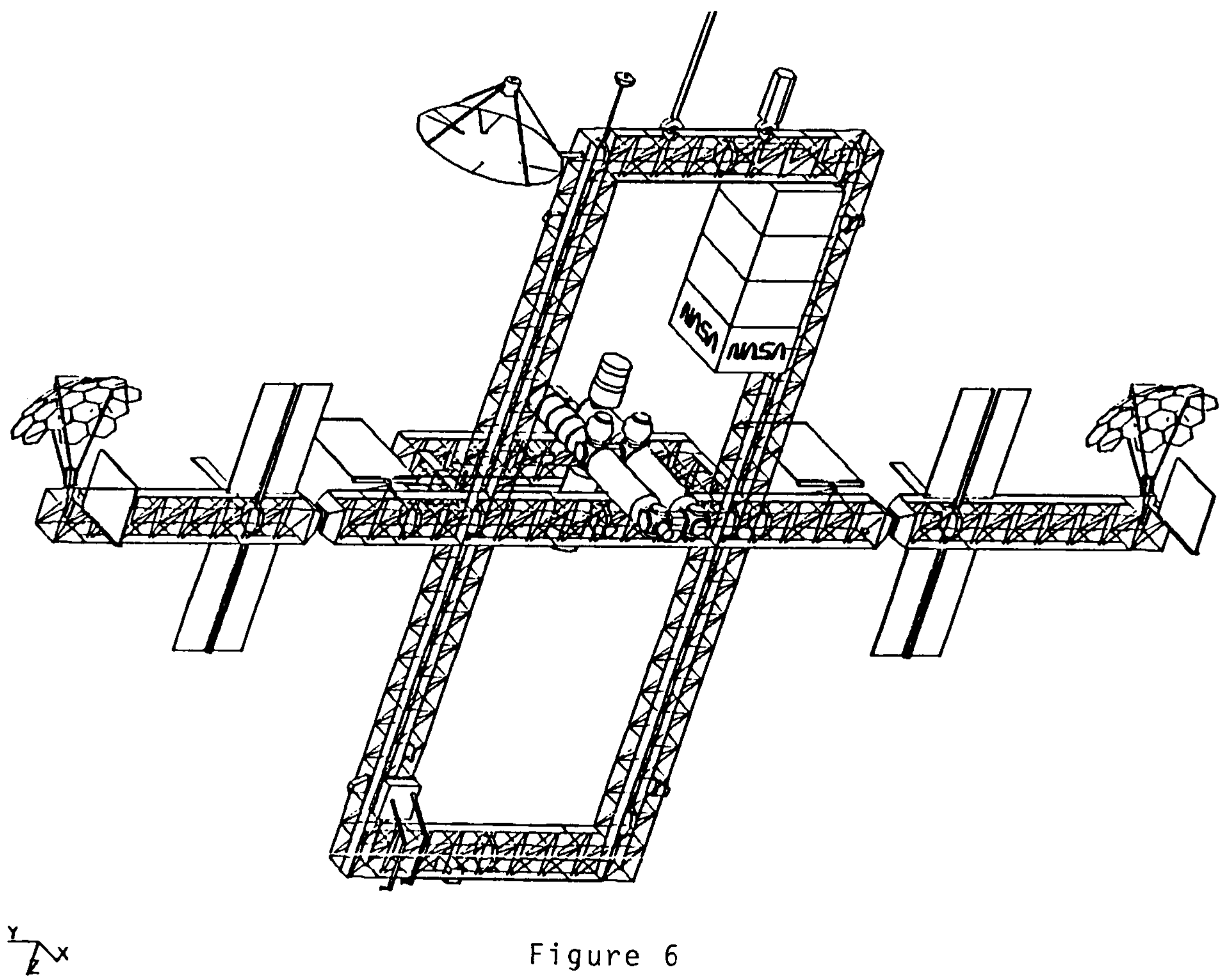

Figure 6

PROGRAM MANAGEMENT APPROACH

The concurrent management review of the Space Station Program resulted in a somewhat changed management structure (Figure 7), with a Program Office being established in the Washington area as part of Headquarters. This Program Office will accomplish the system engineering and integration which involve the interfaces between the hardware elements developed by four NASA centers with their contractor teams and the three international partners.

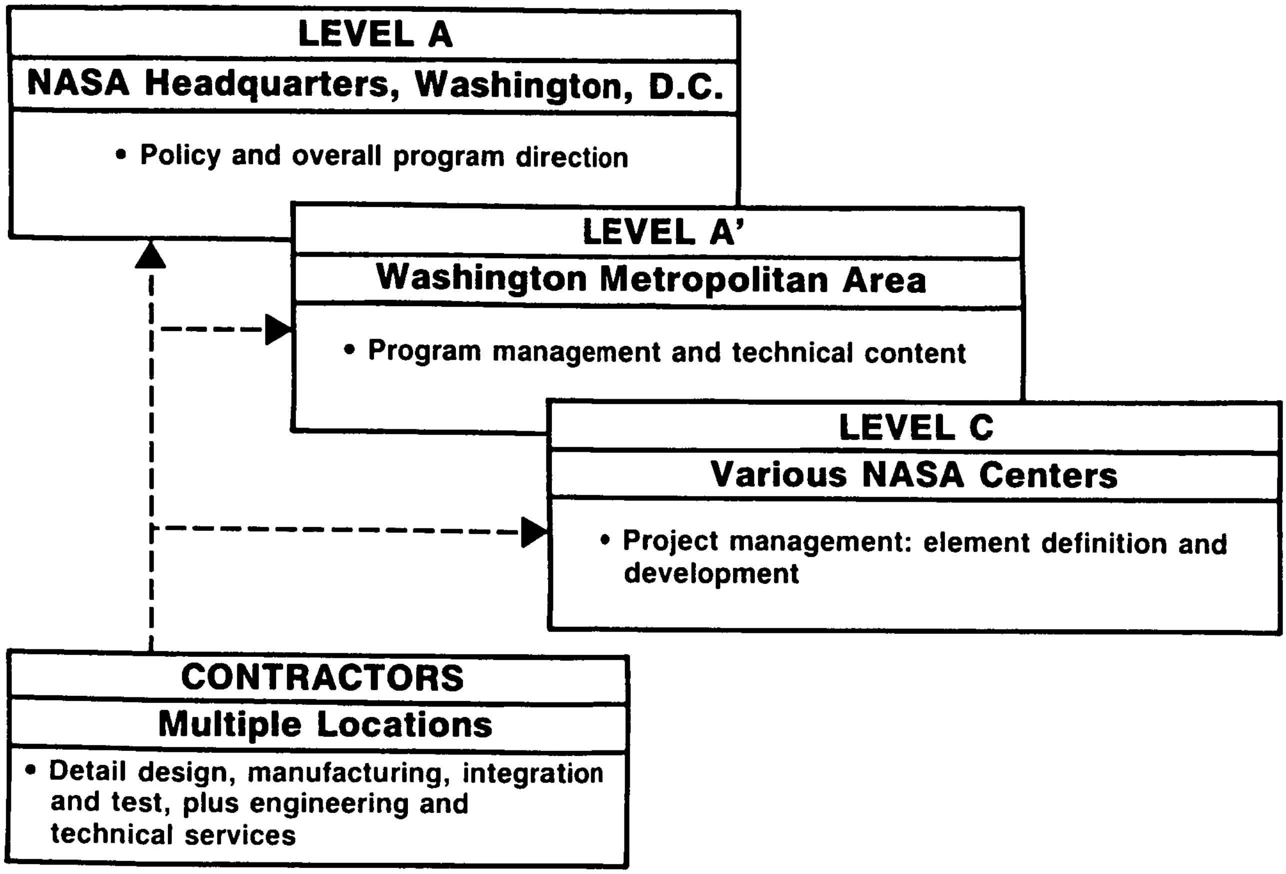

Figure 7

The Space Station elements with the responsible organization (NASA and international) are shown in Figure 8. Present activities are focused on the start of Phase C/D, the Design and Development Phase. The major challenges at present include the synchronization of four RFPs*, the international negotiations, the still ongoing cost review, and the effort to define and plan operations. And while we are working to build the initial Space Station, we also look toward the twenty-first century, when the Space Station will be the base from which we plan manned missions to other planets, to mine the asteroids, and to further explore our solar system and beyond.

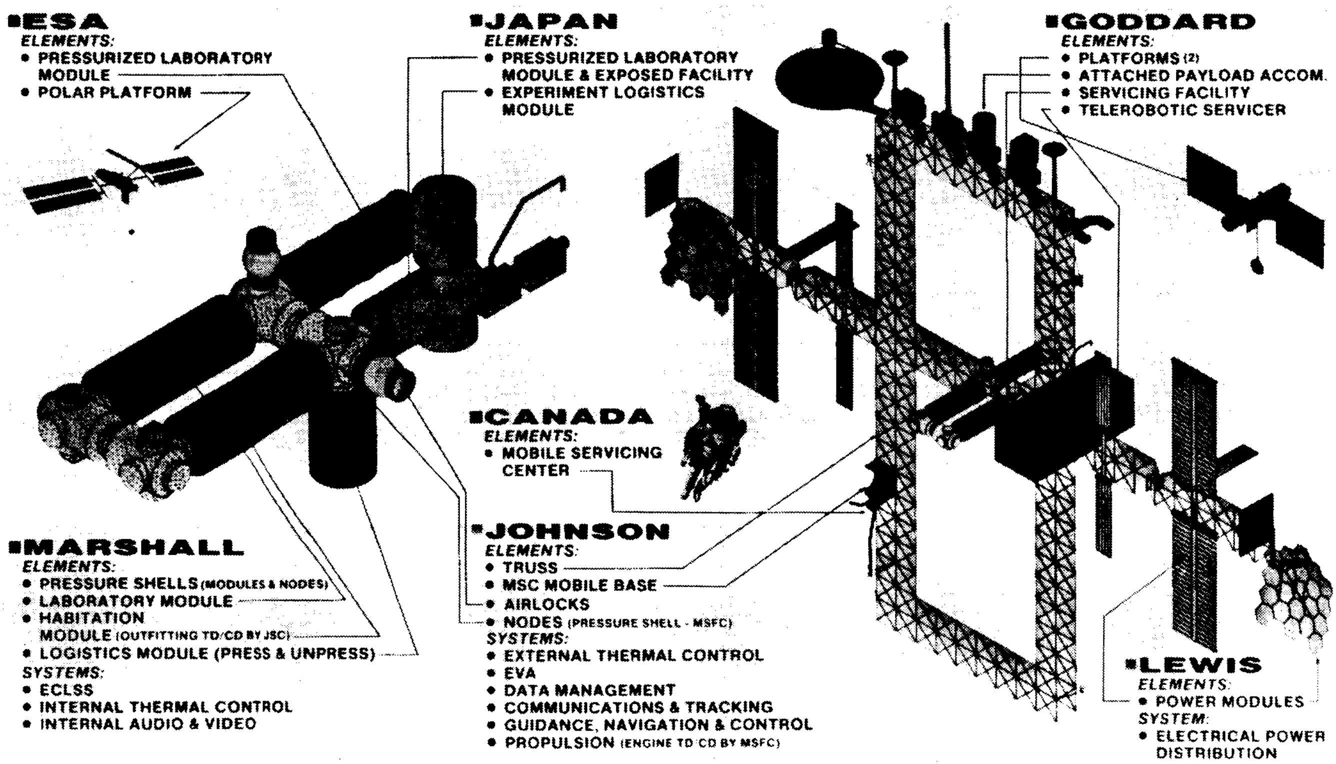

Figure 8

---

*Request for Proposals.

ORIGINAL PAGE IS OF POOR QUALITY