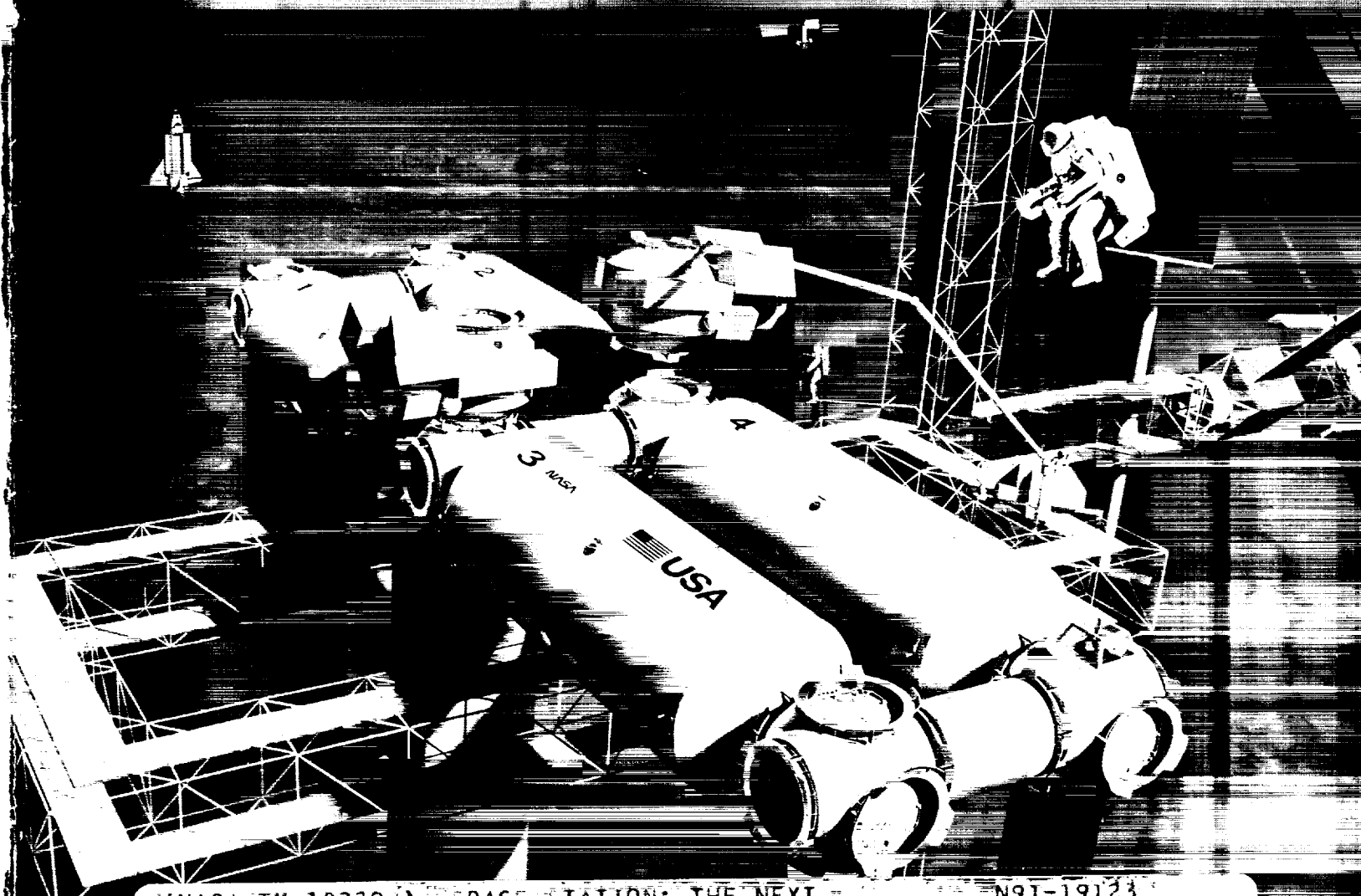
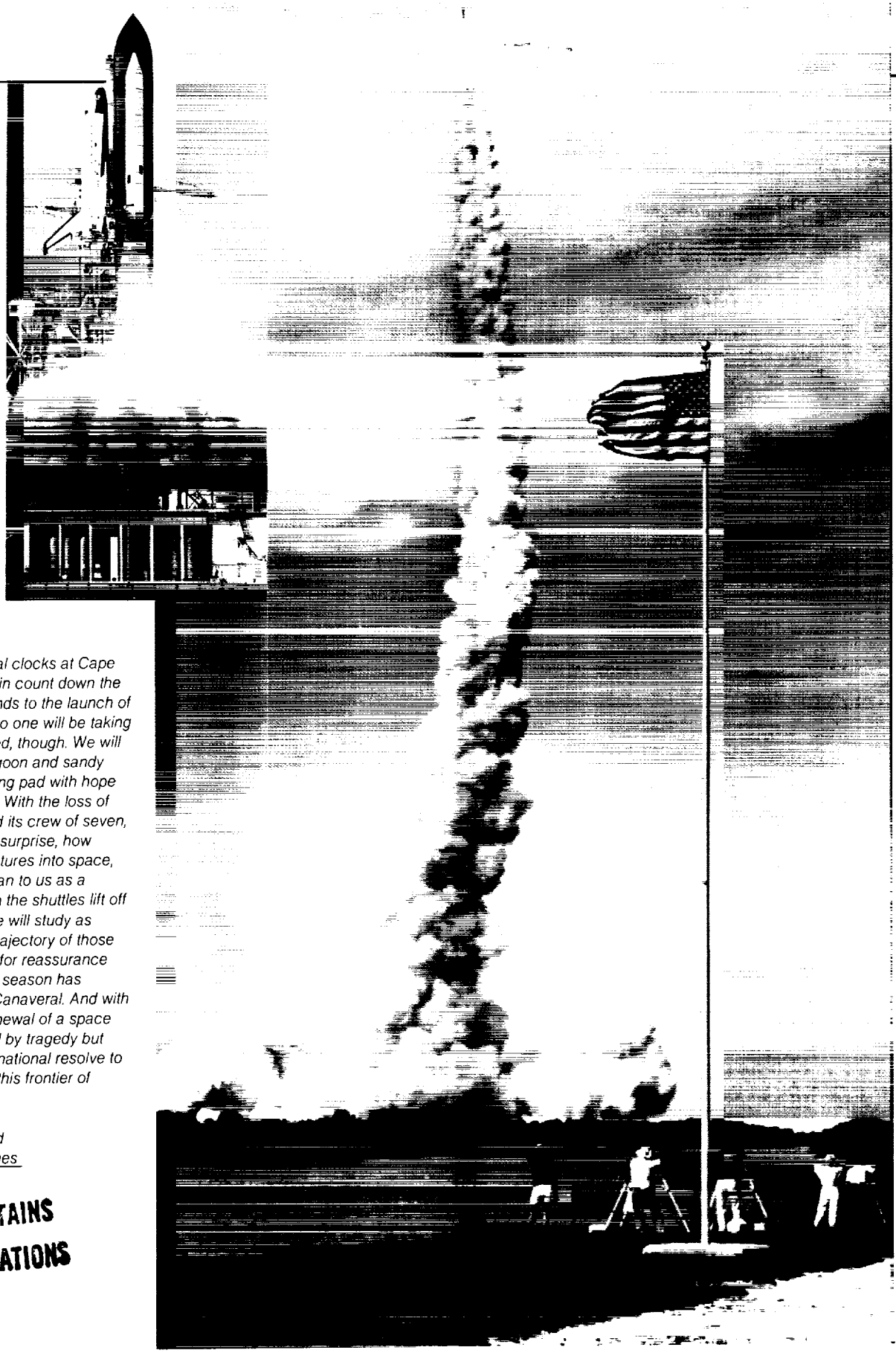
Space Station:
The Next Logical Step

by
Andrew J. Stofan



(NASA-TM-103398) SPACE STATION: THE NEXT LOGICAL STEP (NASA) 12 p CSCL 22B
N91-19123
Unclas
G3/18 0326355

NASA
Space Station



"Someday the digital clocks at Cape Canaveral will again count down the minutes and seconds to the launch of a Space Shuttle. No one will be taking anything for granted, though. We will look across the lagoon and sandy flats to the launching pad with hope and apprehension. With the loss of the Challenger *and its crew of seven, we learned, to our surprise, how much these adventures into space, into the future, mean to us as a people. Now, when the shuttles lift off from their pads, we will study as never before the trajectory of those awesome rockets for reassurance that a new, vibrant season has returned to cape Canaveral. And with it will come the renewal of a space program tempered by tragedy but emboldened by a national resolve to push forward into this frontier of human endeavor."*

John Noble Wilford
The New York Times
March 6, 1986

ORIGINAL CONTAINS
COLOR ILLUSTRATIONS

ORIGINAL PAGE
COLOR PHOTOGRAPH

Space Station:
The Next Logical Step

by
Andrew J. Stofan *

The United States remains committed to the development of a permanently manned Space Station. Recognizing that the Space Station is essential to ensuring American leadership in space during the 1990's and beyond, President Reagan has continued to reaffirm his support for the development of the Space Station, most recently in his 1986 State of the Union address. In the decades ahead, the Space Station will enable us to continue the exploration and use of space, an enterprise in which the United States traditionally has excelled.

A Space Station is both a powerful symbol and a powerful tool. Its value as a means to leadership is evident. The Soviet Union must certainly understand this, for the Russians recently launched the core element of what they say is a modular space station intended to be permanently manned. I believe that such leadership in the years ahead must belong to the United States and that the Space Station Program upon which we've embarked is the best way to secure it. The Space Station was — and still is — the next logical step for our nation in the exploration and utilization of space.

Unmanned Free-flyers

As a permanent facility, with a crew of six to eight, the Space Station will provide enhanced capabilities in space for the United States. The Station will consist of a modular manned base as well as several associated but unmanned free-flyers. By using both manned and unmanned systems, the Space Station will enjoy the substantial advantages offered by both modes of space flight. People will be aboard the Station base, bringing creativity, flexibility, and the human capability to adjust to the unforeseen. Machines will be there too, providing reliability, precision, and the steadfast ability to perform the routine and repetitive as well as the high risk tasks.

The Space Station will be highly versatile. It will be a research laboratory for the conduct of science and the development of new technologies. It will be a permanent observatory enabling us to look down at the Earth and up at the stars. It will provide facilities where new products can be developed and later manufactured. The Space Station will also be a servicing facility for the maintenance and repair of satellites, a storage depot for supplies and a place to assemble large space structures. As the Space Station evolves, it could become a transportation node, a point of checkout and departure for missions to geosynchronous orbit, the planets, and beyond.

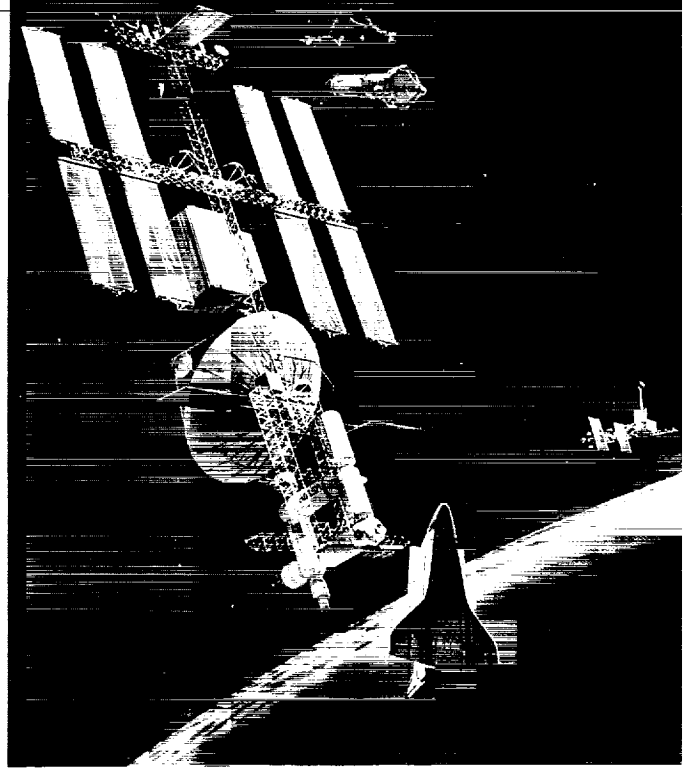
The Space Station is a civil endeavor of the United States. The President approved the program based upon civil requirements and the Department of Defense is not a program participant. However, the Space Station will be an extremely versatile national asset, and NASA believes that in the future it is quite possible that the Department of Defense might well utilize the Space Station's research capabilities.

Recent Progress

Significant progress in the Space Station program has been made in the two and one-half years since President Reagan directed NASA to develop the Space Station. Functional performance requirements have been defined to guide the definition and design of Space Station capabilities. NASA has set in motion a major technology. program in support of Space Station design and operation. A special effort has been initiated to better understand the potential for utilization of automation and robotics (A&R) on board the Station, and a "flight telerobotic system" has been identified as a key way for the Space Station to enhance A&R technologies. NASA and seven industry teams have been conducting extensive system and subsystem analyses and we have completed a Space Station "baseline configuration." In response to a directive by the NASA Administrator, a thorough review of Space Station design and work package assignments was performed.

A Critical Evaluation Task Force reviewed the Space Station baseline configuration in terms of the amount of extravehicular activity required for assembly and maintenance of the Station, launch capacity of the Shuttle fleet when again operational, assembly sequence, and overall technical performance and integrity of the Station. Recommendations made to the NASA Administrator include expanding the size of the nodes which attach the modules together, thereby providing an additional 4,000 cubic feet of pressurized volume, and "stuffing" these nodes with racks of command and control equipment that

**Andrew J. Stofan is the NASA Associate Administrator for Space Station.*



"POWER TOWER" — the picture shown here is an earlier Space Station configuration termed the "power tower." It was used by NASA as a reference configuration in the early stages of the Phase B definition and preliminary design activity.

was either to have been located in the laboratory and habitation modules, or outside on the Station's structure. The Task Force also recommended a revised assembly sequence that would enable earlier scientific use of the Space Station, and would defer some construction tasks until after the laboratory and habitat modules were in place to reduce the amount of time constrained Shuttle-based EVA required to assemble the Station.

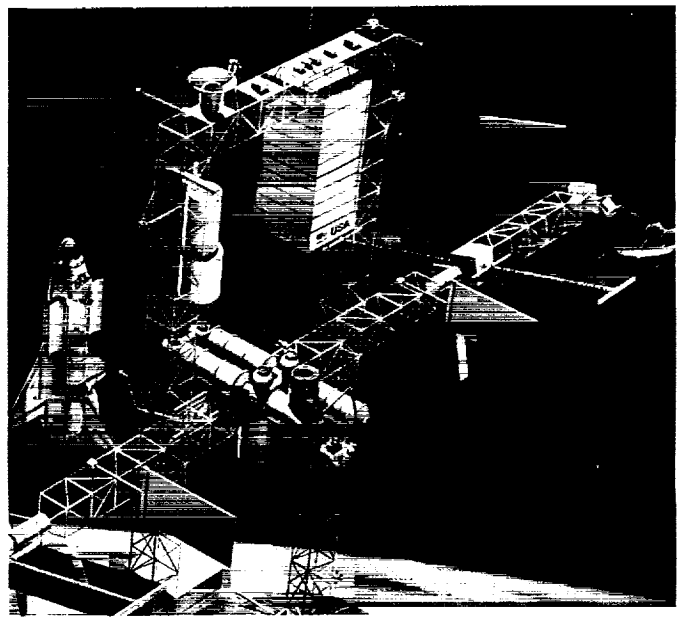
An Executive Technical Committee, under my chairmanship, assessed the impact of these proposed design modifications on the individual NASA centers and contractor roles and recommended the following work package allocations: Responsibility for the laboratory module, habitation module, logistics module and the node structure to the Marshall Space Flight Center; external truss, distributed subsystems, EVA systems, airlock and node outfitting to the Johnson Space Center; platforms, attached payload accommodations, the flight telerobotic system and NASA's role in servicing to the Goddard Space Flight Center; and the power system to the Lewis Research Center. This alignment of Space Station responsibilities is consistent with the expertise resident in the NASA Centers and would retain the principle of end-item accountability so essential to cost control.

We continue to work closely with the special advisory group of scientists established by NASA to provide counsel on how best to realize the scientific potential of the Space Station. An operations management concept is being developed, and a special Operations Task Force has been established to plan the concept's implementation. Agreements have been reached with Canada, Japan and the European Space Agency (ESA) on those elements they will carry into preliminary design.

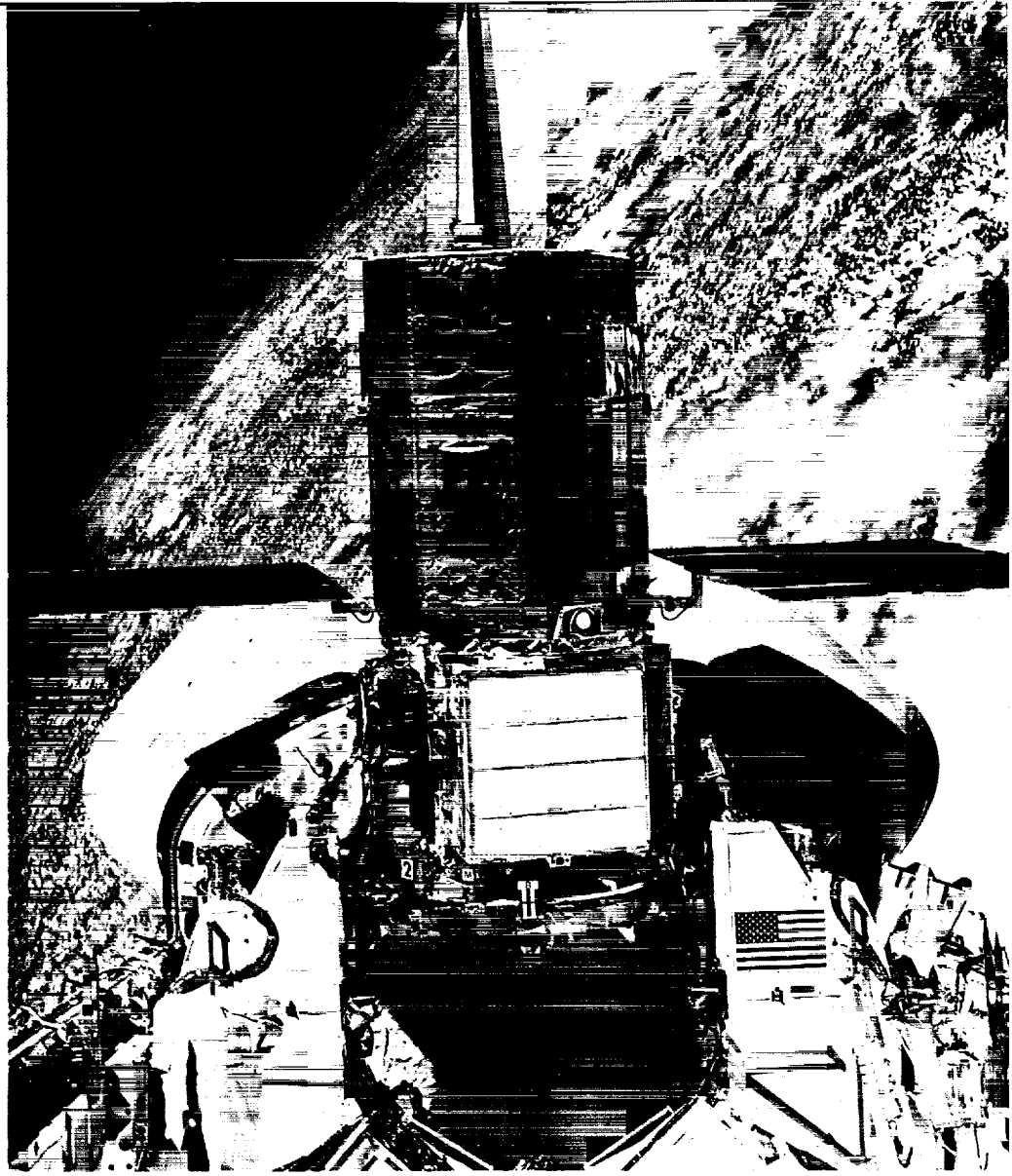
In sum, NASA, industry, and the international partners have made substantial progress in defining this complex program and are now ready to begin detailed preliminary design.

The program plan calls for Space Station detailed design and hardware development to begin in FY 1987. From the start of the Space Station program, NASA has focused its efforts towards initiation of such design and development in FY 1987. Our technology program, our analysis of user requirements, our contractor system definition studies, and our negotiations with the Space Station international partners have all been directed to and based upon this schedule milestone. Industry, the user communities, and our partners abroad also have planned their own Space Station activities on the basis of a development effort beginning next year. This effort would follow the Space Station definition and preliminary design (Phase B), a three year effort that has provided a sound preliminary review of Space Station systems as well as a thorough understanding of the overall Space Station architecture.

This "Dual Keel" Space Station configuration was the result of extensive analysis by NASA and U.S. industry. A design that provides both structural stiffness and flexibility for the user communities, the "Dual Keel" configuration will serve as the focus of Space Station preliminary design activities.



ORIGINAL PAGE IS
OF POOR QUALITY



SOLAR MAX REPAIR — the Solar Maximum Mission Satellite ("Solar Max") is shown here in the payload bay of the Space Shuttle. After the satellite malfunctioned, Shuttle crews retrieved and repaired the spacecraft, which was then redeployed and began once again observing the Sun. The Solar Max repair mission demonstrated again the value of a human presence in space. Maintenance and repair of satellites will be an important Space Station function.

ORIGINAL PAGE IS
OF POOR QUALITY

The Space Station

a laboratory in space

a permanent observatory

a servicing facility

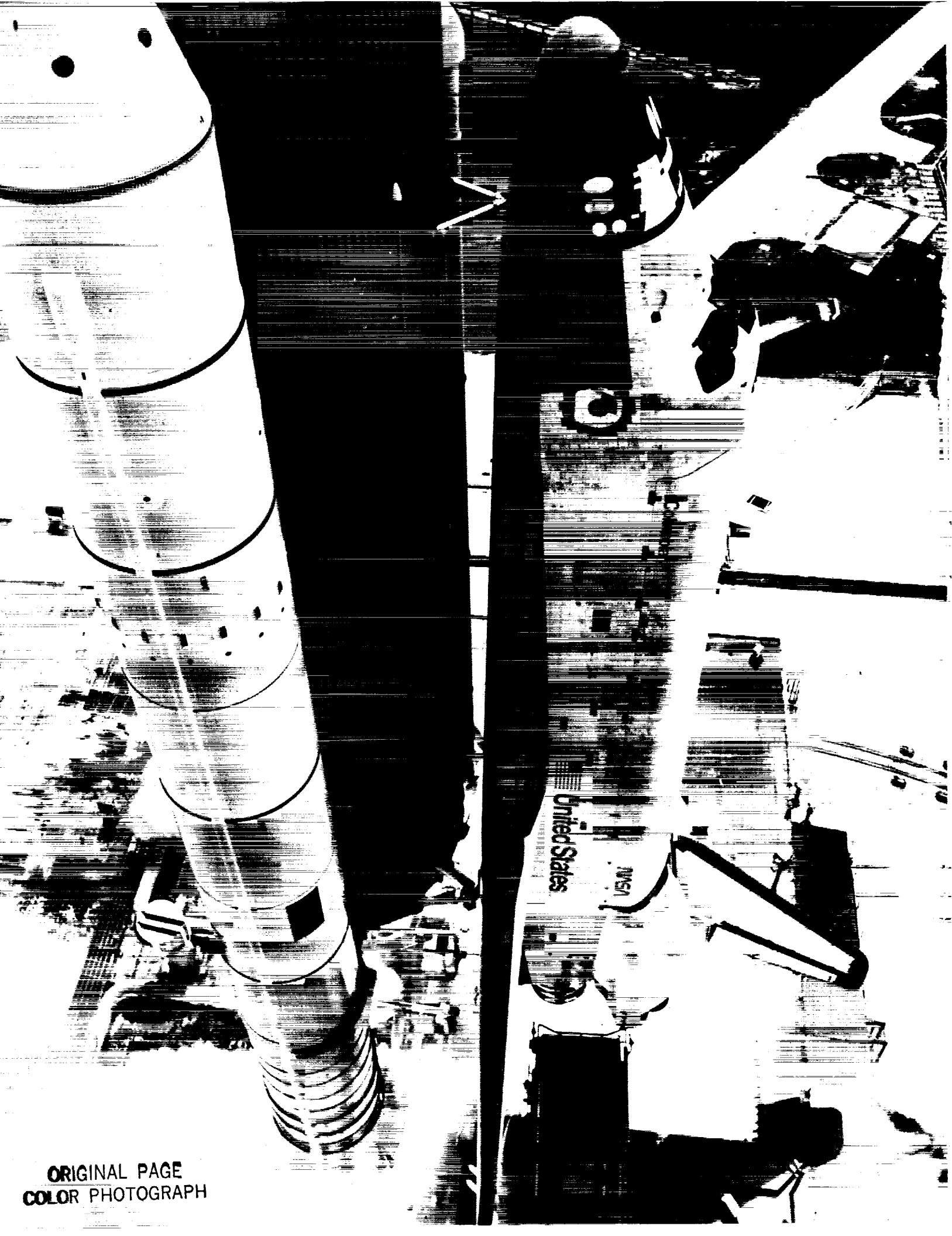
a transportation node

an assembly facility

a manufacturing facility

a storage depot

a staging base



ORIGINAL PAGE
COLOR PHOTOGRAPH

Upon resumption of flight activities, the Space Shuttle will recapture America's preeminee in space and, when the Space Station becomes operational, will provide safe and reliable transportation to and from the Station.

Initiating Space Station development in FY 1987 is extremely important. It will signal to our international partners that the U.S. commitment to Space Station is firm and that their own budgetary and intellectual resources can safely and productively be devoted to a cooperative Space Station Program. It will signal to the U.S. private sector that future investments in commercial space activities can be planned with confidence. Initiation of Space Station hardware development will signal to U.S. industry that the program is on track and that private investment of money and talent is justified. NASA, industry, and our international partners as well as others who anticipate using the Space Station are now poised to begin actual development. Much planning has been done. Substantial resources have been utilized toward proceeding with development in FY 1987.

The Space Station Program plan integrates a wide variety of subsystem engineering, technology development, cost analyses and budgetary projections, international planning, and managerial experience into a coherent whole. The unusually extensive work done so far has made for an exceptionally strong program plan and gives me confidence that NASA and its partners will be ready to initiate development next year. The analysis we have conducted so far as part of Phase B has given us a good understanding of technical Space Station issues. It has also given us a better understanding of managerial issues. In each case, as a result of increased understanding, we are making adjustments. Such adjustments, both technical and organizational, are typical in a program of this scope. By making them now, before we are engaged in detailed design and development and by basing them upon our Phase B experience, we will minimize the likelihood of having to make changes later, during development, when such changes could be extremely unsettling and very costly.

The Space Station Program continues to target 1994 as the time when an orbital capability is achieved. Our definition analysis confirms that such a date is realistic. It also confirms our belief that a useful Space Station can be developed within the constrained budgetary outlook facing both NASA and the nation. During our period of Space Station definition and preliminary design, we are carefully examining the question of Space Station cost and are defining a program to fit within current budget projections. This program assumes that there will be initially one U.S. laboratory module and one U.S. habitat laboratory. The former will be primarily outfitted for materials research. The international partners are also studying elements which would be an integral part of the Space Station. Of course, the Station will be designed from the start to be able to evolve over time so that greater capabilities could be realized in the future.

Space Shuttle

Conceived with a Space Station in mind, the Space Shuttle remains the principal means of transportation to and from the Space Station. An efficient, dependable — and safe — space transportation system is essential to realizing the enormous potential of the Space Station. Beginning in 1993, the Shuttle will lift the Space Station elements into orbit and be used in the assembly and check out of the Station. The Space Shuttle also will bring crews, supplies, and equipment to the Station. Equally important is the Shuttle's unique capability to meet the Station's requirement of bringing payloads back to Earth. Return flights to Earth will carry new commercial and scientific materials made in space at the Space Station. Moreover, equipment and crews that have been in space for several months will be returned to Earth. Only the Space Shuttle can do this. Current U.S. expendable launch vehicles do not have a return capability. Neither does the European Ariane vehicle. The Space Shuttle is the foundation upon which the very concept of a permanently manned Space Station is built.

The loss of *Challenger* makes us all acutely aware of safety and of the absolute requirement that we ensure the safety of both our flight and launch crews. The Space Station will be a safe and reliable system. All of us at NASA and in industry are committed to developing and operating such a system. I have no doubt that we can do so. As a permanent facility, and as one whose flight characteristics are relatively benign, the Space Station poses a unique set of requirements. We will examine a number of these areas, including, for example, the subject of crew rescue and the nature and content of our rescue philosophy. While we cannot entirely eliminate personal risk from the Space Station, we can minimize it and understand it fully.

International Participation

International participation is an important dimension of the Space Station Program. Canada, ESA, and Japan have responded to President Reagan's invitation to join the Space Station endeavor. International cooperation will be extremely beneficial to the Space Station Program. We will have a more capable Space Station as a result, and we will share developmental and operational costs with the partners.

In response to President Reagan's 1984 invitation for U.S. friends and allies to join the Space Station Program, Canada, Japan, and the European Space Agency (ESA), the latter representing ten countries of Western Europe, have conducted considerable analysis of both user requirements and systems definition. Like NASA, they, too,

The Space Station

Why?

Stimulate new technologies

Provide versatile, efficient system for conduct of science

Challenge current Soviet advantage in Space Stations

Ensure leadership in space during 1990's and beyond

Function more efficiently in space, building upon previous national investments and enabling activities now not possible

Develop fully the commercial potential of space

Provide a vehicle for international cooperation in space

Stimulate interest in scientific and technical education

Maintain a continuity and focus to the nation's civilian space program

Provide the basis for those future national endeavors in space outlined by the National Commission on Space

are now poised to begin hardware development. Our three international partners are now conducting definition and preliminary design studies in parallel with our own studies. Last December, each of the partners proposed to study the provision of specific hardware elements for the Station. NASA has responded by indicating which of the proposed elements complement our plans for the utilization of the Space Station, particularly during initial operations.

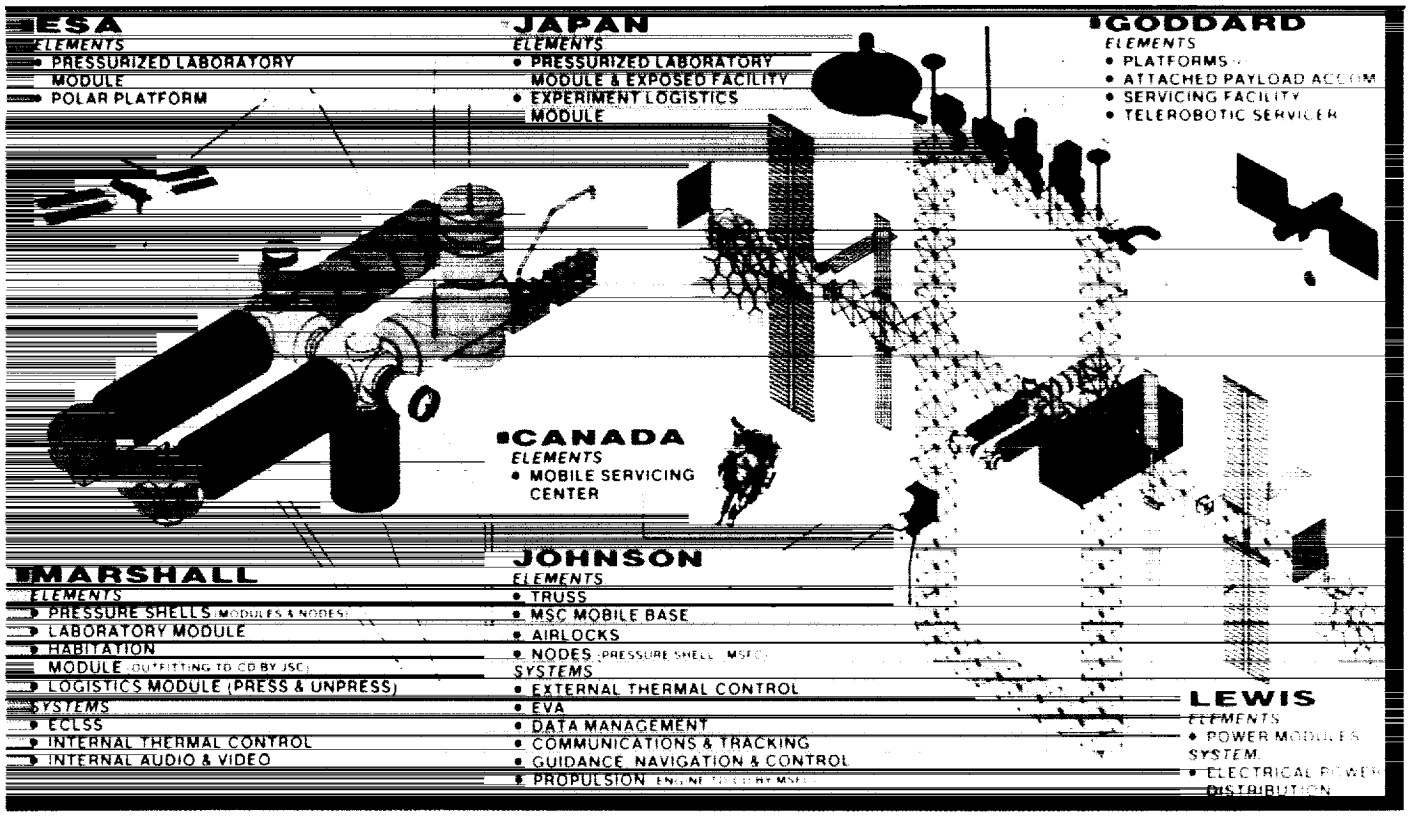
In accordance with the provisions of our Phase B Memoranda of Understanding, we have reached firm agreements with Canada, Japan and ESA for the elements they will carry into preliminary design. Japan will study a pressurized laboratory module with a local manipulator and an external attached workdeck for mounting small to medium-sized payloads requiring exposure to the space environment. This laboratory will be equipped to accommodate general scientific and technology development research activities and to control consoles for monitoring activities at other locations on the Space Station structure. Japan will also study a logistics module for use in resupplying experiments.

Canada's preliminary design will focus on a mobile servicing center which will include the Space Station Remote Manipulator System, a base structure which interfaces with translation capability to be provided by NASA, end effectors, servicing tools, control stations, and special purpose dextrous manipulators. Such a hardware complement would be used to help assemble and maintain the Space Station, as well as help perform maintenance on instruments and experiments mounted on the Station structure. Canada will also perform preliminary design of a maintenance depot for the mobile servicing center which could be used for repair and maintenance and for storing spare parts.

ESA will conduct preliminary design of a permanently-attached pressurized laboratory module and a polar orbiting platform. In addition, NASA and ESA will jointly study a man-tended free-flyer (pressurized module and resource module) concentrating on user requirements and developmental and operational impacts of that element on the Space Station.

To achieve maximum Space Station capability at the lowest cost and with the minimum amount of duplication of effort and resources, we have proposed to our international partners the concept of functional allocation relative to the design, outfitting, and use of the Station. Under this concept, primary areas of the Station will be equipped to optimally perform research for a given function, thereby minimizing duplication of facilities and enhancing the overall capabilities of the initial Space Station to satisfy the maximum range of user needs. In applying this concept, it is essential that all partners have access to all

The Space Station



Space Station facilities, both the manned base and the unmanned platforms. Each partner is being encouraged to provide generic research equipment for use by all. The point we are emphasizing with this concept is a simple one: the Space Station, its platforms, manned base, and logistics complex compose a single system. There is to be one Space Station. We are not going to build a facility consisting of separate national enclaves.

In the months following the baselining of the configuration, which includes the international elements, negotiations will begin, in conjunction with the Department of State, on Memoranda of Understanding between NASA and its Space Station partners for the design, development, and operational phases. Our objective is to have these Memoranda of Understanding concluded prior to the initiation of our own development contracts in 1987 so that international hardware development can be initiated on schedules compatible with those of the United States. Appropriate government-to-government agreements will also be negotiated with the U.S. Department of State, having the lead role in developing these necessary agreements. NASA will, of course, participate heavily in the negotiations.

These agreements will address more than those decisions on which elements of the Space Station each partner will provide. These new agreements will establish long-term partnerships to jointly design, develop, operate, and use the Station over several decades of operation while looking forward to even greater cooperative space ventures in the future. Successful negotiation of these agreements will constitute a major milestone for the Space Station Program.

Science, Commerce, and Technology

Another important dimension of the Space Station Program has been the emphasis given to understanding and incorporating requirements of the user communities. NASA, within the boundaries of technology and resources, is committed to developing a Space Station that serves science, commerce, and technology. From the beginning our focus has been to make effective Station utilization a high priority of our program. In this regard, we have been greatly assisted by the work of the Task Force on the Scientific Utilization of the Space Station, chaired by Dr. Peter Banks of Stanford University. Dr. Banks and his colleagues have provided sound advice and numerous recommendations on how the Space Station and its free-flying platforms can best serve the many demands of space science. It is their view that one of the most important considerations is to deliver a useful facility on the currently envisioned schedule, even if that facility is somewhat less capable than originally conceived. Associated with this consideration, it is equally important,

Space Station Program Plan

Establishes a strong role for NASA in program management

Provides genuine competition among U.S. industry

Supportive of meaningful international participation

Gives strong voice to Space Station user communities

Provides an early focus to operations

Allows for evolution and increased capabilities

Establishes a substantial effort in technology development

Provides for credible cost, schedule, and technical projections through extensive definition phase

Will enable NASA to meet President Reagan's "within a decade" directive

from the Task Force's perspective, that the agency enunciate and implement a plan for evolution of Station capability beyond that which will be available initially.

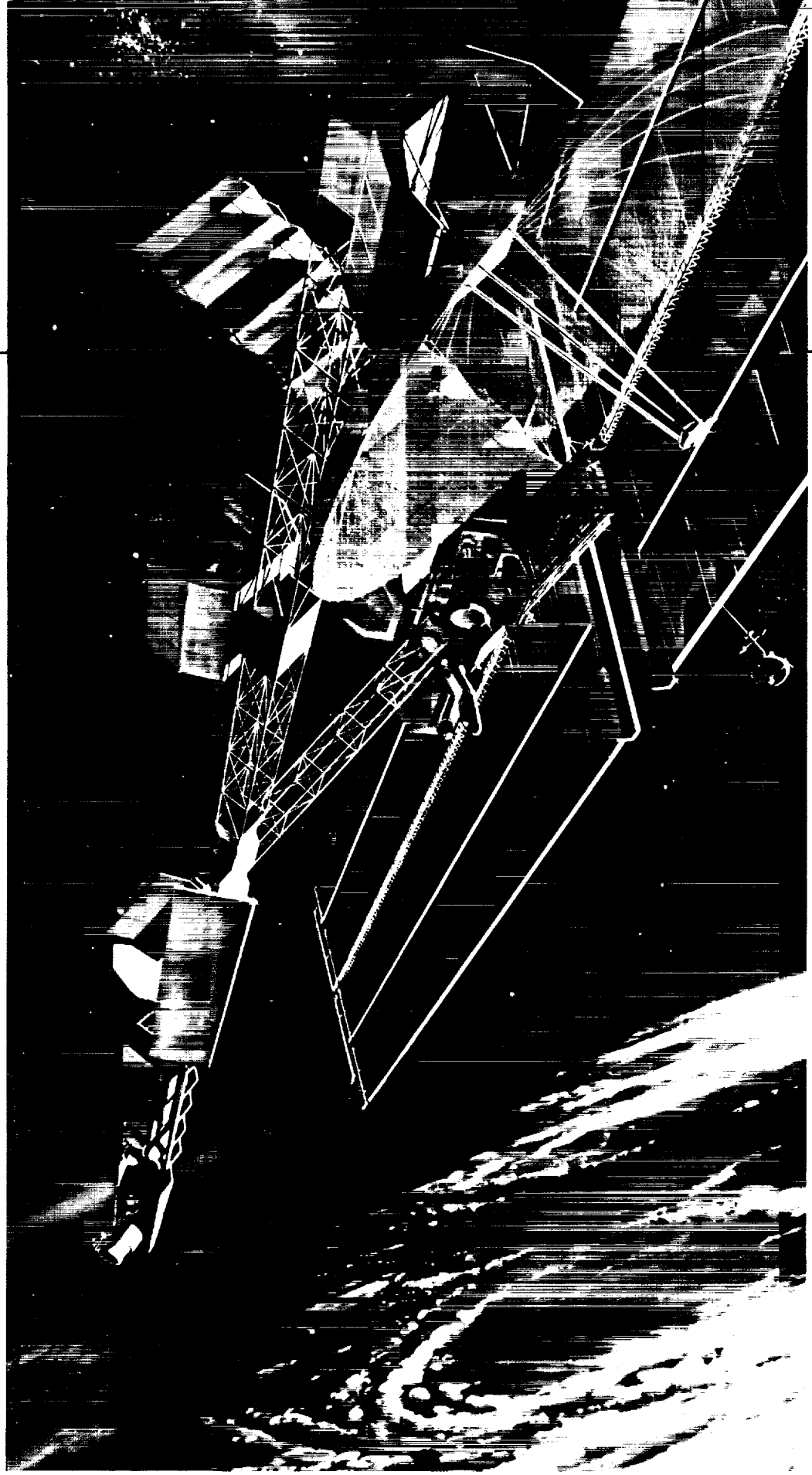
A major NASA goal is to expand private sector investment and involvement in civil space activities. We continue to work closely with NASA's Office of Commercial Programs to realize this goal within the Space Station Program and to seek out those commercial enterprises that might profit from using the Space Station, both the base and the unmanned platforms. During the past 18 months, we supported activities which introduced over one hundred companies to the commercial potential of the Space Station. As a result some two dozen of these companies are currently developing commercial space experiment concepts or are pursuing joint agreements with NASA for commercial ventures. Several major Fortune 500 corporations are funding research to assure readiness to capitalize on Space Station facilities.

Private Sector Participation

In addition to promoting commercial use of the Space Station, we have initiated activities to encourage private sector participation as builders or operators of Space Station systems and services. Entrepreneurs with private funds are encouraged to consider such participation. "NASA Guidelines for United States Commercial Enterprises for Space Station Development and Operation" were released to industry in September 1986. These guidelines have sparked considerable interest in the private sector. We expect to include language in the Phase C/D RFP that could stimulate private sector investment in the Space Station. Our Memorandum of Understanding with Space Industries, Inc., signed on August 20, 1985, on the Industrial Space Facility (ISF) and docking system is another example of cooperation in the possible commercial development of space hardware. NASA and Space Industries, Inc. are exchanging information relating to Space Station and ISF design activities during the definition phase of the program.

Conclusion

The Space Station continues to be the next logical step in this nation's efforts to explore and use the environment of space. It represents a commitment by the United States to leadership in civil space activities. By providing a new capability for the conduct of science in space, the development of new technologies, and the promotion of business, the Space Station will retain American preeminence in space into the next century. As we reexamine the Space Shuttle program, we must at the same time look beyond the *Challenger* accident. Space has been, and with the Shuttle, the Space Telescope, and the Space Station it will continue to be, an arena of unparalleled American success. In space we have gained new knowledge and new technologies. The space program has provided a new dimension to the human adventure and it has instilled in Americans a deep sense of pride. In the 1990's the Space Station will continue and enhance this legacy. As a facility and laboratory in space, its value is extremely practical yet powerfully symbolic. As a program it is about to move into a critical stage. Now more than ever, the Space Station is important to our future and we must move forward as planned.



Platforms are an integral part of the Space Station Program. Such unmanned free-flyers are expected to be co-orbiting with the Station's manned base and to fly in polar orbit as well. User requirements for the Space Station platforms are being studied extensively. These will be incorporated in the "Phase B" systems design work currently underway. Shown here is a picture of what a Space Station platform might look like.

Cover photo courtesy of McDonnell Douglas Astronautics Company.

ORIGINAL PAGE IS
OF POOR QUALITY

NASA

National Aeronautics and Space Administration