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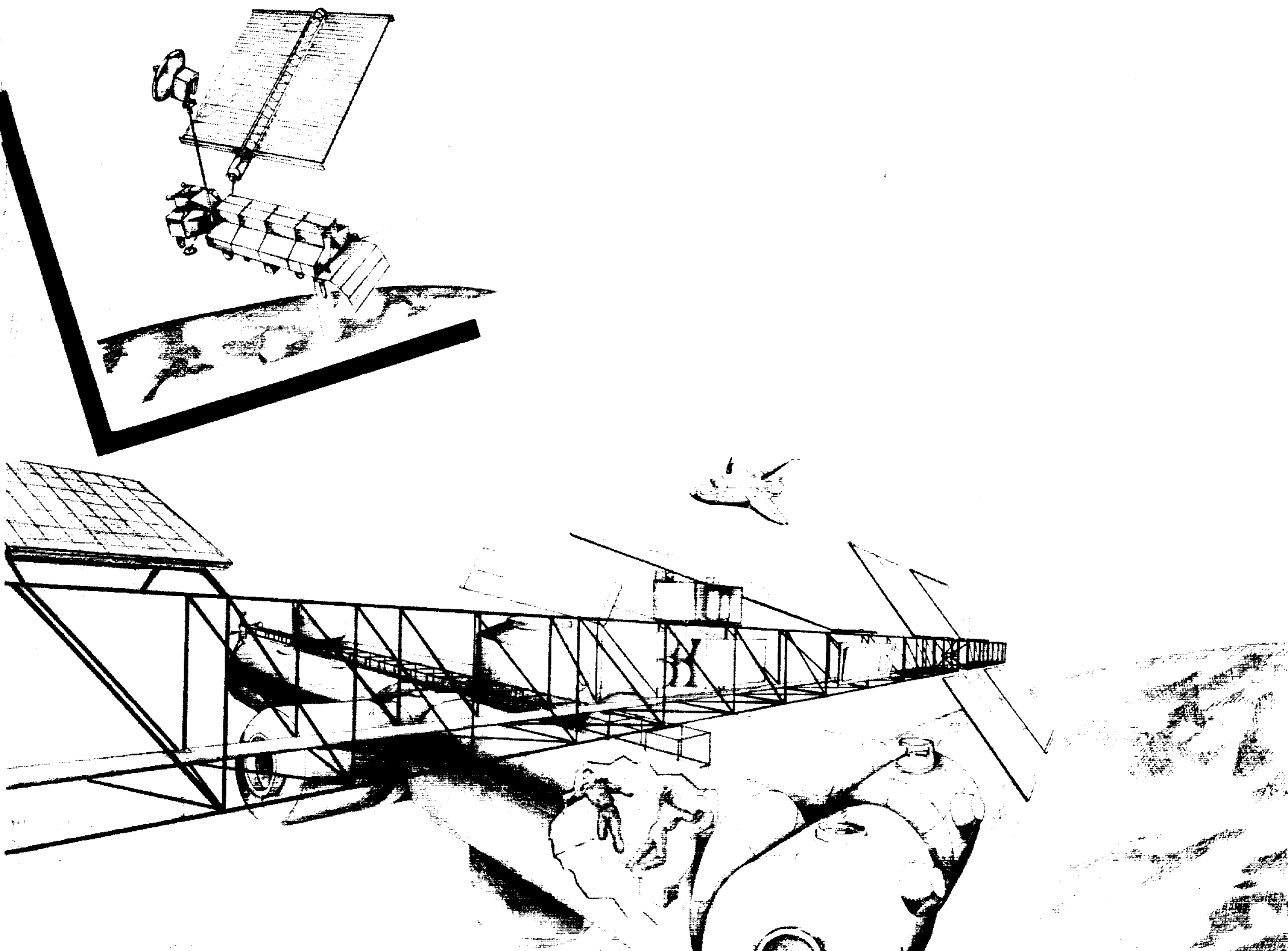
SCIENCE AND APPLICATIONS ON THE SPACE STATION

March 1988



(NASA-TM-101463) SCIENCE AND APPLICATIONS ON THE SPACE STATION: A STRATEGIC VISION (NASA) 18 p CSCL 22B

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A Strategic Vision

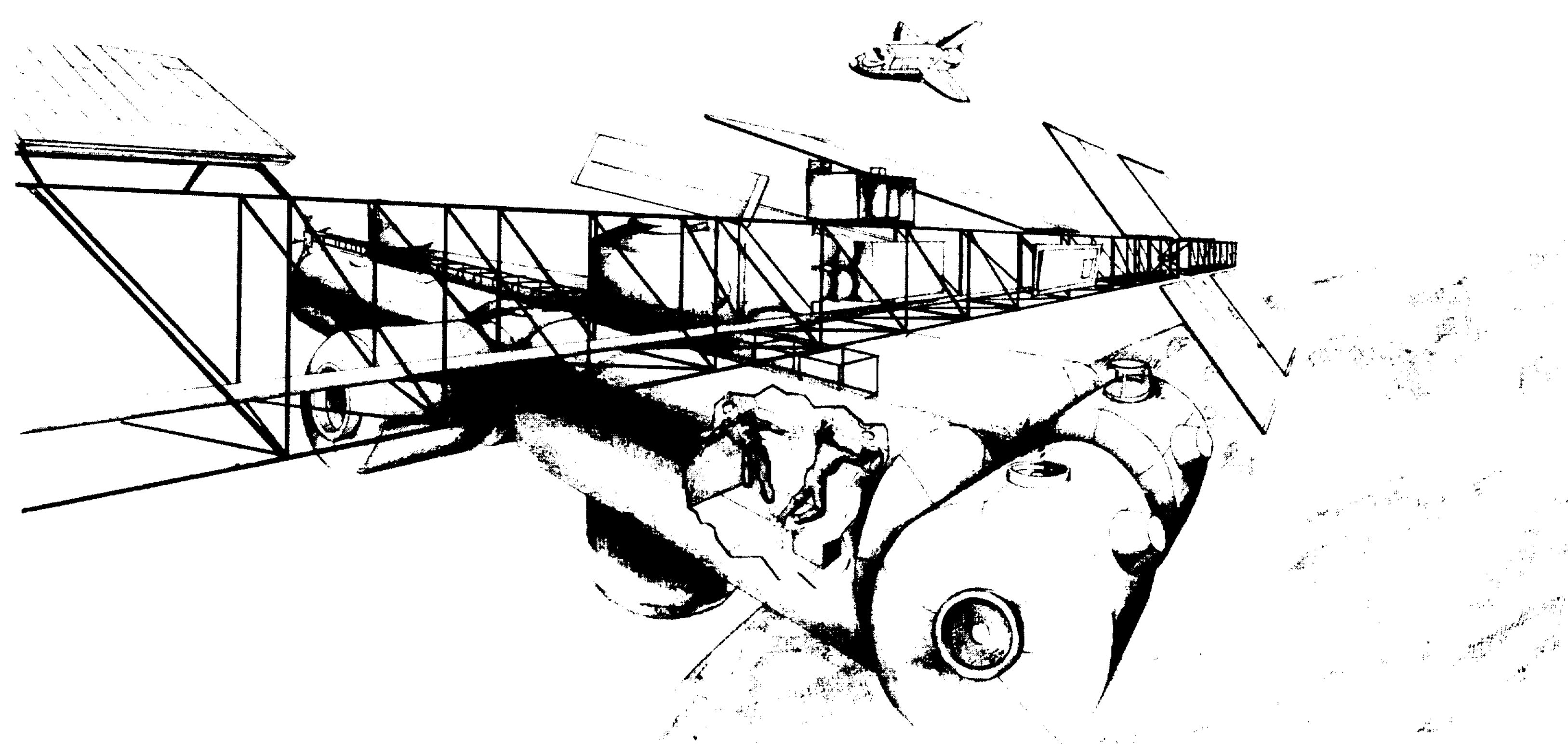
The Space Station program heralds a new era in United States space capabilities. This initiative will not only establish a long-term base for human exploration of the solar system, but will also greatly expand opportunities for scientific research in space:

- The manned Station will furnish an international scientific laboratory for microgravity experiments in materials science and life sciences;
- Polar-orbiting space platforms provided through the program will inaugurate a new generation of global Earth observations; and
- Payloads attached to the manned Station structure will carry out a wide variety of additional scientific investigations.

In the near term, the Space Shuttle, operating with Spacelab, will be essential for the development of Space Station scientific facilities. Operating together in the 1990s, the Shuttle and the manned Station will comprise an integrated system for the conduct of United States space activities in low-Earth orbit.

An Evolutionary Approach to Microgravity Research

This integrated system—the Space Shuttle, Spacelab, and Space Station—will permit an evolutionary approach to microgravity research in space. Before the Space Station commitment, Spacelab research had to be conceived largely as a series of individual experiments, only a few of which could be considered for reflight or continued development. Now Spacelab research may be redefined as an intermediate step in a long-range, evolutionary program of Space Station science. Experiments can be developed on the ground, tested and



refined on Spacelab flights, and ultimately placed on the Space Station for long-duration operation. Such an approach ensures maximum scientific return from planned investigations and encourages the growth of a vigorous microgravity research community. In addition, it is expected to aid in identifying new techniques and processes of commercial value to U.S. ground-based industry.

A Unified Research Program for the 1990s

The Shuttle complements the Space Station program in other ways as well. Shuttle flights will be used to test Earth remote-sensing instruments destined for Space Station polar platforms and to develop payloads scheduled for later Station attachment. In all three areas—microgravity science, global Earth observations, and attached payloads—Shuttle capabilities and Station resources will combine to produce a unified Space Station research program for the 1990s. The FY 1989 budget submission for NASA's Office of Space Science and Applications (OSSA) reflects this new strategic vision.

Related Facilities: The Private Sector

NASA is examining a variety of ways to speed progress toward Space Station scientific program goals. One possibility is the extension of Shuttle flight duration. Another is the use of complementary space facilities developed by the private sector to augment existing Spacelab capabilities. For example, the U.S. Government plans to lease a commercially-developed orbiting microgravity laboratory in the early 1990s. NASA is also considering the use of a commercially-developed pressurized module, to fit in the Shuttle cargo bay and provide additional space for crew-tended microgravity experiments.

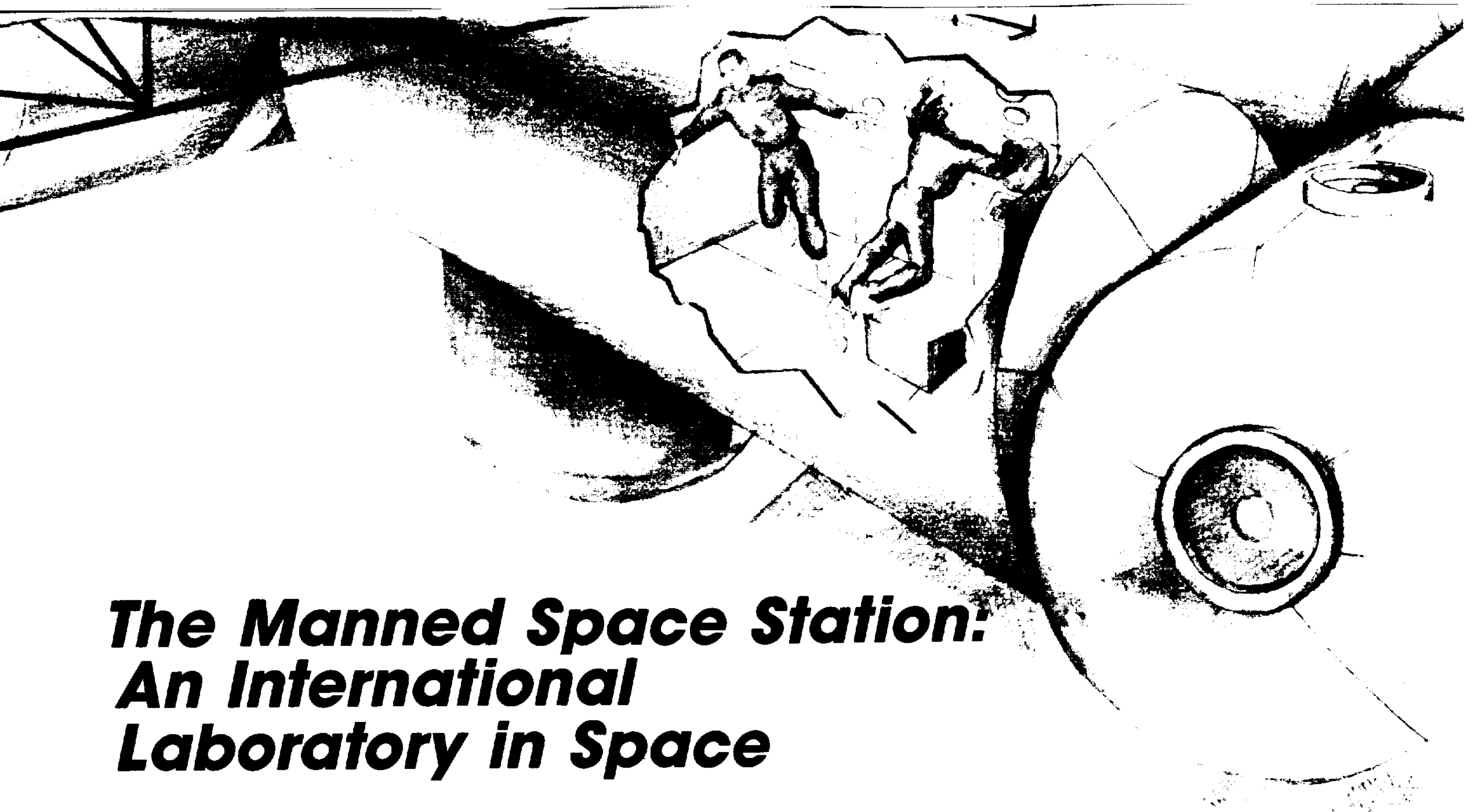
The Space Station Program

The Space Station program will be implemented in phases. Phase I includes the manned Station and two polar-orbiting space platforms.

The Phase I manned Station will incorporate four pressurized modules—two provided by the United States, and one each provided by Europe and Japan. One of the U.S. modules will be devoted to habitation. The other three modules will contain extensive laboratory facilities for experiments in materials science and life sciences, research areas that exploit the microgravity environment of the Station and benefit from human interaction and operation. The Phase I configuration will also provide payload attachment points and some servicing capabilities.

The Phase I polar platforms—one provided by the United States, the other by Europe—will initiate an international Earth Observing System (Eos) for global Earth observations from space. Subsequent polar platforms, designed mainly to carry Eos instruments, are being planned by the United States and Japan. The U.S. platforms will draw upon Space Station technology and will inherit subsystem designs.

Evolutionary program phases could lead to an expansion of the manned Station, the addition of co-orbiting space platforms for a wider range of scientific observations, and provision for more extensive servicing.



The Manned Space Station: An International Laboratory in Space

F*rom the point of view* of research users, the Phase I manned Space Station will constitute an international scientific laboratory in space. Circling the globe at an altitude of 220 miles, the Station will provide full facilities for research in the unique environment of microgravity—the virtual elimination of gravitational effects during orbital spaceflight. The Station external structure will also offer attachment points for payloads devoted to a wide range of scientific observations.

The resident Space Station crew will be continuously available to interact with microgravity experiments. A limited amount of Station and attached-payload servicing will also be done through astronaut extravehicular activity, use of Space Shuttle systems (e.g., the Remote Manipulator Arm), and developments in space robotics and teleoperation that are planned for Phase I (e.g., the Flight Telerobotic Servicer).

A Microgravity Environment for Research and Development

Gravity plays an important role in most scientific phenomena and processes on the Earth's surface. A microgravity environment therefore offers a matchless opportunity to observe fundamental physical, chemical, and biological effects that are otherwise masked by gravitational influences. Brief periods of microgravity may be achieved within ground-based "drop tubes," aircraft, or sounding rockets. However, only orbital spaceflight offers the extended microgravity durations essential for systematic research.

Pioneering microgravity experiments in space during the 1960s and 1970s demonstrated the promise of this field and motivated the present series of Spacelab microgravity missions, which provide up to a week of useful experiment time. In the 1990s, laboratory modules of the manned Space Station will offer microgravity durations of many months for experiments previously tested on Spacelab flights. Some of this research is expected to reveal important applications to ground-based manufacturing and commerce.

Materials Science and Life Sciences

The primary manned-Station research objectives are advances in materials science and life sciences (e.g., plant and animal physiology, gravitational biology, and biotechnology). These are the scientific areas that can most benefit from extensive Station capabilities and from human supervision and interaction. They are also programmatically complementary: by comparison with life sciences, materials science usually requires relatively higher levels of electrical power but lower levels of crew interaction. Experiments in both areas may therefore be advantageously combined in a single Spacelab mission or on the Station.

In anticipation of Space Station research opportunities, an ambitious microgravity research program is planned for 1988 and beyond. For example, missions early in the Shuttle "return to flight" period will carry a number of microgravity experiments as secondary payloads, including an automated directional-solidification furnace, an industrially sponsored study of thin organic films, and a test of red blood-cell aggregation.

In addition to such individual experiments, NASA is also planning major Spacelab microgravity laboratories that can accommodate a range of specialized facilities. Two of these have already been announced:

- Space Life Sciences (SLS) laboratory. The first flight of SLS, in late 1990, will support the most comprehensive suite of biological studies ever conducted in space. Twenty-four complementary investigations of a variety of subjects—including plants, animals, and the Shuttle crew—will explore the effects of microgravity on life and growth. Some materials-science experiments will also be carried.
- International Microgravity Laboratory (IML). Planned for flight in 1991, this OSSA laboratory will offer microgravity research opportunities in materials science, life sciences, and Earth sciences to the international scientific community.

These two laboratories will be flown alternately, allowing experience gained from one to be applied to the other. In addition, NASA plans to develop a new laboratory:

- United States Microgravity Laboratory (USML). Currently planned for initiation in 1992, USML will support materials-science and biotechnology experiments representing a mix of OSSA programs and commercial projects sponsored by industry.

Together, these three laboratories will form the backbone of a systematic U.S. microgravity research program keyed to later utilization of the manned Station laboratory modules. Other nations have also recognized the value of Spacelab flights in the transition to Space Station research; the Japanese SL-J mission and the German SL-D2 mission will each carry numbers of microgravity experiments, including some from U.S. partners.

Opportunities for Attached Payloads

The Station structure will provide an advantageous base for a variety of scientific payloads, particularly those that can benefit from on-orbit servicing. Preliminary studies have revealed many promising attached-payload candidates from a wide range of disciplines. NASA plans steps in 1988 to identify the most outstanding prospects for development and attachment to Space Station during Phase I.

Participation by U.S. Scientific Community

The manned Station will be an international laboratory. To ensure the extensive participation of U.S. researchers, however, it will be operated to the extent feasible like other U.S. national laboratories, such as those dedicated to research in high-energy physics, aeronautics, or astronomy.

In order to achieve this management goal, NASA will seek to provide: (1) ready access to Space Station capabilities for a diverse range of university and industry groups; (2) precursor flight opportunities aboard Spacelab, rockets, or high-altitude balloons and aircraft for promising experiments; (3) timely reflight of experiments that demonstrate outstanding scientific return on Space Station; and (4) a user interface that minimizes technical and programmatic constraints on payload selection, placement, and operation. In pursuing these objectives, NASA will draw extensively upon the experience of both users and management of U.S. ground-based national laboratories.

Materials Science in Space

The earliest materials-science experiments in space, carried out aboard the Apollo 14, 16, and 17 missions, were the first to investigate the effects of microgravity over timescales lasting more than a few seconds. Successive generations of experiments aboard Skylab, the Apollo-Soyuz mission, aircraft and rocket flights, and the current Spacelab series have extended our knowledge of microgravity processes and identified seven broad fields of interest: (1) biotechnology, (2) electronic materials, (3) metals and alloys, (4) glasses and ceramics, (5) combustion science, (6) fluids and transport phenomena, and (7) critical phenomena. All of these fields present opportunities for fundamental research advances, some of which could have landmark impacts on science and technology. Materials-science research in space is also expected to reveal new techniques and processes of commercial value to U.S. ground-based industry. In order to ensure a broadly based research program, NASA will engage the widest possible participation by university and industrial groups. The FY 1989 NASA budget builds on funding initiated by Congressional action in FY 87 and accelerates the implementation of this evolutionary program, with a focus on the development of materials-science research facilities for the Space Station.

Scientific Research Opportunities

Research opportunities in space materials science have been extensively studied for many years. A review recently carried out by an ad hoc committee under the leadership of Nobel laureate J. Robert Schrieffer has provided a definitive blueprint for the program to be pursued following resumption of Shuttle flights and into the Space Station era. The findings of the Schrieffer committee will permit NASA to select experiments of the highest quality for Spacelab flight, ensure that these experiments make optimum use of such flight opportunities, and strengthen the current ground-based components of the program in support of space research. The text below describes three of the many specific research areas that hold particular promise, both for Spacelab experiments and later Space Station investigations.

Materials Science: Examples of Promising Research Areas

Protein Crystal Growth. *Previous experiments have demonstrated the feasibility of growing large protein crystals (up to 1 mm) in microgravity without the formation of multiple seeds, which produce numerous small crystallites that would preclude study by X-ray diffraction techniques. Protein* *crystals grown aboard Spacelab and the Space Station will be large enough, and of sufficient quality, to be studied by conventional crystallography. Once their three-dimensional molecular structure has been determined, these new products may be synthesized on Earth through bioengineering techniques, and steps can be taken to alter, enhance, or eliminate the protein effects in the human body. There are potential applications to the treatment of human diseases and disorders, and to organ transplants and implants.*

Metallurgy. *Fundamental areas of investigation include properties of pure metals, segregation effects in alloy solidification, the microstructure of castings, nucleation and growth phenomena in the absence of container-wall effects, and the process of rapid solidification of highly undercooled melts. For example, the formation of dendrites—whisker-like growths similar to structures found in snowflakes—may be studied in detail. Dendritic growth is an important feature of solidification, with implications for the strength of castings. The high vacuum of space may also be utilized in metallurgical studies. In combination with containerless processing, a vacuum system offers unique opportunities to study metal purification and the basic properties of ultrapure or highly corrosive materials.*

Fluids. *The understanding of room-temperature and cryogenic fluid behavior is a key to microgravity research generally, since nearly all materials are processed in their fluid state. Specific experiments could examine processes and phenomena related to droplet and bubble dynamics, phase transitions, capillary processes, forced multiphase flows, nucleation and cluster phenomena, and electrohydrodynamic effects. Additional fundamental research will provide improvements in measurements of thermophysical properties and furnish data relevant to a wide variety of applications, including liquid propellant storage and transfer, microencapsulation of biomedical materials, meteorology, and the study of planetary interiors.*

National Industrial Competitiveness

Space research has great potential importance to U.S. competitiveness in international markets. Materials science is an area of particular commercial interest. There is widespread agreement that the United States must pursue a vigorous microgravity research program in this area and become ready to exploit new techniques and processes revealed by space experiments. Programs at least as ambitious as those of the United States are already underway in Europe, Japan, and the Soviet Union; they are well planned, well funded, and enjoy substantial political support from their respective governments. The research capabilities of the Space Station, coupled with aggressive U.S. programs in technology advancement and facility development, will allow U.S. researchers once again to compete effectively with other national groups in efforts to increase U.S. competitiveness in the international marketplace.

Materials Science: Participation by Universities and Industry

NASA has long encouraged university and industry participation in space research through Announcements of Opportunity, "Dear Colleague" letters, Joint Endeavor Agreements, Technical Exchange Agreements, and industrial guest-investigator programs. NASA is seeking an even greater degree of private-sector participation for research in the Space Station era. Accordingly, NASA's Office of Commercial Programs is conducting a systematic effort to involve U.S. industry in all aspects of the space program, including the Space Station. In addition, Centers for the Commercial Development of Space have been established in a number of states, and many of them are pursuing microgravity programs. As a result of these efforts, NASA-sponsored research in space materials science is now being conducted at some sixty universities and ten industrial laboratories, as well as at NASA field centers and other government organizations.

Microgravity Facilities for Space Station Research

In anticipation of these interests, six microgravity facilities, listed below with their research objectives, are planned for Space Station utilization and precursor Spacelab flight:

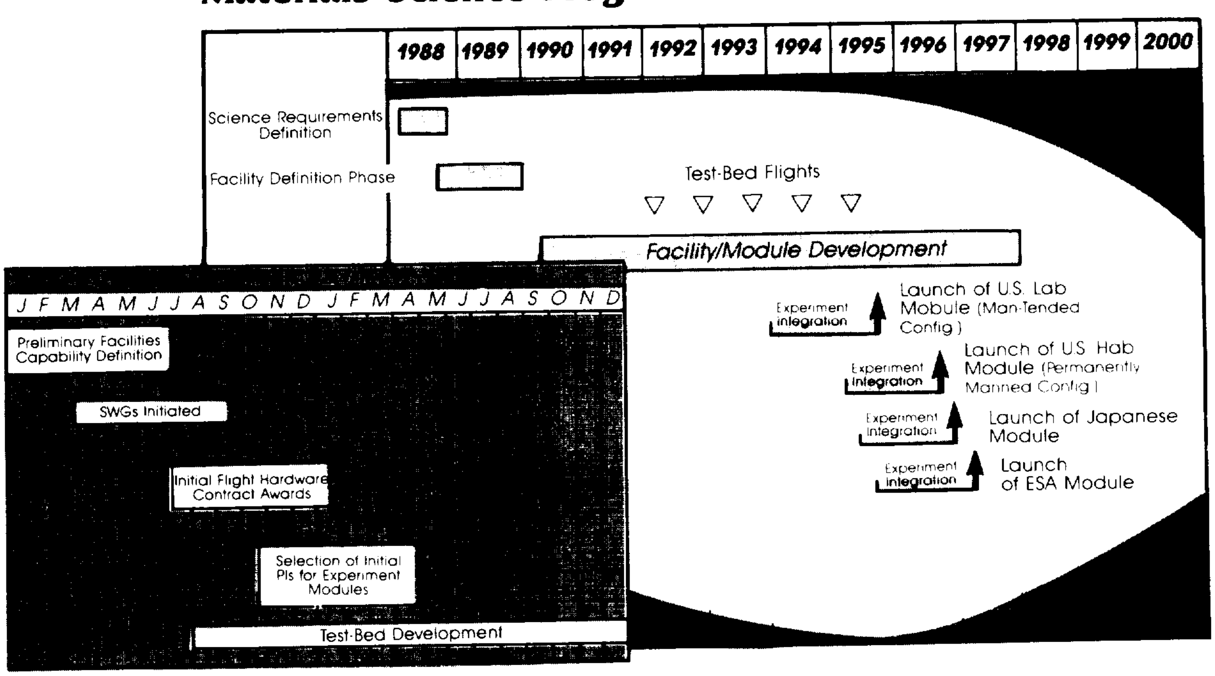
- Biotechnology Facility (BTF). Study of microgravity effects on biological processes and living organisms at the cellular level; enhanced purification and production of biological materials.
- Advanced Protein Crystal Growth Facility (APCGF). Growth of high-quality crystals; pharmaceutical, medical, chemical, and biotechnology applications.
- Modular Containerless Processing Facility (MCPF). Basic support of a wide range of experiments through hybrid-design levitation techniques.
- Space Station Furnace Facility (SSFF). Studies of metal and alloy solidification; crystal growth, with applications to electronic devices; development of materials with unique or improved properties.
- Modular Combustion Facility (MCF). Studies of fundamental combustion processes and phenomena; provision of data for combustion-related applications (e.g., fire safety and control, advanced furnaces).
- Fluid Physics/Dynamics Facility (FP/DF). Further understanding of fundamental fluid behavior; improvements in measurements of thermo-physical properties; provision of data for fluid-related applications (e.g., fluid management in space).

These facilities will be used extensively within the two major microgravity laboratories (IML, USML) devoted largely to materials-science research.

NASA Implementation Plan

The NASA budget for FY 1989 is the first to reflect a specific implementation plan, payload development timetable, and funding allocations for materials science aboard Spacelab in anticipation of Space Station operations. During FY 1989, NASA plans to issue an Announcement of Opportunity or NASA Research Announcement (NRA) for utilization of Space Station facilities for materials science. The chart below outlines the main features of the NASA plan.

Materials Science Program Plan



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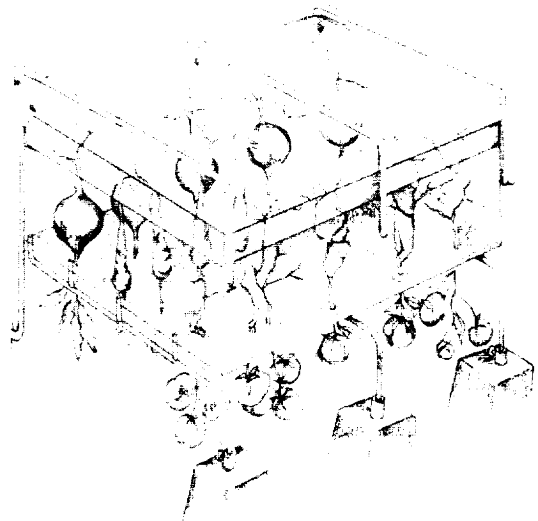
Life Sciences in Space

Life on Earth, from microbe to man, has been shaped by gravitational forces in ways that are only now beginning to be revealed by space investigations. Previous space missions have confirmed a complex interaction between gravity and life, but these have been too limited or constrained to permit authoritative biological research. The manned Space Station—offering controlled examination of a variety of species in long-duration microgravity under the skilled supervision of a resident crew—will present research opportunities unparalleled in the history of the life sciences.

NASA's interest in the life sciences began with the earliest manned missions, when there was little information about the effects of spaceflight on human health and performance. Biomedical investigations will remain an essential component of research in the Space Station era, beginning with the near-term Extended Duration Crew Operations (EDCO) program. Future Spacelab and manned Station research will place space medicine on a sound scientific footing and permit expansion of the envelope of human performance in space.

At the same time, Space Station facilities will permit extraordinary advances in biology. The emergence of life into a microgravity environment will be a momentous instance of evolution in action, analogous to the first emergence of terrestrial life from the sea. Space Station astronauts will oversee scientific studies of life born and raised beyond Earth as part of a comprehensive Space Biology Research Project.

In addition to advancing scientific knowledge, these investigations will have major implications for human habitation and exploitation of space in the next century. The NASA budget for FY 1989 reflects a systematic plan for life-sciences research in space. Implementation of this plan will require the close coordination of NASA field centers, universities, and industry.



Extended Duration Crew Operations (EDCO)

At the present time, fewer than 25 men have spent more than 90 days in space, and no woman has spent more than 10 days in space. The U.S. space program has direct information on long-duration human exposure in space only from the 1974 Skylab program, which provided residence times of 84 days for three astronauts. However, all U.S. and Soviet data confirm that extended microgravity produces numbers of physiological changes, the most important being loss of bone mineral content, muscle atrophy, and cardiovascular deconditioning. In order for human beings to live and work in space for extended periods, these and other dysfunctions must be carefully assessed, so that appropriate countermeasures can be developed.

The EDCO project is designed to provide crucial data needed to meet these objectives, with the goal of allowing operational certification of Space Station crews for flights of 180 days and longer. It will include the development of Spacelab and Space Station medical criteria, clinical and test protocols, instrumentation, and crew equipment.

The Space Biology Research Project

By contrast with EDCO, which is a targeted clinical effort, the Space Biology Research Project will seek to advance our knowledge of fundamental biological processes through systematic variable-gravity research. Four areas will be stressed: space physiology, gravitational biology, controlled ecological life-support systems, and exobiology. A major objective is a deeper understanding

Primary Research Components of the Space Biology Research Project

Space Physiology. *This suite of studies will exploit the ambient microgravity environment, together with the variable gravity produced by specially designed research centrifuges, to examine the physiological effects of gravity on mammalian systems, especially human systems. Experiments will focus on the mechanisms by which gravity influences bone and muscle, fluid and hydrostatic systems, orientation in space, homeostatic control, and response to environment. Results are expected to have clinical applications on Earth (e.g., treatment of osteoporosis).*

Gravitational Biology. *Gravity plays a key role in the development of most, if not all, biological systems. The opportunity to examine microorganisms, plants, and animal species throughout multiple life cycles in a microgravity environment is unprecedented in the history of biology. Experiments will focus on identifying the organ or site of gravity reception; determining the effect of gravity on reproduction, development, maturation, and evolution; and investigating physiological responses. In particular, this program will sponsor scientific studies of life born and raised beyond Earth.*

Controlled Ecological Life Support System (CELSS). *Research on the Space Station will promote the development of a bioregenerative life-support technology for use within the spacecraft. CELSS will investigate the use of biological components (plants and microorganisms) to perform in space the same functions performed on Earth: production of oxygen, potable water, and food from biological wastes. Goals include the development of crops with high yields in microgravity and low-gravity (lunar and martian) environments, assessment of crop productivity, enhancements of crew habitats, and evaluation of CELSS performance characteristics.*

Exobiology. *The Space Station provides an unprecedented opportunity to collect intact fragments of interplanetary dust particles ("fossils" of early solar-system development) and possibly interstellar particles for post-flight analysis. Experimental modeling of gas-grain interactions can also be carried out on the Station, with applications to the study of solar-system formation. This research will provide important clues to the origin of life, particularly the cosmic history of organic molecules from the formation of biogenic elements to their incorporation into living organisms.*

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of the relationship between gravity and life, as revealed through synergistic experimentation across a suite of species ranging from single-celled organisms to human beings.

Facilities in Support of Life Sciences in Space

To support these and other life-sciences investigations, a comprehensive Life Sciences Research Facility (LSRF) is envisioned for Space Station operations. The LSRF, which will evolve through Spacelab, will provide plant and animal habitats, a highly flexible isolation workbench, laboratory equipment, communications and data systems, and other essential research resources. A key LSRF component is the 1.8-meter Centrifuge Facility, planned to support both short- and long-term studies of cells, tissues, plants, and small animals under conditions simulating variable gravitational acceleration. Although servicing and maintenance will normally be performed on orbit, the modular design of the facility will permit components to be returned to the ground for repair and replacement. Precursor testing of the 1.8-meter centrifuge and related program hardware will be carried out aboard Spacelab flights as part of a program to be initiated in FY 89. At an appropriate later time, NASA may seek to add a larger centrifuge to the Space Station to provide a broader range of accelerations.

Life Sciences: Importance to Future of Human Spaceflight

The current era of human spaceflight, barely a quarter of a century old, represents only the initial steps of man into space. There is little doubt of greatly expanded human space activity in the next century. On January 5, 1988, President Reagan approved a revised national space policy that sets the direction of United States' efforts in space for the future. One of the overall goals stated in this policy is:

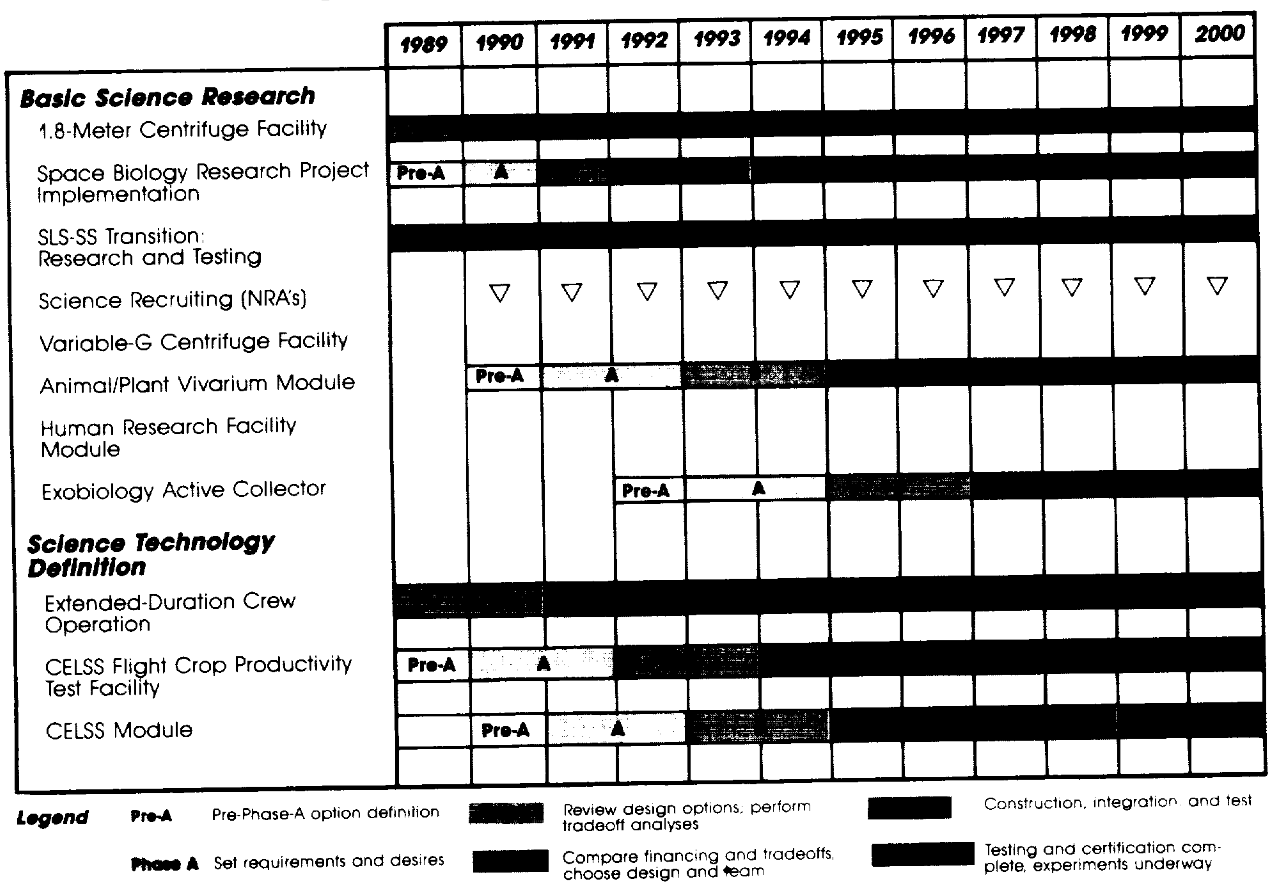
> *"To expand human presence and activity beyond Earth orbit into the solar system."*

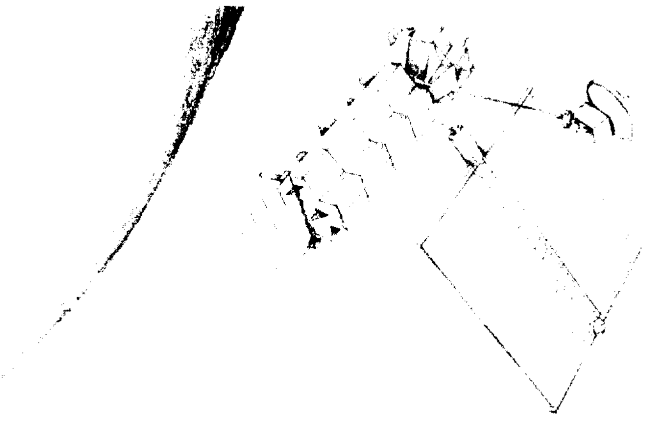
For practical reasons, human space operations will be concentrated initially in low-Earth orbit, where advanced life-support systems and new technology may be most conveniently developed and economically deployed. The Space Station provides a unique opportunity for progress in this direction. It also provides a highly visible United States commitment to the future of human space exploration.

NASA Implementation Plan

The FY 1989 NASA budget provides details of the agency's planning and commitments for an integrated program of life sciences research in space. It includes planning for both EDCO and the Space Biology Research Project in anticipation of later implementation and operations phases. During FY 1989, NASA will also issue a Research Announcement for definition studies of life-sciences facilities for the Space Station and will initiate development of the 1.8-meter Centrifuge Facility. The chart below summarizes the main features of the NASA plan.

Life Sciences Program Plan





The U.S. Polar Platform

There is now strong evidence for global changes in the Earth's atmosphere, oceans, and land surfaces, caused in part by human industrial and agricultural activity. The extent and long-term character of these global trends have generated worldwide concern and led to the initiation of international research programs to investigate their causes and consequences.

Space technology will play a key role in future Earth observing systems designed to study global change. The United States will provide leadership in this area by providing the first polar-orbiting platform to become part of an international Earth Observing System (Eos) in space.

Global Change

Changes in the composition of the Earth's atmosphere are among the most alarming effects that have now been documented. For example, the atmospheric concentration of carbon dioxide is increasing worldwide, largely as the result of fossil-fuel burning. Rising carbon-dioxide levels create a global warming trend by trapping infrared radiation near the Earth's surface (the "greenhouse effect"). According to current climate models, continuation of the present trend into the next century would produce the most disruptive climate change ever faced by organized human societies. The atmospheric concentrations of other greenhouse gases, such as methane, are also increasing steadily.

In addition, the release of man-made chlorofluorocarbons (CFCs) may pose a threat to the Earth's ozone layer, which shields terrestrial life from harmful solar ultraviolet radiation. Once transported into the stratosphere, these industrial chemicals are decomposed by ultraviolet radiation to yield atomic chlorine, a potent catalyst of ozone destruction. The CFCs are now known to play a role in the annual development of the "ozone hole" over Antarctica, and it is feared that they may shortly contribute to ozone depletion on a global scale.

Because of the coupling among the Earth's components—atmosphere, oceans, land surfaces, and biosphere —changes in any one component eventually affect the others, producing effects that are global in scope. The systematic investigation and long-term monitoring of such effects in general require global observations from space.

International Response to the Challenge of Global Change

The study of the Earth is inherently international. Current United States global-change research, which is carried out primarily by NASA, the National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF), with the participation of other agencies, is being complemented by a variety of international research programs in which the U.S. is a participant. The World Ocean Circulation Experiment, the International Satellite Cloud Climatology Project, and the Ocean Drilling Program are representative examples.

In addition, the International Council of Scientific Unions in 1986 endorsed an International Geosphere-Biosphere Program (IGBP) designed to describe and understand (1) the processes that regulate the total Earth system, (2) the changes that are occurring in that system, and (3) the manner by which these changes are influenced by human actions. These and other initiatives demonstrate the commitment of nations around the world to the study of the Earth as a system and to the investigation of global change.

United States Leadership: The Earth Observing System (Eos)

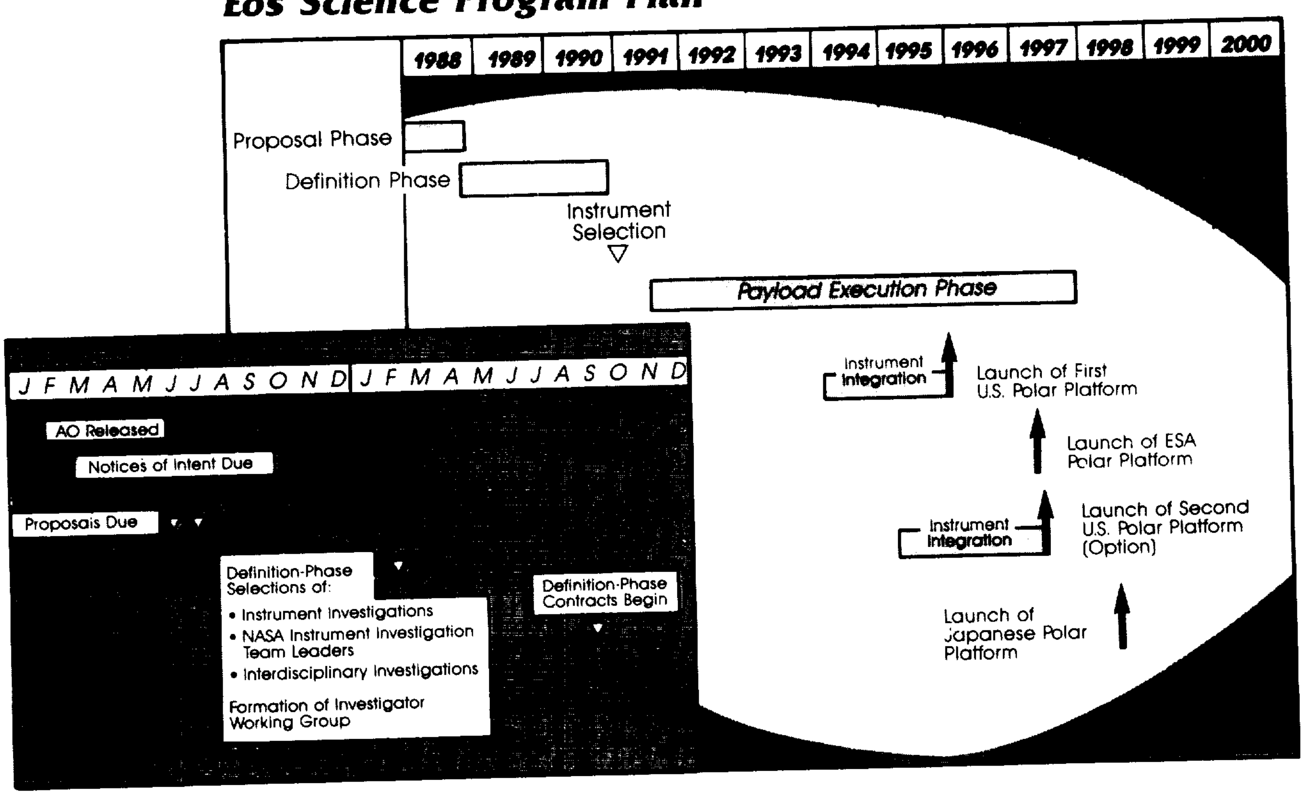
The study of global change requires a series of highly capable space platforms in polar orbit, each designed to accommodate numbers of instruments for simultaneous observations of global variables. The Earth Observing System (Eos), now under study by NASA for initiation in the early 1990s, will provide this observational capability. The U.S. polar platform to be provided through Phase I of the Space Station program is scheduled to be the first of two U.S. platforms for Eos. Additional platforms planned by the European Space Agency and Japan will complement the Eos missions of the U.S. platforms and may carry out other investigations.

As currently planned, Eos will provide for three instrument complements to be furnished by NASA, NOAA, and the agencies of other nations. The NASA instruments will be designed primarily to study the Earth's surface and atmosphere, whereas the NOAA instruments will be devoted to a variety of operational objectives, such as weather observations and measurements of the Earth's radiation budget. Instruments provided by foreign groups will furnish key supplementary data, to which the U.S. will have access. All of the international Eos partners are involving the scientific community in this mission through Announcements of Opportunity (issued in January 1988) to participate in science investigations and instrument development.

NASA Implementation Plan

The NASA budget for FY 1989 includes funding for Advanced Technology Development (ATD) of all elements of an integrated Earth Observing System (Eos) in space. An Announcement of Opportunity for Eos, covering both polar-platform and manned-Station components, was issued in January 1988. The chart below outlines the main features of the NASA plan.

Eos Science Program Plan



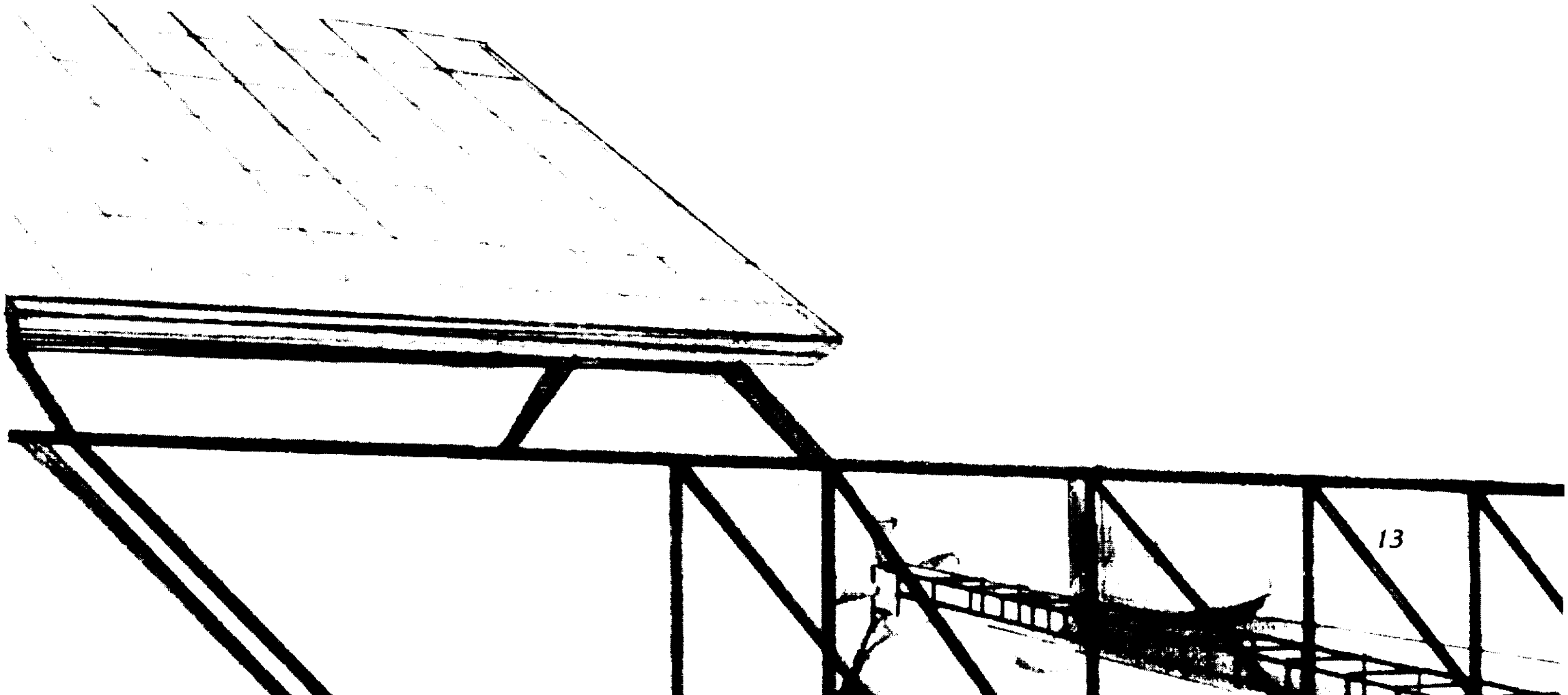
Opportunities for Attached Payloads

The exterior of the manned Space Station structure will provide attachment points for payloads designed to study the Earth and its environment, the sun, other bodies in the solar system, and cosmic objects. Station attachment offers a number of advantages, including provision of electrical power, communications, and some pointing capabilities furnished by the Station itself, together with opportunities for resupply of consumables and instrument exchange by the resident Station crew. These flight opportunities will supplement those provided by dedicated, free-flying satellites, which will continue to be needed by observational disciplines. NASA has already identified many promising candidate payloads that can benefit from Space Station orbit, configuration, and operation.

Examples of Attached Payload Candidates

The OSSA strategy for the utilization of Space Station for attached payloads is evolutionary in nature. Early payloads will not be overly demanding on environmental or precision pointing requirements. While specific payload selections have yet to the made, the following list illustrates the variety of experiments presently being studied for Space Station attachment:

- Plasma Interaction Monitoring System for space plasma physics research and surveys of the charged particle environment that could affect attached payload operation;
- Solar Terrestrial Observatory/Solar Instrument Group for advanced studies of solar features and properties;
- Solar Terrestrial Observatory/Plasma Instrument Group for studies of particle radiation from the sun;
- Cosmic Dust Collector for isotopic, molecular, and structural analysis of interplanetary (and possibly interstellar) dust particles as "fossils" of the primitive solar system;
- Large Area Modular Array of Reflectors for surveys of cosmic X-ray sources at low resolution and high sensitivity;
- Pinhole Occulter Facility for mapping of solar X-rays;

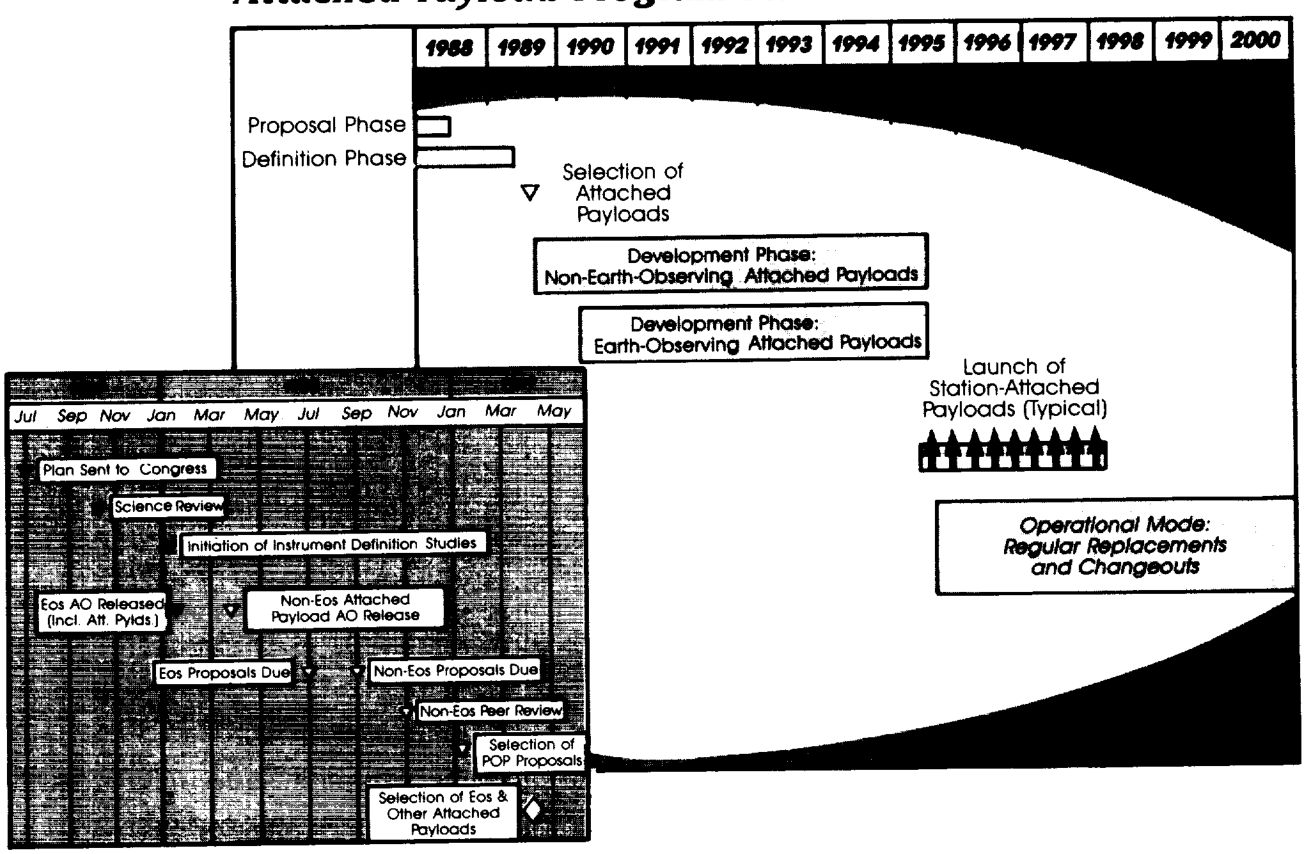


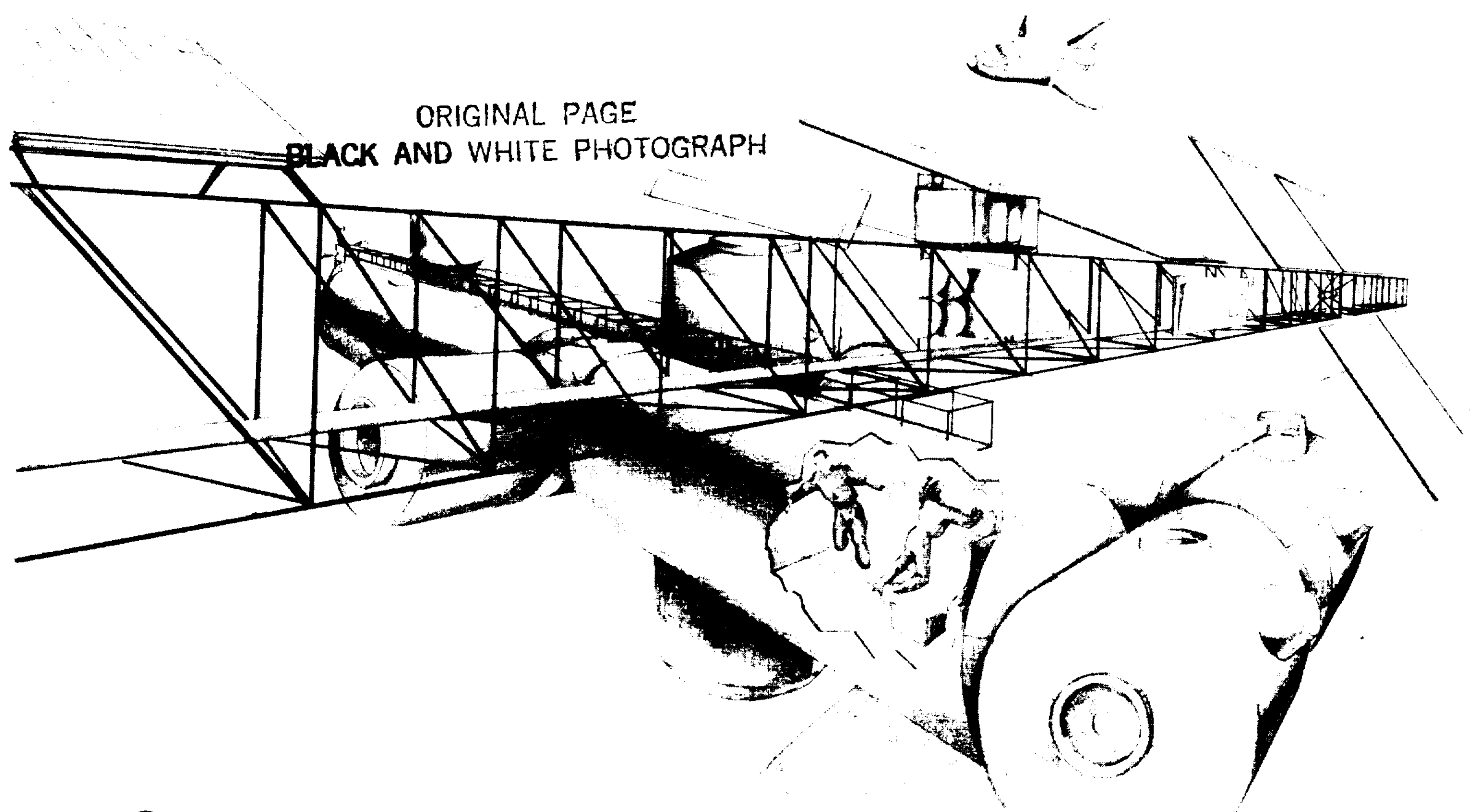
- Astrometric Telescope Facility for accurate stellar position measurements, as part of a systematic program to detect the presence of planets in orbit around other stars;
- Astromag cosmic-ray detector, employing a superconducting magnet to carry out studies of high-energy cosmic radiation;
- Earth Radiation Budget Instrument to continue an important long-term data set on the Earth's global radiation budget;
- Tropical Rainfall Measuring Mission for measurements of rainfall extent and intensity in the tropics, as part of a systematic study of global change;
- Laser Atmospheric Wind Sounder for accurate wind measurements, using advanced laser techniques; and
- Tropical Regions Imaging Spectrometer for low-latitude surveys of the Earth's surface under a wide variety of illumination conditions.

NASA Implementation Plan

Definition studies and advanced technology development have begun for the payloads listed above, and deployment opportunities during the Station assembly sequence are being identified. Continued progress toward payload selection is being ensured through two Announcements of Opportunity (AO's). The first AO, issued in January 1988, concerns instruments for the Earth Observing System and attached payloads for Earth observations. An AO for attached payloads in all other disciplines will be issued during the first half of 1988. NASA will decide upon an initial complement of attached payloads during the first half of 1989. The NASA FY 1989 budget request includes funding for this initial payload complement. The chart below outlines the main features of the NASA plan.

Attached Payload Program Plan





Summary

The following discussion summarizes the central themes relating to science and applications on the Space Station and NASA FY 1989 funding requests for the implementation of this program. At the end of this section is a guide to the location of Space Station-related items in the OSSA budget.

A Strategic Vision

Operating together, the Space Shuttle and manned Space Station will constitute an integrated system that permits an evolutionary approach to microgravity research in low-Earth orbit. Experiments can be developed on the ground, tested and refined aboard short-duration Spacelab flights, and then deployed on the Space Station for long-duration operation. This sequence ensures the maximum scientific return from planned investigations, encourages the growth of a vigorous microgravity research community, and increases the chances for identifying new techniques and processes of commercial value to ground-based U.S. industry. Shuttle flights will also be important for the development of Earth remote-sensing instruments and attached payloads.

The Space Station Program

In addition to the manned Station, which will provide full microgravity research facilities and some servicing capabilities, the Phase I configuration provides for two polar-orbiting space platforms (one supplied by the United States, the other by Europe) that will initiate a new generation of global Earth observations. Evolutionary phases could provide for an expanded manned capability, co-orbiting platforms designed to widen the range of scientific observations, and more extensive servicing capabilities.

Microgravity Research

The principal scientific activity aboard the manned Station will be microgravity research in materials science and life sciences. These are the fields that can most benefit from the extensive capabilities of the Station and interactions with Station personnel.

Materials-science research will be carried out in a wide variety of subfields, such as protein crystal growth, metallurgy, and properties of fluids. These and other investigations are also expected to reveal new techniques and processes of commercial value. The NASA FY 1989 budget request includes funding for facilities essential for the implementation of an evolutionary program in space materials science.

Life-sciences research will include a near-term Extended Duration Crew Operations (EDCO) project, together with a long-range Space Biology Research Project providing for investigations in plant and animal physiology, gravitational biology, life-support systems, and exobiology. Many, if not all, of these investigations are relevant to prospects for future human spaceflight of very long duration. The NASA FY 1989 budget includes funding for a 1.8-m centrifuge and specific planning for the EDCO initiative as well as the Space Biology Research Project and related facilities.

Polar Platforms and the Earth Observing System (Eos)

The Phase I Space Station configuration provides for two highly capable space platforms in polar orbit. The first of these, provided by the United States, will inaugurate an Earth Observing System (Eos) for global Earth observations essential to the study of global change. The second Phase I platform, provided by Europe, will also carry Eos instruments. Additional polar platforms are being planned for later implementation by the United States and Japan. Proposals for the development of Eos instruments were solicited by NASA in a January 1988 Announcement of Opportunity. The NASA FY 1989 budget request includes funding for Eos definition and advanced technology development, in anticipation of a subsequent proposal for an Eos new start.

Opportunities for Attached Payloads

The attachment points provided in the Phase I manned Space Station configuration will permit additional scientific investigations in a wide variety of fields, including solar studies, plasma physics, planetary science, Earth science, and astrophysics. These opportunities will supplement those offered by dedicated, free-flying satellites, which will continue to be needed by observational disciplines. The NASA FY 1989 budget request includes funding for development of the initial complement of attached payloads.

Guide to Space-Station Related Items in OSSA Budget for FY 1989

Physics and Astronomy

Shuttle/Spacelab Payload Mission Management and Integration (for precursor microgravity and life-sciences missions)

Space Station Integration Planning

Space Station Attached Payloads

Life Sciences

Flight Experiments:

— Extended Duration Crew Operations Planning

— Space Biology Research Project Planning

— 1.8-meter Centrifuge Facility

Planetary Exploration

Research and Analysis:

— Attached payload Advanced Technology Development

Environmental Observations

Payload and Instrument Development:

— Earth Observing System Advanced Technology Development

Materials Processing in Space

Microgravity Shuttle/Space Station Payloads

— Microgravity Materials Science Facility Development

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