Space Station

A Step Into The Future

By
Andrew J. Stofan

Cover illustration courtesy of Rockwell International

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The Space Station is an essential element of NASA's ongoing program to recover from the loss of the Challenger and to regain for the United States its position of leadership in space. Such leadership was won through imagination, daring and hard work. It will take substantial quantities of all three for our country to again lead the way in the exploration and utilization of the space frontier.

Our first priority at NASA is and must be the safe return of the Space Shuttle to flight operations. To this end we are making significant progress. Our efforts are aimed not only to a successful flight in 1988, but also to a Shuttle program that supports a substantial number of flights in the years ahead. Concurrently, we are reconfiguring our space science and applications program, mindful of the central position this program holds in the country's overall space activities. We are defining NASA requirements for expendable launch vehicles, giving shape and specificity to the mixed fleet we will have in the future. To establish a strong technical foundation for the future, we will be initiating a Civil Space Technology Initiative to be implemented in cooperation with industry and academia. We have made substantial modifications to the NASA organizational structure to assure a stronger centralized management. And we have underway a strategic planning process that will help us understand the future and better define NASA's goals and missions.

The Space Station is important because it is about the future. The Station will become operational in the mid-1990's and will function as a research laboratory for some 20 to 30 years, well into the 21st century. What we are doing now, by undertaking the development of a permanently manned Space Station, is preparing for the future. We are building a complex spacecraft in which men and women — living and working in Earth orbit — will conduct scientific and technological research. The Station will be the centerpiece of our future activities in space. It will not be the only thing we are doing, but it will be a critical element of our civil space program.

The frontiers of space eventually will beckon us again to leave the confines of Earth and explore once more the lunar surface or land upon Mars, the planet that most closely resembles our own. When this will occur is uncertain. That it will occur is not at issue, for the intangible imperative of human exploration will not, in the long run, be denied. It appears likely that man will journey back to the Moon or to Mars within the next forty years. Much technology development needs to occur before such an expedition could be mounted. Much research needs to be conducted about the biological effects of long duration space flight. A Space Station is the only place where such activity can be accomplished. The Space Station thus will be a laboratory for preparatory work essential to any future manned space exploration. And it will serve, when the mission begins, as a point of departure for this lengthy, bold yet hazardous journey. The Space Station is thus an enabling capability for the future.

The Space Station Program itself has made substantial progress. The President's directive to NASA to develop, within a decade, a permanently manned Space Station was made over three years ago. Since that directive, an enormous amount of work has taken place, at NASA, in industry and overseas. Let me note briefly here some of the major efforts we've undertaken. Taken together, they give me confidence that we are indeed on the right track.

We have completed with industry an extensive, 21-month definition and preliminary design study. This "Phase B" analysis was supplemented by a critical evaluation of the Space Station's configuration conducted by a special NASA task force. We have conducted a special review of the Space Station Program with the White House and have agreed upon a phased approach to Station development. A Revised Baseline configuration has been established and the competition for Space Station hardware development has been initiated. NASA is currently reviewing industry's Phase C/D proposals and hopes to have contracts negotiated late in 1987 or early 1988.

We have completed a 3-year effort in technology development and are now defining a transition program for future technical advances. A special effort has been made to better understand the potential of the Space Station for utilizing automation and robotics (A&R), and a Flight Telerobotic Servicer has been identified as the centerpiece of our efforts in this area. Extensive analysis of user requirements has been made and is continuing. These requirements are influencing Space Station design. A major effort to understand operational considerations also has been made and a special

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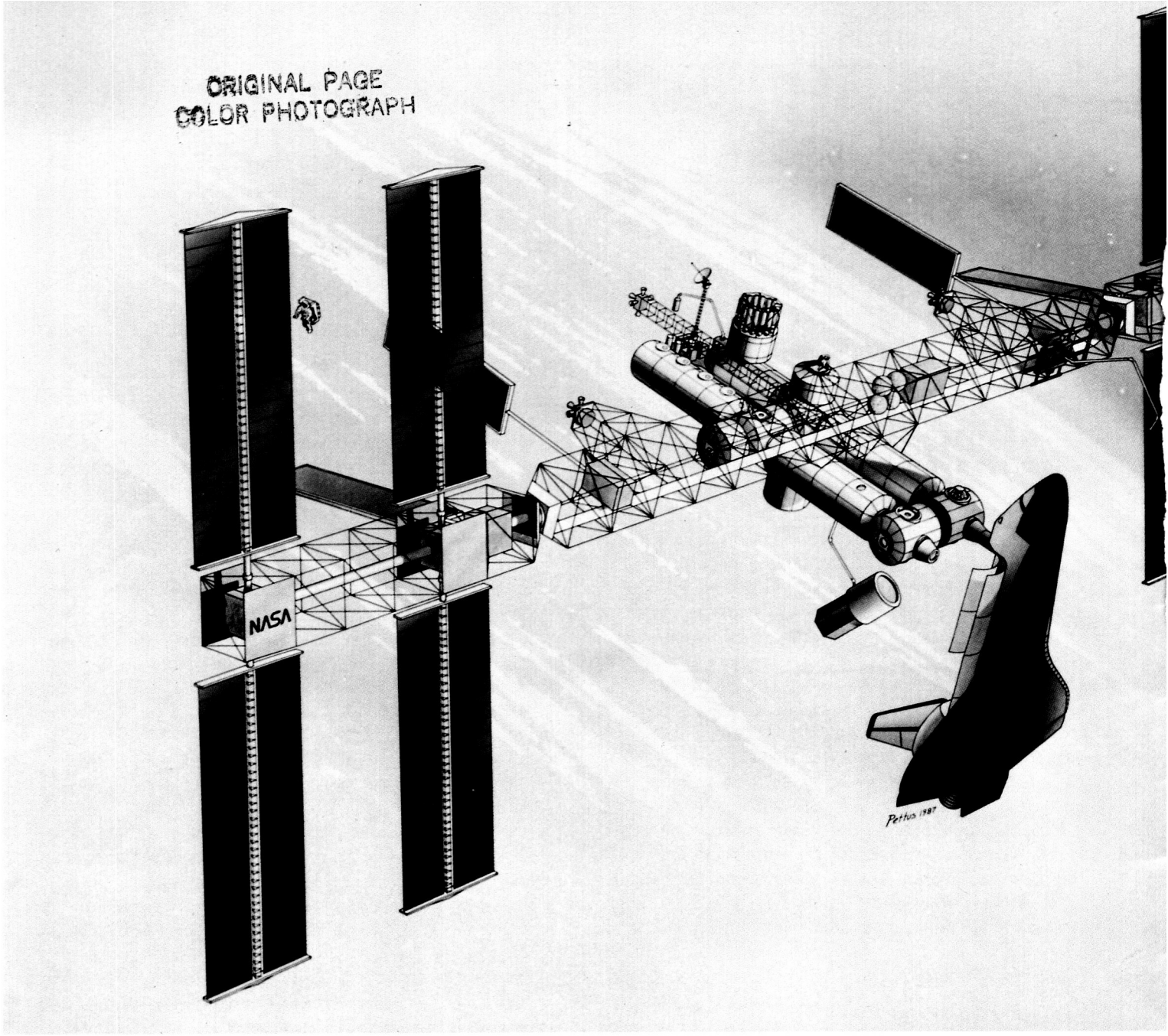

To balance the need to reduce federal spending while establishing a permanently manned Space Station in the mid-1990's, NASA and the Administration have adopted a phased approach to Station development. This approach provides an initial capability at reduced costs, to be followed by an enhanced Space Station capability in the future. NASA has evaluated hardware proposals from industry that reflect this phased approach. Contractor selection can be anticipated shortly.

The phased approach utilizes a design derived from the baseline configuration developed by NASA and industry during the Phase B studies, and confirmed by NASA's Critical Evaluation Task Force. Termed "Revised Baseline Configuration," and shown in Figure 1, this design features a 110-meter-long horizontal boom to which are attached in the middle four pressurized modules. At each end are located four photovoltaic arrays generating a total of 75 kw of power. Two attachment points for external payloads are provided along this boom. The four pressurized modules include a laboratory and habitation module to be provided by the United States. The European Space Agency (ESA) and Japan each will be providing an additional laboratory, assuming current negotiations with them are successful. ESA also will be providing a Man-Tended Free Flyer, a pressurized module capable of operations both attached to and separate from the Space Station core. Canada is expected to provide the first increment of a Mobile Servicing System.

The Revised Baseline Configuration includes a logistics module and the necessary logistics system. It also includes a Flight Telerobotic Service (FTS). The centerpiece of the Space Station program's response to a congressional mandate to enhance the technologies of automation and robotics, the FTS will be used in the assembly and maintenance of the Station. The Goddard Space Flight Center is responsible for its development.

Integral to the Space Station concept are free-flying, un-

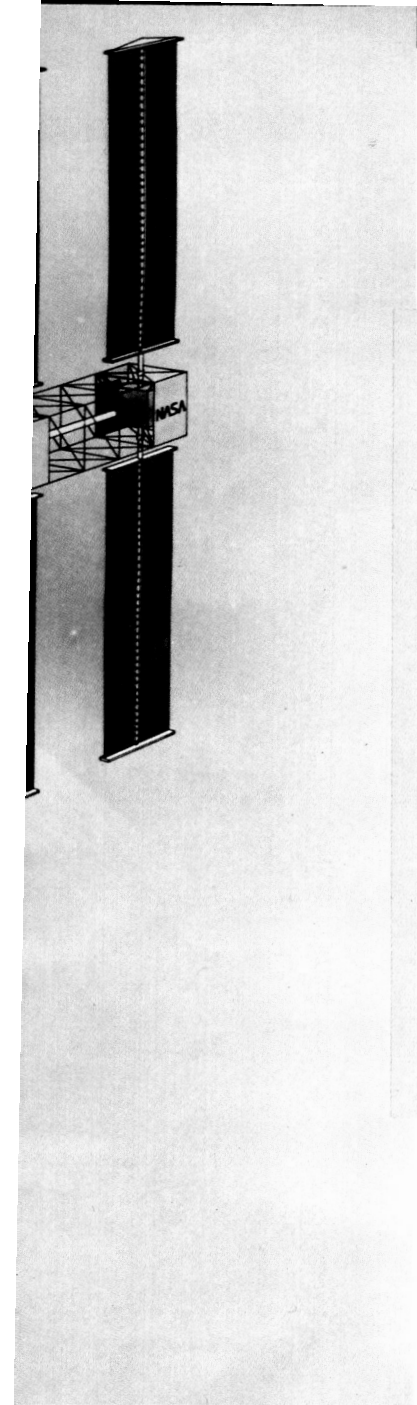

Figure 1

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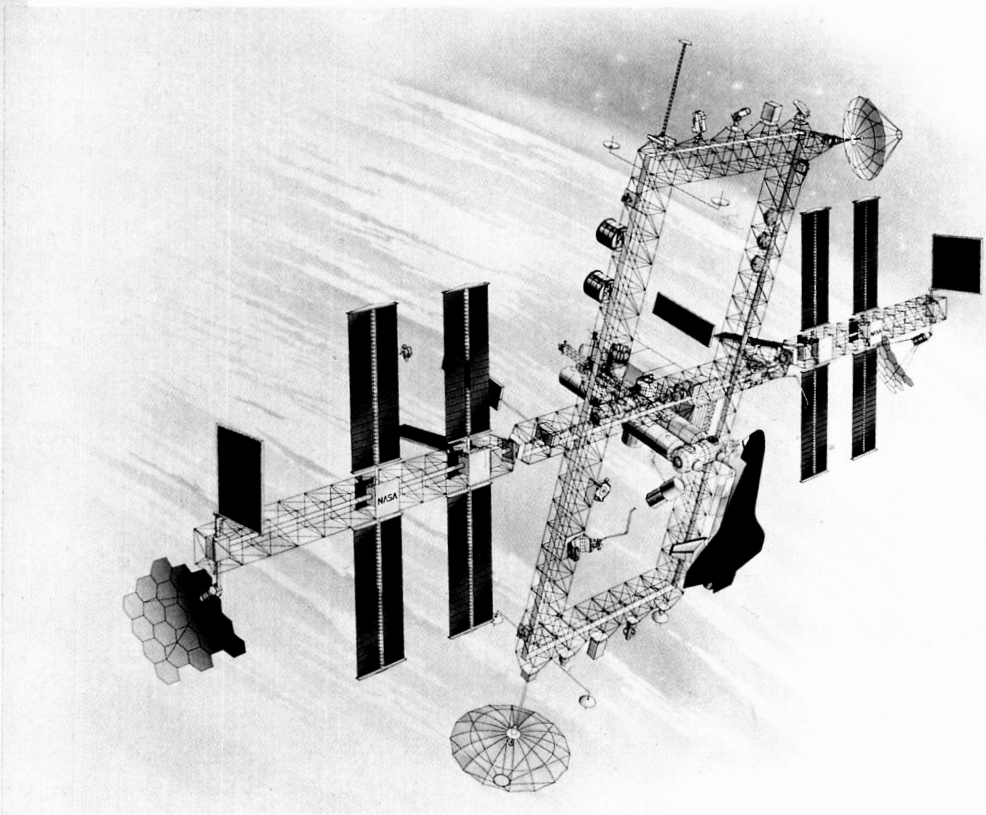

Figure 2

manned platforms. These provide a different set of capabilities from those of the manned base. Two such platforms, both to be flown in polar orbit, are included in the Revised Baseline Configuration. They will be developed by the United States and the European Space Agency.

The Revised Baseline Configuration achieves two fundamental goals established by NASA in response to President Reagan's Space Station directive. The configuration realizes a permanently manned presence in space. And it provides diverse and useful capabilities for those who wish to work in space.

In addition, the Revised Baseline Configuration provides for meaningful international participation. Moreover, power levels will be substantial, 75 kw, and the Station will be designed to accommodate more power and the additional modules that inevitably will be desired in the future.

Illustrated in Figure 2 is a configuration with enhanced capabilities. It builds on the horizontal boom and module pattern of the revised baseline. This configuration would feature dual keels, two vertical spines 105 meters long joined by upper and lower booms. The structure carrying the modules would become a transverse boom of a basically rectangular structure. The two new booms, 45 meters in length, would provide extensive accommodations for attached payloads, and would offer a wide field of view. Power would be increased significantly, with the addition of a 50 kw solar dynamic power system. Satellite servicing capabilities would be provided, in large part by the addition of a U.S. supplied servicing bay. This enhanced configuration might well include an unmanned, free-flying platform that would co-orbit with the Space Station manned base.

Operations Task Force has reported to me the findings and conclusions of its six month review.

In addition, we have restructured the program's organization, established a Technical and Management Information System (TMIS) to achieve timely and effective program control, and procured a Program Support Contractor to assist us in management and integration activities.

We have analyzed the capability for man-tended Space Station capabilities and have incorporated such a potential in the Station's assembly sequence. We have established guidelines for private sector participation in Space Station development, and are soliciting industry's ideas on how best to realize via the Space Station increased commercial activities in space. We have reviewed extensively transportation requirements for the Station and are presently examining what role Expendable Launch Vehicles might have in supplementing the Space Shuttle in Space Station operations. We have reviewed the related subjects of Station safety and crew rescue and look forward to the results of a Phase B study to be conducted on crew emergency return systems. We have completed extensive discussions with Canada, the European Space Agency and Japan on their participation in the Program, concluding one set of agreements on international cooperation for Space Station definition and, currently, negotiating with our partners on cooperation during development and operations. We have conducted a recent and thorough review of Space Station costs.

A particularly special effort has been made to solicit and listen to the advice of those outside NASA whose experience and expertise will benefit the Space Station Program. Several such efforts should be mentioned here: the first is the Task Force on the Scientific Uses of the Space Station whose work is helping to assure that the Space Station will be a productive tool of scientific research. The second was the National Research Council's ad hoc Committee on Space Station Engineering and Technology Development whose 1985 report helped to shape technical aspects of the Program. A third effort is expected to be completed this month. The National Research Council has examined the program and endorsed the Space Station configuration, commenting on transportation, cost and management issues. The Administration will utilize the Committee's analysis in formulating NASA's FY 1989 budget request to Congress.

The result of all this activity is a program that is well defined and, in my view, well conceived. NASA has made the Space Station program a major, priority project. All the field centers have participated, and in devising the program we have tapped the rich experience and extraordinary talents of people in both NASA and industry.

Let me review a few of the Space Station policies that have shaped the program. These policies have guided our overall activities and have given direction to our technical analysis:

- The Space Station is first and foremost a research laboratory. We are building an orbiting laboratory — for the conduct of science, the development of technologies and the stimulation of commercial space enterprises. The Station will support both laboratory sciences and observational sciences. Its architecture incorporates both a manned base and free-flying, unmanned platforms. Men and women representing those who will use the Space Station for research have been participating in the design of the facility and must continue to do so.
- The Space Station is a permanent facility, to be in operation 24 hours a day, 365 days a year. No longer will we simply visit space. We will be there, living and working in space, all the time. This makes the Space Station different from what we have done in the past. The potential is enormous, for humans are the most sophisticated of all machines. By being in orbit for months instead of days, Space Station crews will be able to take full advantage of human creativity, dexterity and perception. And with a significant amount of unmanned, automated systems, the Space Station will optimize the role of its crew. Thus, it will capitalize on the proven capabilities in space of both man and machine.
- The Space Station is a civil endeavor. President Reagan approved the program on the basis of its civil scientific and commercial potential. NASA, the nation's civil space agency, has both the mandate and responsibility to develop our Nation's permanently manned Space Station. Clearly, the

The Space Shuttle will be the primary transportation system for the Space Station. With its unique ability to carry crew and payloads to orbit, and to return them safely to Earth, the Shuttle will be an essential dimension of Station operations. Five Shuttle flights to the Space Station each year are planned, once assembly is completed. These flights are likely to be supplemented with logistics flights using expendable launch vehicles.

Significant progress is being made by NASA in returning the Space Shuttle to flight operations. The goal is safe, dependable and frequent operations that take advantage of the Shuttle's unique capabilities. NASA is targeting the summer of 1988 for resumption of Shuttle flights.

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Courtesy of Boeing Aerospace Company

Station will be a national asset, but there must be no doubt that it will be used for peaceful purposes consistent with our commitment to the peaceful uses of outer space. It may be that in the future the Department of Defense will utilize Space Station capabilities. Their use, like all uses, would be for peaceful purposes.

- The Space Station will have significant international participation. In directing NASA to develop the Space Station, President Reagan invited friends and allies of the United States to join the endeavor. Canada, Europe and Japan responded and much work already has been done cooperatively. At present, we are negotiating formal agreements for cooperation during Space Station hardware development and operations. I am optimistic about their outcome. NASA expects to continue the U.S. tradition of conducting cooperative space endeavors with other countries. In addition to obvious foreign policy benefits, international participation in the Space Station Program means a more capable Space Station.
- The Station must be designed to evolve in time to a more capable system. The Space Station will be in orbit some 20 to 30 years. New requirements will arise during that time. New technologies will emerge. The Station must be able to accommodate them. The configuration we have devised is designed to support such growth. Provision for future increases in power for additional pressurized modules and for more attachment points to support external payloads are built into the configuration. It is essential that they are. We cannot be certain of the exact direction or pace Space Station evolution will take, but we can be sure it will occur.

President Reagan is committed to the development of a permanently manned Space Station. Congress has been supportive, in both providing funds and appropriate guidance. NASA is dedicated to building a Station that, in serving science, technology and commerce, assures for the United States a future in space that is as exciting and rewarding as our past. In cooperation with our partners in industry and abroad, we intend to develop a Space Station that is intellectually productive, technically demanding and genuinely useful.

This article, in edited form, appeared in the September, 1987 issue of ***Aerospace America*** *and is printed here with the kind permission of the American Institute of Aeronautics and Astronautics.*

The Space Station Program

A Brief Look Back

By Terence T. Finn

In January 1984, during the State of the Union address, the President of the United States directed NASA to develop a Space Station. Mr. Reagan said the Station was to be permanently manned, and be developed within a decade. A civil endeavor, devoted to peaceful purposes, the Space Station was to stimulate new technologies, enhance science and applications, and help realize the commercial potential of space. To be operating well into the 21st century, the Space Station was — and is — envisioned to be the flagship of future NASA programs, assuring for the United States preeminence in the utilization and exploration of space.

The contemporary Space Station Program traces its beginning to the statement by James M. Beggs that the Station was the agency's next major goal following the early success of the Space Shuttle. Beggs spoke in July 1981 at Senate confirmation hearings to be the NASA Administrator. In May of 1982, he established a Space Station Task Force. The Task Force, under the leadership of John D. Hodge, spent the next two years defining preliminary requirements for a permanently manned Space Station and developing a conceptual architecture to accommodate these requirements. U.S. industry participated extensively in these two activities via Task Force sponsored Phase A studies. Concurrently, the NASA Space Station Technology Steering Committee established a major agency effort in technology assessment and development.

From the beginning, NASA Space Station Program planning has focused on accommodating users. The Station is, afterall, a research and development laboratory that must enable a variety of disciplines to utilize its unique capabilities. User requirements must be identified, validated and then translated to generic system capabilities, within the obvious restraints of technology, budgets and schedule. Starting in 1983, NASA conducted a number of Space Station user workshops. International user workshops have also been held, the first being in Copenhagen in May 1985. Outside counsel was sought and utilized with the establishment in April 1984 of a Task Force on the Scientific Utilization of the Space Station (TFSUSS). The National Academy of Science's Space Science Board and Space Applications Board contributed advice as well. Within NASA the user focus was reenforced through the establishment of user oriented divisions within the Office of Space Station and of a Space Station Program Chief Scientist. In addition to developing requirements, the user community reviewed Request for Proposals, critiqued configuration analyses, participated in Change Boards and generally participated at all levels in Space Station Program planning.

Systems definition and preliminary design for the Space Station began formally in April 1985 with industry performing extensive 21 month Phase B analyses. Structured around "work packages" and involving key aerospace companies, these studies developed the technical understanding of the Station systems and elements. The products generated by this effort included: a baseline configuration; a functional design; and a plan to proceed into development. Validated by a Critical Evaluation Task Force (CETF) review of Space Station design in the fall of 1986, the NASA – industry Station analysis was further reviewed early in 1987 by the Administration. This led to the adoption of the phased approach to Space Station development and to the Revised Baseline Configuration. These are the subject of the current National Research Council review. They also form the basis of the Phase C/D detailed design and hardware development proposals received from industry this July and now under evaluation by NASA.

Both systems definition and user requirements have been affected by a key parameter of Space Station Program planning: the necessity of providing for Station evolution. As a permanent facility, the Station will evolve in time as new requirements and technologies emerge. Space Station evolution was a concern of the Space Station Task Force and the current design philosophy, in both industry and NASA, retains this focus. Space Station evolution workshops were held in September 1985 and August 1986. Additional workshops are expected to be held in the future.

As expected, the Space Station configuration has evolved in the past five years. Station architecture has remained remarkably constant, but "the design" has changed as tech-

nical understanding matured. In 1983, the Space Station Task Force and its Concept Development Group produced a "planar" configuration. This served as the starting point for the "power tower," the reference configuration utilized in Phase B. This in turn was modified in the summer of 1985 by the dual keel configuration and adopted formally by NASA at the Systems Requirements Review in the spring of 1986. This configuration was reviewed extensively by the Critical Evaluation Task Force and altered slightly. This year, the CETF configuration was changed to a simpler Revised Baseline Configuration with a potential Enhanced Configuration that is similar to the dual keel design.

In directing NASA to develop a permanently manned Space Station, President Reagan invited friends and allies of the United States to join the endeavor. Informal discussions with potential partners had begun as early as 1982 as NASA sought their views on requirements and architecture, as part of the definition effort necessary for a Presidential decision. In June 1984, the Space Station Program was discussed by the leaders of the nations attending the London Economic Summit. International meetings were held in Washington, D.C., in 1984 at which preliminary guidelines for international cooperation were presented by NASA and discussed with officials from Europe, Canada and Japan.

Agreements to set the framework for cooperation in the definition phase were signed in the spring of 1985 with Europe, Japan and Canada. These Phase B agreements provided for parallel preliminary design and detailed definition studies and established a process to identify elements for the initial Space Station which could be developed by the partners. Based on the process established by these agreements and preliminary results of the definition studies, program level agreements were reached in 1986 with all three partners. These agreements identified hardware elements for the Space Station which each partner would carry into development, subject to further formal agreements being reached covering detailed design and development.

Negotiations are presently underway to establish the formal basis for Space Station cooperation with Europe, Canada and Japan during the development and operations phases. Such international cooperation would result in a more capable Space Station. It also would continue the tradition in the U.S. of having mutually beneficial cooperative activities in space.

Congressional involvement in Space Station Program planning has been both extensive and supportive. In addition to providing the funds requested by NASA for the Space Station, Congress — both House and Senate — has provided guidance and direction. The Senate has directed that NASA utilize the Space Station Program to enhance the technologies of automation and robotics. The House has directed that a man-tended concept be incorporated in the agency's planning. Both of these have been done. Congressional interest in Space Station operations and in Station science planning is also high. Since 1984, Congress has required NASA to submit a number of Space Station reports. Among those sent to Congress are a Management Plan and Procurement Strategy in December 1984; a report on Operational Cost Parameters in December 1985; a report on a Man-Tended Approach in May 1986; and a report on Implementing Selected Design Parameters in April 1987.

Space Station Program planning has been a wide ranging and thorough enterprise. Since the President's directive in 1984, substantial progress has been made in a host of areas: user requirements, technology development, systems design, management analyses, international planning. To be sure, the program has not always had smooth sailing. But the years of preliminary analysis have been well spent. The technical understanding of the Space Station is substantial, and NASA — late in 1987 — appears ready to begin detailed design and development.