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DEFENSE DIVISION NOTE

DDN 75-3

CURRENT AND PROJECTED GOVERNMENT AND COMMERCIAL SPACE ACTIVITIES

April 1975

J. S. Patton

Approved by
R. S. Timm

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Abstract

This note is a summary of the growing national and international use of outer space for peaceful purposes by government and commercial activities. Emphasis is placed on (i) the coming use of the Space Shuttle as a lower cost, more efficient space transportation system and (ii) the real and potential benefits that civilian space applications represent in meeting domestic and global economic, energy, and environmental needs. Of special significance are programs incorporating remote sensing systems, such as earth resources and meteorological satellites. The highlights of scientific knowledge obtained from space also are covered. The study concludes by examining the industrial and commercial employment of space now and in the future. This note was prepared to furnish background information in projecting future military exploitation of the space medium.

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Introduction

In the 18 years since Sputnik orbited the earth, use of outer space by governments and commercial firms for nonmilitary purposes has accelerated at a rapid pace.[1] Today, the National Aeronautics and Space Administration (NASA), other US agencies, and a growing number of businesses engaged in telecomunications and other fields are deeply involved in a wide array of space-related activities. On the international scene, many nations are represented in similar governmental and commercial programs, either alone or in concert with other nations. With the advent of the Space Shuttle in the 1980s and with the emphasis being placed on space applications to alleviate mounting economic, energy, and environmental problems, the effort over the next two and one-half decades clearly is destined to dwarf the size and scope of the present multibillion-dollar civilian investment.

NASA Background

NASA came into existence in 1958 and absorbed the facilities, personnel, and policies of the National Advisory Committee for Aeronautics (NACA). Established in 1915, NACA had conducted comprehensive research and testing for US military and civilian aviation and already had been laying a substantial RDT&E foundation for the fledgling space program.[2]

Motivated by the Soviet space challenge and the subsequent moon race, NASA rapidly mushroomed and, at the peak of its Apollo program, employed some 420,000 people and spent almost $6 billion annually on its programs. Today, the agency's annual budget has stabilized at approximately $3.5 billion (with no offset for inflation), and its work force has dwindled to about a fourth of its maximum size. Yet, despite these reductions, NASA is continuing the broad spectrum of activities spawned during the space heyday.

During the past 15 years, NASA's principal effort in terms of resources expended and visible accomplishments has centered around man in space. Following the launching of Alan Shepard into a partial orbit in 1962, the agency progressed from the MERCURY manned shots through the GEMINI, APOLLO, and SKYLAB programs. This summer will witness the APOLLO SOYUZ Test Project (ASTP), in which US and Soviet astronauts will meet above the earth and undertake a number of joint experiments in space.

Also, during 1960-1975, NASA has stressed the scientific exploration of the earth, moon, planets, sun, and the stars. This effort has culminated in recent probes to Mercury, Venus, and Jupiter and has vastly increased man's knowledge of those solar bodies. During the flight of TIROS I in 1960, the earth's cloud cover was first seen from above on a global scale. Since that time, NASA has been conducting an active program of civilian space applications that, in addition to weather, include communications, earth resources, earth and ocean dynamics research, space manufacturing, and pollution monitoring. Its aeronautical and space research facilities have continued to produce practical results in aerodynamics, propulsion, reentry techniques, life sciences, and many other basic disciplines. Finally, NASA has pioneered in the transfer of aerospace technology to civilian users, ranging from government and industry to public consumers.

Space Shuttle and Space Lab

The highest priority program now under way at the agency is the Space Shuttle, in which there is an extensive NASA-Air Force interface. The Shuttle is expected to be operational in 1980 and promises to make space transportation much less costly and more effective. The system features a winged vehicle about the size of a DC-9 and derives its name from its ability to shuttle repeatedly from earth to orbit and back. A partially reusable manned launch system, it will replace most of today's expendable boosters. It will be able to remain in space up to 30 days and carry up to 65,000 pounds in low earth orbit.

The Shuttle offers operational advantages over existing launchers because payloads can be checked out in orbit before deployment. They can be retrieved, repaired, and redeployed in space as necessary, or brought back to earth for refurbishment and reuse. The system will put men in space on a routine basis, not only as members of the crew but also as scientists and technicians conducting experiments, servicing operational satellites, and performing special missions, such as rescue and recovery.

The size—15 feet in diameter and 60 feet long—and weight-carrying capacity of the Shuttle's orbiting vehicle will free spacecraft designers from constraints that have made satellite development very time-consuming and expensive. It will be possible to use relatively cheap construction materials and standard laboratory equipment for many payloads in place of the specially built, highly miniaturized components that have been expensive to develop and test. The availability of check-out specialists aboard the payload capsule should reduce many of the failures that satellites have experienced. When added to the cost saved through the reusable launch components, these advantages are further evidence of the revolutionary potential of the system to provide relatively inexpensive and reliable space transportation.

With these versatile capabilities, the Shuttle in the 1980s will deliver into space virtually all US military and civilian payloads, as well as many of those for international users. Approximately 50 to 80 Shuttle missions yearly are expected to be needed to handle the space payload volume in the coming decade.[3] The breakdown of missions, according to the 1973 NASA Payload Model, is anticipated to be:

Science—Astronomy, physics, life sciences, lunar and planetary missions	34 percent
Applications—Earth resources, communications and navigation, space processing, etc.	35 percent
Department of Defense—Various military-related missions	31 percent

NASA and other nonmilitary users will concentrate most of their flights at Kennedy Space Center in Florida; less than one-fourth of the missions will originate at Vandenberg Air Force Base. The Department of Defense, which relies to a greater extent on polar orbiting vehicles, will use Kennedy and Vandenberg on about a 50-50 basis.

While the Shuttle is capable of transporting payloads up to 500 miles above earth, the system cannot meet the requirement of many missions for higher altitudes and for low orbits which require high energy. To offset this shortcoming, a Space Tug is required. The Tug is a reusable stage that will fit in the Shuttle cargo bay and carry the payload. It will furnish the extra power to put and retrieve payloads in orbits exceeding the Shuttle's capability and to achieve earth escape velocities for transplanetary spacecraft. The Air Force plans to develop an Interim Upper Stage (IUS), or orbit-to-orbit stage, utilizing existing technology and components. The IUS is expected to be operational in December 1980 and will be designed to deliver about 3,000 pounds to synchronous altitude. NASA is developing the follow-on Tug, which will have a retrieval capability not included in the IUS, an on-orbit servicing capability, and a capability for carrying 8,000 pounds to synchronous orbit.

The 1973 Payload Model, referred to earlier, prescribes that 43 percent of the Shuttle missions will require upper-stage capabilities. Of these upper-stage missions, the Department of Defense will need 47 percent, NASA 30 percent, and commercial and international users 23 percent.

A unique international aspect of the Shuttle is the Spacelab, a special pressurized compartment being developed by 10 European countries at their own expense. Spacelab will be carried in the payload bay and will serve as a space laboratory for US and foreign scientists and engineers to conduct a broad spectrum of man-associated experiments and other research. In addition to the manned laboratory module, a separate Spacelab payload or pallet has been developed to support telescopes, antennas, and other instruments requiring direct space exposure. It is being built by European industry under the management of a West German consortium; about $400 million in funds are being provided by the European Space Research Organization (ESRO). Delivery of the initial Spacelab flight unit is planned for 1978.

During 1974, three joint working groups met to plan their respective efforts for utilizing Spacelab. A NASA-ESRO Joint User Requirements Group is considering a wide variety of scientific and application disciplines, including communications and navigation, earth observation, and space processing, in order to ensure that timely inputs are available for Spacelab design. A second Joint Planning Group was established at midyear to recommend experiments for the first Spacelab flight in 1980, which will be a combined NASA-ESRO mission. The third group, the AMPS Working Group, consists of scientists from seven nations and is considering definition of Spacelab missions involving atmospheric, magnetospheric, and plasmas-in-space disciplines.

Space Applications

The year 1975 will represent one of the most active periods of US civilian spaceflight. A total of 28 launches is scheduled by NASA; two-thirds of these will be devoted to satellites carrying payloads related to applications programs. Figure 1 lists NASA's 1975 space launches.

According to the Administrator of NASA, the use of satellites for practical applications has been accepted as a means of providing beneficial services that are economically profitable. Because certain Air Force developments parallel civilian developments, the subject of civilian space applications will be covered in considerably more detail than space science and other NASA programs.

Among space applications, the program receiving top attention at NASA is earth observations, which includes earth resource surveys, weather, and pollution monitoring. The earth observation program has generated widespread governmental and commercial interest, both at home and abroad. The primary reason is that the program is keyed to acquiring information about the earth that can assist in supplying food, water, and natural resources (including sources of energy), in defining acceptable environmental tolerances, and in achieving more reliable weather forecasting. The results obtained to date by the earth resources and meteorological satellites and by associated experiments in the Skylab flights have demonstrated a host of near-term practical benefits, capitalizing upon space technology in general and remote-sensing systems in particular.

Earth Resources

The successful launching of Landsat-2 (formerly ERTS-2) in January 1975 provided a second earth resources satellite in orbit. The first, Landsat-1 is still observing the global surface after more than 2-1/2 years of operation. The orbit of Landsat-2 has been adjusted with respect to that of Landsat-1 to permit coverage of a given area every 9 days; the coverage available with Landsat-1 alone was 18 days.[4] This greater frequency of coverage with remote sensing systems allows closer monitoring of crop growth and of rapidly changing phenomena such as flooding and environmental pollution.

Mission	Description	Launch Date
LANDSAT-2	Second experimental Earth Resources Technology Satellite to test and demonstrate the utility of satellite remote sensing of earth resources, including crop inventories, water resources, etc.	Jan 1975 (Launched)
Synchronous Meteorological Satellite - SMS-B	Second developmental satellite to provide continuous weather observations and help develop an environmental network for routine observations and early warning of storms	Feb 1975 (Launched)
Comsat Intelsat IV F6	Continuation of Intelsat series of synchronous satellites providing commercial global telecommunications service to members of the International Telecommunications Satellite Consortium. Reimbursable.	Feb 1975 (Failed to Launch)
Telesat-C	Third in a series of Canadian communications satellites to provide television, voice, data, and other communications throughout Canada. Reimbursable.	Mar 1975
Geodynamic Experimental Ocean Satellite - GEOS-C	Oceanographic and geodetic satellite to measure ocean topography, sea state, and other features of the earth.	Mar 1975
Comsat Marisat A	Comsat Corporation satellite to provide maritime satellite communications services. Reimbursable.	Apr 1975
Nimbus-F	Experimental meteorological satellite to test instruments for expanding capabilities for remote sensing of the atmosphere.	May 1975
Orbiting Solar Observatory OSO-1	Scientific satellite to investigate a variety of specific features of the sun.	May 1975
Comsat Intelsat IV F1	Continuation of Intelsat series of synchronous satellites providing commercial global telecommunications service to members of the International Telecommunications Satellite Consortium. Reimbursable.	May 1975
Small Astronomy Satellite SAS-C	Third in a series of small astronomy satellites to survey the celestial sphere and search for sources radiating in the X-ray, gamma ray, ultraviolet, and other spectral regions both inside and outside our galaxy.	May 1975

Figure 1 Space Launches by NASA in 1975

Mission	Description	Launch Date
Synchronous Meteorological Satellite/ Geostationary Operational Environmental Satellite - SMS-C/GOES-A	The first operational synchronous meteorological satellite of the National Weather Service of the Department of Commerce to provide continuous day and nighttime global cloud-cover observations. Reimbursable.	June 1975
Apollo/Soyuz Test Project ASTP	The U.S. launch for the joint U.S.-Soviet manned space flight. American astronauts in an Apollo spacecraft will rendezvous and dock with Soviet cosmonauts in an orbiting Russian Soyuz spacecraft to test a new universal docking system and to conduct joint and unilateral experiments.	July 1975
Relativity (Gravity Probe)	Scientific satellite to make a test of Einstein's Theory of Relativity.	July 1975
European Space Research Organization - COS-B	European scientific satellite to study extra-terrestrial gamma radiation. Reimbursable.	July 1975
Comsat Marisat B	A second Comsat Corporation satellite to provide maritime satellite communications services. Reimbursable.	July 1975
Comsat Intelsat IVA-A	First of a series of improved Intelsat Consortium satellites that will have almost double the capacity of the present Intelsat IV satellites. Reimbursable.	July 1975
Viking A	Planetary mission to explore Mars from orbit around the planet and with a capsule on its surface.	Aug 1975
Viking B	Same description as Viking A.	Aug 1975
Armosphere Explorer D	A scientific satellite to investigate the chemical processes and energy transfer mechanisms which control earth's atmosphere.	Sep 1975
Symphonie B	Second joint French/German experimental communications satellite designed for TV, telephone, and data transmission. Reimbursable.	Sep 1975
Comsat Intelsat IVA-B	Second of a series of improved Intelsat Consortium satellites. Reimbursable.	Oct 1975

Figure 1 Space Launches by NASA in 1975—Continued

Mission	Description	Launch Date
Improved TIROS Operational Satellite - ITOS-E2	Operational meteorological satellite of the National Weather Service to provide daytime and nighttime cloud cover imagery. Reimbursable.	Nov 1975
Dual Air Density	Two scientific spacecraft will be placed in orbit to obtain simultaneously measurements of the composition of upper and lower levels of the atmosphere.	Nov 1975
RCA-A	First of a series of domestic communications satellites for RCA. Reimbursable.	Dec 1975
Cooperative Applications Satellite/ Communications Technology Satellite CAS-C/CTS	Canadian-U.S. cooperative experimental communications satellite to develop and test the technology of high-power satellite communications systems.	Dec 1975
Comsat Domestic Communications Satellite - CDCS-A	Domestic communications satellite for Comsat Corporation. Reimbursable.	Dec 1975
Atmosphere Explorer E	A second scientific satellite to investigate the chemical processes and energy transfer mechanisms which control the earth's atmosphere.	Dec 1975
TRANSIT	Optional Navy navigation satellite. Reimbursable.	Dec 1975

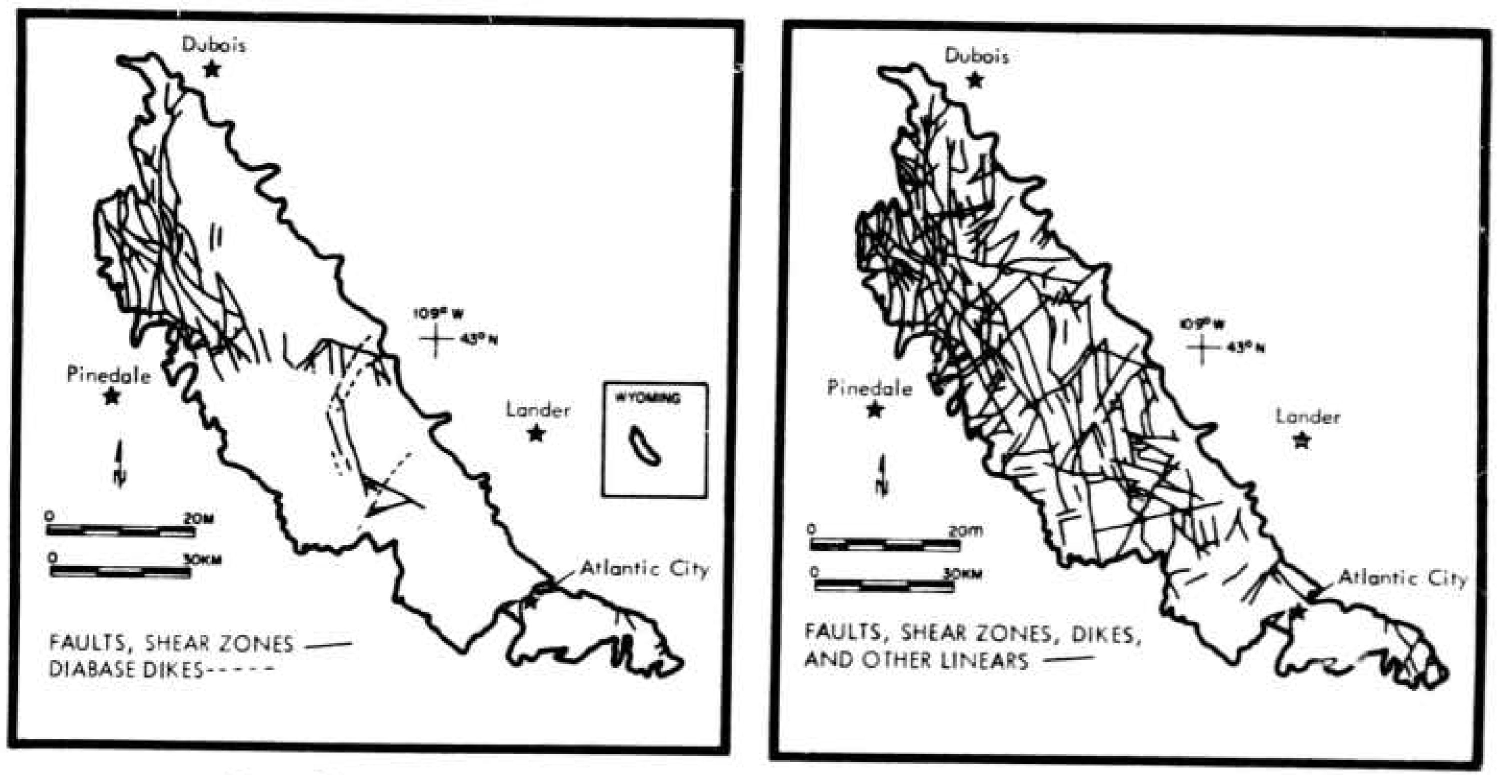
Figure 1 Space Launches by NASA in 1975—Continued

Landsat-3, scheduled for launching in 1977, will have an additional multispectral scanner to detect thermal infrared radiation emitted, for example, by growing crops or by natural and manmade discharges into rivers, lakes, bays, and estuaries. The new satellite will possess twice the resolving power of its predecessors, and thus will permit more precise surveys of urban land use and acreage measurement of crops.

The earth resources effort now is moving from basic experimentation to a phase in which resource managers are directly involved in tests to determine how well the data apply to their respective problems. Emphasis is being placed on comparing Landsat information with data obtained from conventional sources in terms of accuracy, validity, usefulness, costs, and benefits. For example, in investigations related to agriculture, the accuracy of acreage measurement of particular crops already has exceeded 90 percent, and studies indicate that estimating the yield of red winter wheat is feasible. The Department of Agriculture, the National Oceanic and Atmospheric Administration (NOAA), and NASA are engaged in a Large Area Crop Inventory Experiment (Project LACIE). Their purpose is to determine the potential use of Landsat data in crop monitoring and production estimating.

Other examples include water resource management, energy exploration, range management, and extension of the Great Lakes shipping season. The U.S. Geological Survey has introduced Landsat data to help understand and manage critical water resources in South Florida. Oil companies believe earth resource data to be valuable as a first step in discovering petroleum deposits because of an ability to show major fault systems, domes, uplifts, and other geological features. Figure 2 reveals the dramatic increase in knowledge about fractures and other linears as the result of Landsat-1 photography in Wyoming.

Investigators from the Bureau of Land Management, the University of Nebraska, and the Remote Sensing Center at Texas A&M University have concluded that an important indicator of range forage conditions—biomass or density of vegetation—can be estimated accurately through utilizing satellite information. Similar studies of grazing areas in the Sahelian drought regions of West Africa also reveal that Landsat data have direct application in programs designed to alleviate the effects of water and land starvation. The Coast Guard, NOAA, and NASA are cooperating in Project Icewarn, which seeks to lengthen the Great Lakes shipping season through the use of all-weather remote sensing information.



Mapped before ERTS-1

Observed by ERTS-1

Figure 2 Geological Structure of Wind River Range, Wyoming

Weather and Climate

The launching of two synchronous meteorological satellites in the last 8 months provided an operational capability to obtain very precise cloud images over the continental United States and most of the Atlantic and Pacific Oceans, both night and day, at intervals of about 30 minutes. These two satellites will be able to monitor short-lived but severe thunderstorms, such as those that produce tornadoes. The synchronous capability complements the lower altitude satellites that the National Weather Service has been operating for some years. This high-low combination enables the world's weather to be observed on a global, daily basis, with a marked increase of information over the United States and its immediate surroundings.

During the next 5 years, NASA, together with NOAA, the Air Force, and the international meteorological community, will pursue an aggressive program of developing increasingly sophisticated orbital, airborne, and sea-based sensing platforms, plus data integration and global atmospheric research. All these activities are intended to improve short- and long-range weather forecasting. Figure 3 summarizes the broad range of meteorological phenomena under investigation and the more acute weather conditions affecting man's livelihood and even survival on earth. Among the many interesting developments planned by NASA is a Severe Storm Observing Satellite (Stormsat), which, with the current synchronous systems and related programs, is aimed at early detection and warning of catastrophic local storms.

Another new satellite planned is Tiros-N, a polar orbit system to be launched in 1978. It borrows from the technology and hardware of the DOD meteorological satellite, thus reducing costs and development effort. Tiros-N, which will have much more capable sensors than existing low-altitude satellites, also will incorporate a British-developed device for measuring stratospheric temperature and a French system for collecting and releasing data from ground-based platforms.

Polution Monitoring

The third area of the earth observations program is pollution monitoring. Here, the emphasis is on air, water, and,

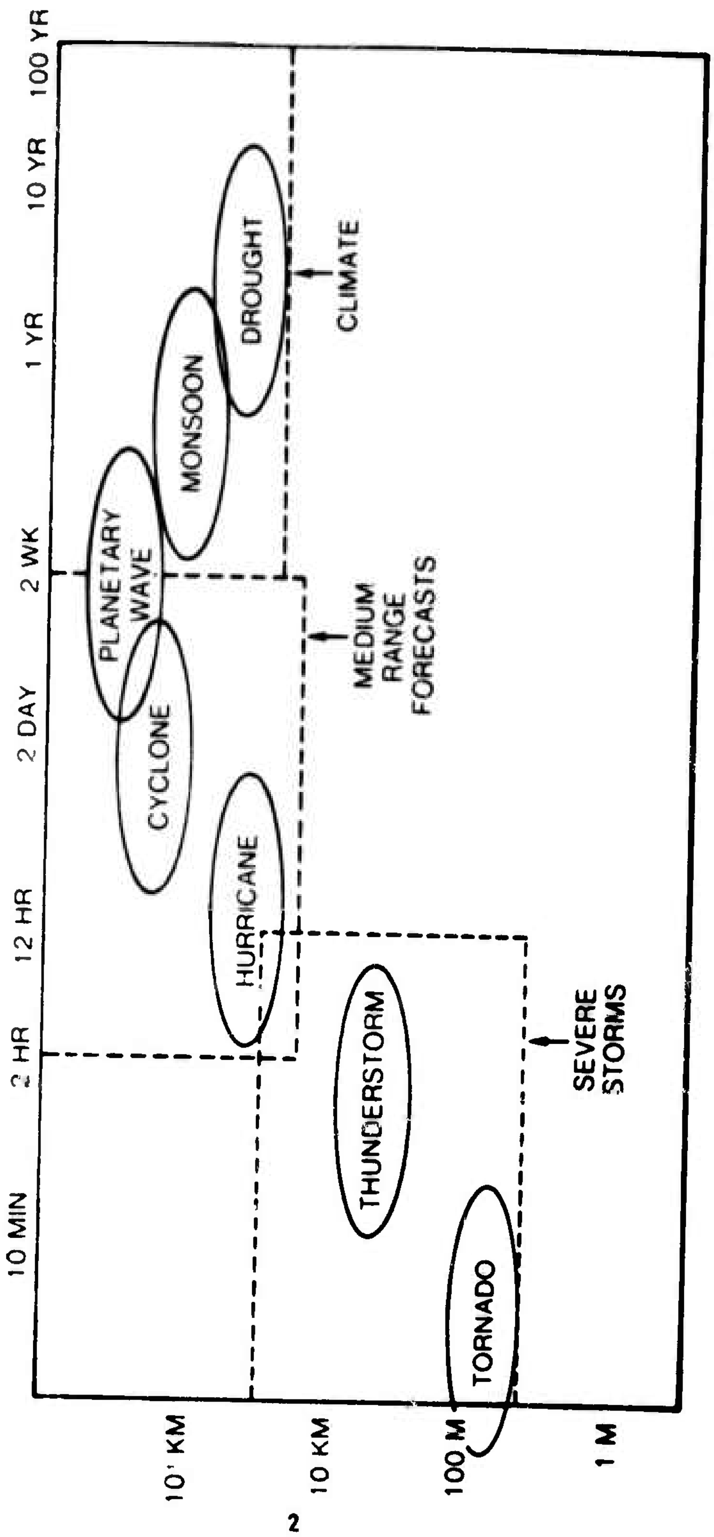


Figure 3 Time and Space Scales of Atmospheric Variability

to some extent, land pollution. Of particular significance is the stratosphere, the region from 15 to 50 miles above the earth. At this point, the sensitivity of the stratosphere to foreign materials introduced into it is not very well understood. Because it contains the ozone shield protecting the earth against ultraviolet radiation from the sun, the stratosphere merits special pollution research. In water pollution, remote sensing techniques to detect quality indicators such as chlorophyll and sediments, as well as the dispersion of waste, are under investigation.

The Nimbus-G satellite, to be launched in 1978, will be the first space system specifically dedicated to measuring pollution in the stratosphere, atmosphere, and water. Also in 1978, one of the small Applications Explorer satellites will carry a Stratosphere Aerosol Gas Experiment (SAGE).

Space Communications

May 1974 saw the launching of the Applications Technology Satellite-6 (ATS-6). This successful development moved space telecommunications beyond the ever-increasing military, civilian, and commercial transmission of messages via satellites into the remote delivery of health care, education, and cultural information to isolated regions. The Department of Health, Education, and Welfare now is using the satellite to broadcast advanced graduate training courses to teachers in Appalachia, career guidance to teenagers in schools throughout the Rockies, and emergency medical care and child education (utilizing two-way television) to remote Alaskan villages. The ability of the large and powerful ATS-6 to broadcast high-quality television to small and inexpensive local receivers will be extended in May 1975 to some 5,000 villages in India after the satellite is moved eastward to a point over Lake Victoria in Africa. A year later, the satellite will be returned to a position over the Western Hemisphere in time for the September 1976 school year in the United States.

Late in 1975, the last NASA communications flight project, the Cooperative Applications Satellite (CAS-C), will be launched as a joint Canadian-US development. CAS-C features a powerful traveling-wave-tube transmitter designed to make satellite communications feasible with small, low-cost ground stations in a 12-GHz frequency band specifically allocated to satellite broadcasting. This effort represents a major technological step forward and could lead to significant commercial uses with resultant economic benefits to US industry. As noted in Figure 4, the Canadian-US satellite is intended to serve a wide variety of users, similiar to those already experimenting with the ATS-6.

Since January 1973, the agency has been refocusing its efforts toward advanced satellite communications technology. This research is concentrating on developments for better use of the available microwave spectrum, such as bandwidth compression, antenna design, multiplexing research, and on follow-on experiments to be conducted in laboratories and on satellites.

Among other communications-related programs, NASA, the Air Force, and the Department of Transportation in 1976 plan joint space search and rescue experiments. The three agencies also are cooperating in studying the role of satellites and space technology for disaster warning and for locating ships and aircraft requiring emergency assistance. Another NASA program with potential military and commercial implications is "teleconferencing as a substitute for travel," designed to reduce travel to management and other meetings. The teleconference network developed for the APOLLO program has been expanded for the Shuttle, and 21 conference rooms at various NASA locations are interconnected via a wideband switching center linked by dedicated circuits for transmitting voice and data signals.

Earth and Ocean Dynamics

The Earth and Ocean Dynamics Applications Program (EODAP) consists of an interrelated series of experimental space systems aimed at understanding more about the movements of the oceans and the earth's crust. Major areas of the program, which utilize the "high ground" of space, are (i) global monitoring and forecasting of ocean surface conditions and (ii) monitoring of motions of the whole earth and its crusts to comprehend the processes that create earthquakes. In the oceanic area, data from satellite observations can lead to optimal ship routing, storm damage avoidance, power plant siting, thermal fish mapping, and other commercial applications. Scientists believe that the physical motions and distortions of the earth leading to earthquakes, tidal waves, volcanic eruptions, and other calamities can be precisely measured from space, even though tectonic plates move only fractions of a meter each year.

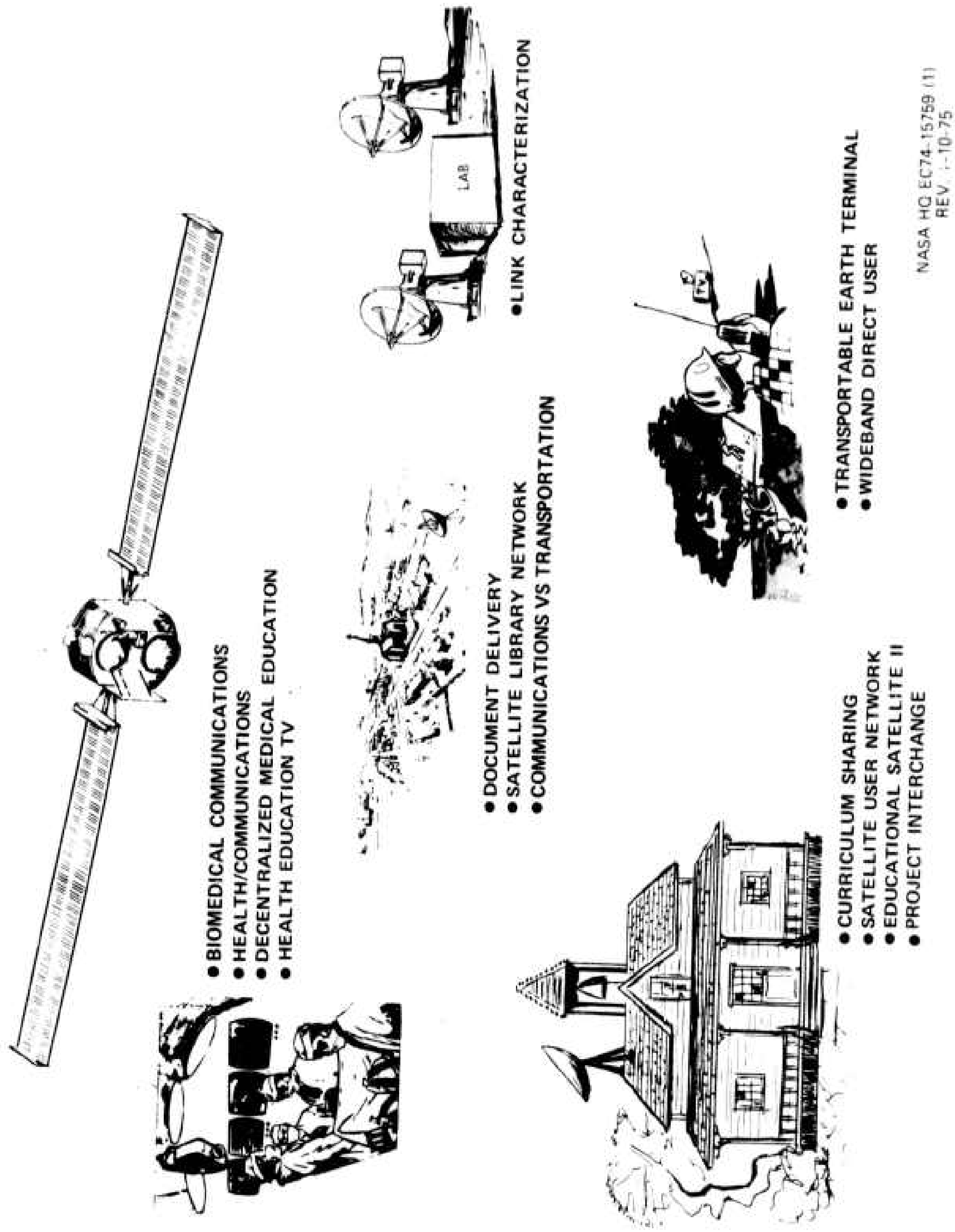


Figure 4 Canadian Technology Satellite (CTS) User Experiments

The present EODAP effort is concentrated in three projects: the Geodynamic Experimental Ocean Satellite (GEOS-C), the Sea Satellite-A (SEASAT), and the Laser Geodynamic Satellites (LAGEOS). The GEOS-C satellite, scheduled for launch in March 1975, will demonstrate the capability of satellite radar altimetry to measure sea surface topography and sea state on a global basis. The Department of Defense and NOAA are cooperating with NASA in this program.

As the first truly oceanographic satellite, SEASAT-A will be capable of furnishing continuous, worldwide, timely data on global ocean dynamics and other physical properties of the seas to a wide community of governmental and private sector users, including DOD, NOAA, DOT, and several other Federal agencies. Figure 5 summarizes anticipated benefits for various Federal Government users of the SEASAT program. SEASAT-A will capitalize on prior sensing developments for satellite and aircraft remote sensing applications, including Skylab and GEOS-C. Launch of the satellite is scheduled for 1978.

LAGEOS, scheduled to be launched into a 3,200-nautical-mile orbit from Vandenberg in March 1976, consists of a dense, half-ton sphere, covered with 426 laser retroreflectors, and associated ground measurement stations. Both the satellite design and orbit have been selected specifically to measure crustal and dynamic motions of the earth. The Lageos project is complemented by three extensive ground experiments, employing both laser tracking and very long baseline interferometry and concentrating on faults in California and the Pacific area.

Space Processing

The primary goal of NASA's program for processing in space is to identify, develop, and demonstrate techniques that take advantage of the space environment so that experiments can be performed and materials produced under zero-gravity conditions. Some believe that the production of vaccines, for instance, can be conducted much more effectively in zero gravity because convection and sedimentation—hindrances to manufacturing viral antibodies on earth—are not present in space. For many years, the pharmaceutical industry has spent millions of dollars annually in research to develop methods for refining and purifying products such as vaccines, sera, enzymes, and blood fractions.

Benefit Area	Major Interpretive Benefit Measurement	Institutional User	Direct User
Gravity Field Mapping			
Ocean Current Dynamics	Ocean Geoid Mapping	U.S. Geological Survey	Homes and Businesses in Earthquake Locales
Earth Internal Dynamics	Tectonic Plate Fine Structure	National Environmental Satellite Service	Any Utilizer of the Environment
Satellite Orbit Determination		Navy and Air Force NASA	
Sea Condition/Weather Forecasting			
Weather Hazard Avoidance	Wind/Wave Interactions	National Weather Service	Maritime Shipping
Route Planning	Storm Growth and Propagation	Fleet Numerical Weather Center	Marine Resource Industries
Extended Operational Times	Water/Ice Contributions to Thermal System		Ocean Recreation
Ice Navigation			
Eased Navigation	Ice Extent/Thickness/Breakup	International Ice Patrol	Arctic Marine Shipping
Extended Season	Lead identification	Army Cold Region Laboratory	
	Iceberg Location	U.S. Geological Survey	
Management of Coastal Resources			
Resource Protection	Resource Location	Army Corps of Engineers	Ocean Recreation
Resource Management	Resource Yield Forecasting	Coast Guard	Fisheries/Aquaculture/Mining/Petroleum/etc.
	Shoal and Coastline Dynamics	National Marine Fisheries Service	
	Transport of Nutrients, Pollutants, etc.		
Ocean Research			
Global Climatology	Ocean Currents and Circulations	NOAA	University and Private Ocean Research Institutes
Global Ocean Dynamics	Air Sea Interactions	Navy	
	Wave Propagation	NSF	Man

Figure 5 Benefits for Users of SEASAT Program

The Skylab missions showed that basic and applied materials research in space is highly promising, particularly for developing products that possess unusual properties and purities. These include specific types of living cells and other biologicals for medical use; high-quality crystals and materials for electronic applications; new types of optical glass; ultra-pure metals and ceramics, and materials with controlled properties for specialized optical, magnetic, and structural applications. The capability to manufacture materials with these properties and purities for industrial and commercial use requires low-cost, easily accessible processing facilities in orbit, such as the Shuttle will furnish.

The potential of space processing for commercial and industrial applications and for zero-gravity research may be deduced from a recent projection that, by the year 2000, the vaccine industry alone expects to be doing $12 billion in annual business. An additional market of $2 billion for viral insecticides for the year 2000 also is forecast.

Shuttle Applications

The capability of the Shuttle to serve as a manned processing facility in zero gravity exemplifies other generalized uses for the reusable, returnable platform. The Shuttle will provide for the synoptic viewing of large areas of the earth, its atmosphere, and its environment. Two such cases are the making of detailed, highly accurate measurements of atmospheric composition over selected regions and the mapping from space of sources of communications interference from ground or space sites. The second case will be complemented by experiments attempting to identify regions of the radio spectrum that are most effective for communications.

Another broad use is to fill the need for an orbiting development facility. In this space environment, final proof of concept and optimization of flight systems can be tested before they are placed in long-duration, automated spacecraft. Figure 6 illustrates a large deployable antenna that can be tested in space with the Shuttle, thus eliminating the uncertainties of ground simulation and infrequent spaceflight opportunities.

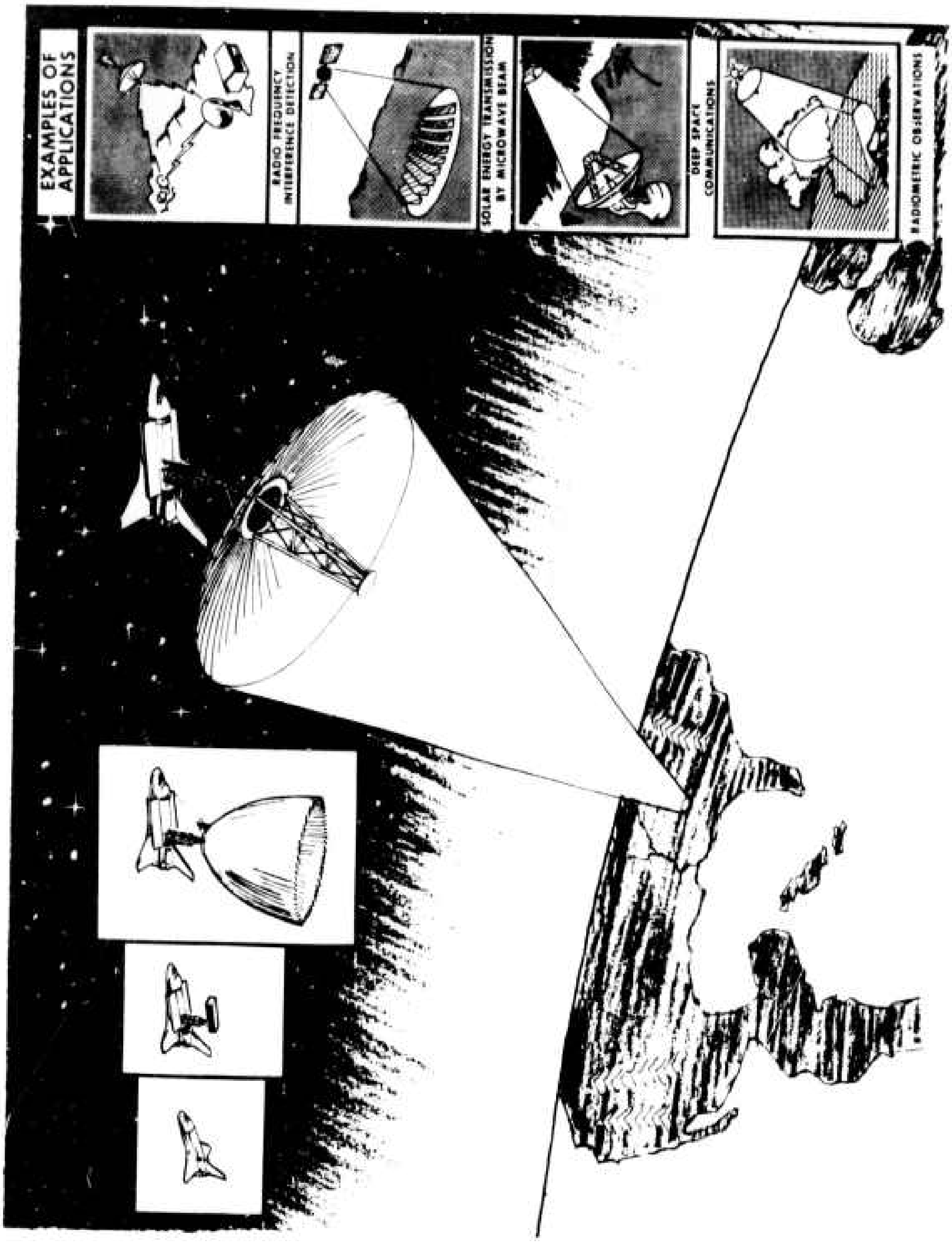


Figure 6 Large Deployable Antenna—Shuttle Experiment

Special Studies

In addition to a number of studies on cost, economic, and environmental benefits possible through specific remote sensing systems, two major NASA-sponsored efforts are under way to evaluate the overall practical uses of space applications for peaceful purposes. In the summer of 1974, the Space Applications Board of the National Academy of Engineering studied the needs of resource managers and other potential users of satellite-acquired information and services.[5] The interim report of the Board's Summer Study contained this provocative statement:

> Indeed, the single most important result of the study may be that these potential users, many of whom had little interest in the space program at the outset, were strongly interested at the end of the study in the benefits which they judged that space systems could bring to their business activities, whether in the private or public sector.

NASA is now engaged in a year-long comprehensive planning study, "The Outlook for Space: 1980-2000," which closely parallels the general objectives of the New Horizons II military space study. The NASA study recognizes that the Shuttle, Spacelab, and Tug, as well as other technological developments and changes in national and international priorities, will create new opportunities for exploring and exploiting space for peaceful purposes. Prominent among the areas under investigation are the various applications already discussed and such imaginative concepts as the use of space for supplying terrestrial energy. In addition, acquisition of space-acquired knowledge of earth fundamentals and expansion of scientific space exploration by manned and unmanned vehicles are featured. Some 65 promising projects in these categories have been identified, and a proposed core program now is being developed from these proposals. The study completion date is June 1975. NASA also is conducting a companion study, "Outlook for Aeronautics: 1980-2000," that has similar objectives.

Space Science

From 1960 to 1974, NASA launched more than 300 science-related vehicles into earth orbit or on interplanetary missions. It also sent more than 1,700 sounding rockets into near-earth space. The agency's FY 1975 and 1976 budgets call for more than half a billion dollars in annual space-science expenditures. Data obtained from the more than 2,000 scientific satellites, probes, and rockets launched to date have furnished detailed knowledge of the earth's relation to the environment of space, a completely new understanding of neighboring planets, greatly expanded comprehension of the solar system, and a much more definitive perception of the past, present, and future of the universe, including man's place in it.[6]

Earth-orbiting satellites have discovered and mapped in detail the highly complex magnetosphere[7] and the effect of solar radiation on the ionosphere and atmosphere. Other spacecraft, operating above the curtain of the earth's atmosphere, have looked into distant space to study ultraviolet, infrared, X-ray, and gamma rays and have made multiple discoveries about the stars, galaxies, pulsars, quasars, black holes, and other mysteries of the universe. Automated space vehicles have orbited Mars and have flown by Venus, Mercury, and Jupiter, contributing to an understanding of these planets and how they differ from the earth. Other spacecraft have mapped the moon in detail and have observed the sun and solar wind from widely separated points in the solar system.

As part of its booster program, NASA has launched scientific and applications satellites for numerous customers, including other governments, corporations, and universities. The amount of reimbursement to NASA depends upon its degree of contribution to fulfill the participating customer's needs, which may extend to development of the satellite, the launch vehicle, and reduction of data. These payloads of launches do not include the payloads of Spacelab and other Shuttle payloads, about a third of which will be devoted to scientific missions in the 1980s. Nevertheless, widespread domestic and international interest in cooperative Shuttle payload flights for science and other purposes has been expressed, including recent overtures from the Soviets.

During the past year, NASA has experienced some outstanding scientific and technological successes. Mariner 10 flew by Venus in February, by Mercury in March, and again by Mercury in September 1974. A third Mercury pass was made in March 1975. Mariner 10 already has collected a wealth of scientific data and pictures of the two planets nearest the sun. Its accomplishments include a best photographic resolution of the surface of Mercury of 30 feet and prints of Venus showing the planet's dense cloud blanket, as well as its ultraviolet "clouds" that apparently rotate around it every 4 days.

Going away from the sun, Pioneer 11 made close-up observations and measurements of Jupiter and is now on a trajectory to Saturn, as is its predecessor, Pioneer 10. In 1979, the latter probe is scheduled to reach the orbit of Uranus, some two billion miles from the earth and the theoretical boundary of spacecraft communications.

In August 1975, two unmanned Viking spacecraft will be launched with a dual mission: to orbit around and to land on Mars. The Viking program, which represents the most complex and technologically advanced unmanned system NASA has ever attempted, consists of a 5,320-pound orbiter and a 2,000-pound lander. The system will attempt the first detailed analysis of soil and surface conditions on Mars and will constitute the first direct search for evidence of life on another planet.

In space astronomy, telescopes on an orbiting astronomical observatory (OAO-3), launched 2-1/2 years ago, still are surveying the sky in invisible ultraviolet light. A specialized, small astronomy satellite (SAS-C) will be launched in May 1975 to measure X-rays and gamma rays from space, as well as other possible sources of radiation that cannot be seen from the ground. In 1977 and 1978, three High-Energy Astronomy Observatory satellites (HEAO) will be launched to measure very high radiation in distant space. Carrying relatively heavy payloads, they will attempt to verify evidence that supernovae and pulsars are X-ray sources and that X-rays are linked to radio galaxies and quasars, as well as to explore other deep space puzzles.

One of the more spectacular early Shuttle missions calls for a Large Space Telescope (LST) to be launched in 1981-1982. The LST, weighing 10 tons and orbiting at 380 miles, will feature a 3-meter (10-foot) telescope that will be able to observe deeper into space and with more detail than ever before possible. It will be used as a national facility, supporting worldwide astronomical needs of an international user community.

International Programs

Since the first cooperative satellite project with another nation, the United Kingdom's Ariel 1, which was launched by NASA in April 1962, the agency has conducted a vigorous international program. This effort has featured the launching of some 30 satellites designed, constructed, instrumented, and paid for by other nations; each country bears its own costs.

In addition, approximately 30 foreign experiments have been carried on NASA satellites, more than 800 cooperative sounding rocket flights have been completed, some 20 nations are operating or assisting NASA in operating global tracking and data acquisition stations, and more than 80 countries have been engaged in ground-based activities contributing to US space research.[8] The ASTP and Spacelab programs, mentioned earlier, represent special international cooperative enterprises, inasmuch as they are the first space developments of major significance to be undertaken by the Soviet Union and by ESRO with the United States.

Cooperation between the Soviet Union and the United States extends beyond the ASTP; the 1972 Nixon-Breshnev agreement established joint NASA/Soviet Academy working groups in space science and in applications. On the scientific side, the results of recent Soviet missions to Mars were briefed to Viking project personnel, and US life science experiments will be flown aboard the next available Soviet biological satellite. In space applications, weather data from sounding-rocket networks have been exchanged, and a joint experiment in coordinated microwave measurements in the Bering Sea has been completed. The Joint Working Group on Study of the Natural Environment has continued its efforts to define projects in remote sensing, principally in the areas of agriculture, land use, and geology.

International Earth Resources

One of the most extensive and promising international projects is the worldwide remote sensing program, which is utilizing data from both Landsat platforms now in orbit and from the Skylab's Earth Resources Experimental Package (EREP). Investigators from 52 countries and five international organizations have been designated to take part in NASA's Landsat and EREP programs. A list of these countries and organizations is given in Figure 7. The figure also summarizes recent applications of the programs, such as the use of Landsat imagery in determining the extent of flooding in Pakistan and the Japanese monitoring of serious water pollution in Osaka Bay. Other applications that indicate the value of remote sensing as a global tool include detecting desert locust breeding grounds in Saudi Arabia (similar to a screw worm experiment in Mexico) and locating islands as large as 80 square miles in the Amazon River basin that had not appeared on any previous maps.

AFRICA:

Botswana (1,3)
Central African Republic (3)
Ethiopia (3)
Gabon (3)
Guinea Republic (3)
Kenya (1,3)
Lesotho (1,3)
Libya Arab Republic (3)
Mali (1,2,3)
Nigeria (3)
South Africa (1,3)
Swaziland (3)
Zaire (3)
Liptako-Gourma Authority (3)
FAO (1,2,3)

ASIA:

Afghanistan (3)
Bangladesh (1,3)
Indonesia (1)
Iran (1,2,3)
Israel (1,2)
Japan (1,2,3)
Korea (1,3)
Malaysia (1,3)
Pakistan (3)
Philippines (1,3)
Sri Lanka (3)
Thailand (1,2,3)
Turkey (3)
Republic of Viet Nam (3)
CENTO (3)
Mekong Commission (1,3)
FAO (1,2,3)

EUROPE:

Belgium (1)
Federal Republic of Germany (1,2,3)
Finland (1,3)
France (1,2,3)
Greece (1)
Italy (1,2,3)
Netherlands (1,2)
Norway (1,3)
Spain (1,3)
Sweden (1,3)
Switzerland (1,2,3)
United Kingdom (1,2,3)
Organization of European Communities (3)

CENTRAL AND SOUTH AMERICA:

Argentina (1,2,3)
Bolivia (1,2,3)
Brazil (1,2,3)
Chile (1,2)
Colombia (1)
Ecuador (1)
Guatemala (1)
Peru (1,3)
FAO (1,2,3)

NORTH AMERICA:

Canada (1,2,3)
Mexico (1,2,3)

AUSTRALASIA:

Australia (1,2,3)
New Zealand (3)

(1) ERTS-1 Investigations
(2) Earth Resources Experiment Package (EREP/Skylab) Investigations
(3) ERTS Follow-on Investigations

Figure 7 International Participation in NASA's Earth Resources Investigations Programs

APPLICATIONS OF EARTH RESOURCES SATELLITE
DATA BY FOREIGN COUNTRIES

Natural Disaster Assessment: Use of ERTS imagery taken before and during recent floods in Pakistan assisted local officials to make a quick and accurate determination of the extent of the flooding and, using this information, to provide timely assistance to those farmers attempting to reclaim their crop lands. In a number of cases where claims were in dispute, information from the ERTS imagery contributed to their prompt settlement.

Geological Engineering: ERTS imagery of Bolivia recently permitted detection of a geological fault across the planned route of a natural gas pipeline. The ERTS data was subsequently used to select a revised pipeline route which was both shorter and less expensive to construct.

Environmental Application: Japan has used ERTS data to monitor serious water pollution in the Osaka Bay area. Conventional monitoring techniques had proved ineffective for monitoring of this pollution due to existing strong tidal currents in the Bay area.

Range Management: ERTS imagery of the Republic of Niger has revealed a large man-made feature with indications of improved vegetation cover and soil moisture. Upon investigation, this feature proved to be a 110,000-hectare fenced ranch where a grazing management program had been initiated. This has led to a better understanding of how range management techniques can help reverse the process of desertification in the Sahelian region of Africa.

Water Resources Studies: In N.E. Thailand, ERTS imagery has been used to estimate the available water supply and seasonal fluctuations in that supply in the planning of agricultural development and irrigation projects.

Figure 7 International Participation in NASA's Earth Resources Investigations Programs—Continued

As a result of the demonstrated value of earth resources data and the prospects for greatly expanded benefits, increasing global interest is being shown in acquiring ground facilities to receive and process information from Landsat vehicles. Such stations are already operating in Canada and Brazil, and an Italian counterpart will be functioning by mid-1975. (The region covered by the Italian station will embrace an area bounded by Scandinavia, Western USSR, Africa down to the Sahel, Spain, and Israel.) Iran and Zaire have concluded agreements with NASA and will fund the construction of Landsat ground facilities. Each station will be connected through communication links to other receiving and processing facilities, including the NASA ground stations in the United States.

Agreements for a station in the United Kingdom and a second receiving site in the Canadian maritime provinces are expected shortly. West Germany, Norway, Japan, and Australia are in the "relatively serious" category of potential users.[9] Inquiries have come from India, Indonesia, Philippines, the People's Republic of China, Soviet Union, Poland, Rumania, Chile, Argentina, and several Middle Eastern countries. Kenya and an FAO station in West Africa also have been mentioned as possible sites.

The World Bank (the International Bank for Reconstruction and Development) has found satellite-obtained earth resources data to be a very useful asset in determining the potential success of projects that will need financial support. Landsat data were employed to assess the feasibility of developing inland fishery areas in Tanzania and Bangladesh, as well as that of an irrigation project in Northeastern Thailand. In Nepal, information revealed that a site selected for a large farming settlement had no water and no easy access; consequently, another location was chosen.

The Bank also can utilize the information to check on short-term critical situations, such as the extent of flood damage in Bangladesh, so that it can provide timely assistance to farmers attempting to reclaim their lands. A relatively impoverished, undeveloped new nation such as Bangladesh, which has poor communications and inadequate mapping, especially can use earth resources data for solving many problems. For example, conditions suitable for growing "Boro" floating rice were found to exist much further north in the new nation than was indicated by existing agricultural reports. Also, satellite data indicated that many new islands were available for farming and that others had been eroded by flooding. (This was also the case for the Amazon.)

United Nations

To date, international cooperation has proved to be most effective between individual nations and among inter-allied bodies such as ESRO and Intelsat—all of which have mutual interests, investments, and benefits to be gained from space programs. As a result, a large number of nation-to-nation and nation-to-international-organization agreements have been signed, pledging joint cooperation and collaboration.

The question arises as to United Nations involvement in space matters, both at the General Assembly and at the Specialized Agencies levels. The General Assembly tends to be politically oriented, and issues such as national sovereignty over space boundaries have surfaced in that chamber. Programs such as earth resources, which enable satellites and aircraft to obtain data over a specific country's territory, have prompted political reservations—and perhaps some economic and national security reluctance as well—on the part of some UN members.

Yet, with the success of Landsats-1 and -2, as well as that of other earth observations satellites, indications are that the subject of sovereignty, at least for orbital overflight, may be becoming less of a political issue. The concept of using Landsat data for commercial exploitation of national resources of one country by another and for UN monitoring and regulatory purposes could create knotty problems and long debates within the Assembly and the Security Council.

Within the UN, both the United States and the Soviet Union have signed the Treaty on the Peaceful Uses of Outer Space, and, thus, are officially committed to orbital earth resources programs. In 1968, some 60 nations participated in the Conference on the Peaceful Uses of Outer Space in Vienna and expressed no reservations in extensive discussions of earth resources. Also, the UN has unanimously affirmed several measures to facilitate sharing of information and participation among member states. The UN also is responsible for the registration of all space objects.

At the World Food Conference in Rome during 1974, Secretary of State Kissinger announced the Large Crop Inventory

Experiment (Project LACIE) and observed that the earth resources experiment initially will be conducted over North America. He stated that if it was successful, it would be expanded to other areas of the world. He called it, "...a promising and potentially vital contribution to rational planning of global agricultural production."

In addition to the Food and Agricultural Organization, which has shown strong interest in Landsat-1 photographs of drought conditions in the sub-Saharan region of Africa and elsewhere, some of the other Specialized Agencies are deeply involved in space applications. For example, the World Meteorological Organization is concerned with the multinational employment of weather satellites. The International Telecommunications Union is concerned with the assignment of radio frequencies for space communications. The International Civil Aviation Organization is investigating the future exploitation of satellites for assisting in air traffic control and navigation in the operation of the world's airways.

Looking to the future, US objectives of international space cooperation for peaceful purposes are expected to take these directions:

- Contributions to the development and beneficial exploitation of space applications on an international as well as a national scale.
- Development of patterns of international use of the Shuttle in a way that optimizes its economy and efficiency as the central space transportation system of the future.
- Continuation and expansion of US and USSR collaboration in selected space projects of mutual value.
- Encouragement of Japan to participate in joint space programs.
- Continued emphasis on the substantive rather than the cosmetic aspects of cooperative programs.

Industrial and Commercial Uses

During the past 10 years, domestic and foreign industry and commerce have evidenced rising interest in employing space systems to meet their growing needs for economic, natural resource, and environmental data. Paced by the telecommunications industry, the utilization of satellites linked to ground terminals already has resulted in a global, multibillion-dollar investment. The potential in other fields, such as earth resources and pollution control, presages still further exponential growth. By 2000, numerous business and government services that today are accomplished solely on the ground will be taking advantage of the space medium in order to achieve better efficiencies and competitive costs, as well as to perform tasks not now feasible or not yet discovered. On the subject of cost, it is interesting to note that the first US satellite cost about $100,000 per pound of payload put in orbit. Today, that figure is under $1,000 per pound, and with the advent of the Shuttle, payload costs should drop to $100 per pound or less.

Successful launchings of Syncoms 2 and 3 into synchronous orbits in 1963 and 1964 opened the door for relatively simple and reliable commercial communications systems. Earlier, the American Telephone and Telegraph Company's Telstars and NASA's Relay series showed that active-repeater satellites were feasible. The Syncom project, which broadcast the 1964 Olympic Games in Tokyo to the United States as the first trans-Pacific TV program, demonstrated that satellites are useful for transmitting voices, narrow-band television images, and data over long distances.[10]

A second significant factor leading to the boom in communications satellites has been technological progress in antenna development. The price of antenna equipment has decreased from $15 million for the first earth station erected in Maine 12 years ago to $250,000 to $2 million today, depending upon the size of the installation. These costs will be further reduced. Brazil, which is considering a domestic space network involving some 2,000 antennas, expects to obtain them for $100,000 apiece.

The establishment of the International Telecommunications Satellite consortium (Intelsat) in 1964 provided the operational organization needed to make global space communications a commercial reality. The Communications Satellite Corporation (Comsat), which became financially solvent in the same year, manages Intelsat and owns one-third of the international communications cooperative, which launched its first satellite in December 1968.[11]

Today, 89 participating nations operate some 103 antennas at 81 stations in 59 countries. Intelsat generates approximately $250 million annually for the United States on a $1.4 billion investment. The availability of many thousands of voice channels has reduced the price of a 3-minute telephone call to London from New York from $12 in 1947 to $5.40 today. Moreover, satellites have proved that they can readily replace undersea cable circuits, which frequently are cut by trawlers.

In the United States, a corresponding shift to satellites for domestic communications is occurring. The system involved is referred to as "Domsat." Four or five US companies, including Comsat, A.T.& T., Western Union, and RCA, either have spacecraft flying or soon will have them in orbit. In the competition to become operational as soon as possible, the companies are investing from $70 million to $200 million each in the space and ground segments of their systems. The Comsat/A.T.& T. system contains 28,800 voice circuits and 24 television bands alone.

In 1972, the telecommunications industry in the United States grossed $18 billion in revenues. By 1980, the estimated income from television alone will top $4.5 billion; Domsat and Intelsat will be major users. It is evident that space communications have become big business already in the United States and that they will continue to burgeon under the pressures of competition and technological opportunities in the next two decades, especially after the Shuttle becomes operational.[12]

Domestic use of communications satellites is not confined to the United States. Canada and the Soviet Union are already operating such systems, and Algeria is constructing a domestic network of 14 antennas to link its entire nation by satellite. Iran, Saudi Arabia, the United Kingdom, France, Japan, and Indonesia also are expected to acquire domestic commercial systems. Indonesia plans to build 60 antennas to connect its 2,000-odd islands. Brazil and the Philippines are understood to be planning even larger networks of ground stations to serve their geographically separated populations. The move toward domestic networks is primed not only by inadequate communications but also by the factors of prestige and security inherent in national control and operation.

In a document prepared for its 1974 Summer Applications Study, NASA predicted a greatly increased commercial and government demand for space communications in the 1980s and 1990s. This demand will be for transmitting domestic and international telephone, TV, and data message traffic, for operating aeronautical and maritime communications and position location satellites (such as NAVSTAR), broadcasting to small fixed terminals, and collecting data utilizing thousands of small terrestrial telecommunications units. The ATS-F is expected to create new markets in health and educational television for operational satellite services. Transfer of library materials and employment of satellites for postal use (electronic mail services) also are potential future commercial applications.

However, the growth of communications satellites for civilian use is not without constraints. At least two situations present major problems. First, the number of synchronous satellites that can be deployed is not infinite, because only a limited number of orbital positions are available. Potential crowding may be seen in Figure 8, which depicts the location of operational and planned satellites on the overall synchronous orbital arc. The figure also shows, in the shaded areas, the preferred portion of the orbital arc for communicating via satellite to the continental United States and also to CONUS plus Alaska and Hawaii. While the problem of orbital spacing as illustrated is relieved somewhat by use of different frequency bands, it is, at the same time, compounded by DOD, foreign, and noncommunications satellite missions not depicted on the chart. Intersystem interference can also occur among nonsynchronous satellites.

Second, the radio frequency spectrum allocated to communications satellites is restricted. At present, this spectrum is below 10 GHz, except for the newly assigned higher bands for the CTS (CAS-C) and ATS-F experimental vehicles. To alleviate these two conditions, NASA is closely examining possible avenues for utilizing higher frequency bands, especially above 10 GHz. It is also trying to find ways of sharing existing frequency allocations more efficiently. In its assigned role of providing technical advice to the Federal Communications Commission and the Office of Telecommunications Policy, NASA has developed several promising computer programs related to orbit and spectrum utilization. It is using these and other techniques, such as research into the effects of propagation phenomena and high levels of manmade noise, in an attempt to reduce the possibility of interference between satellite communications systems.

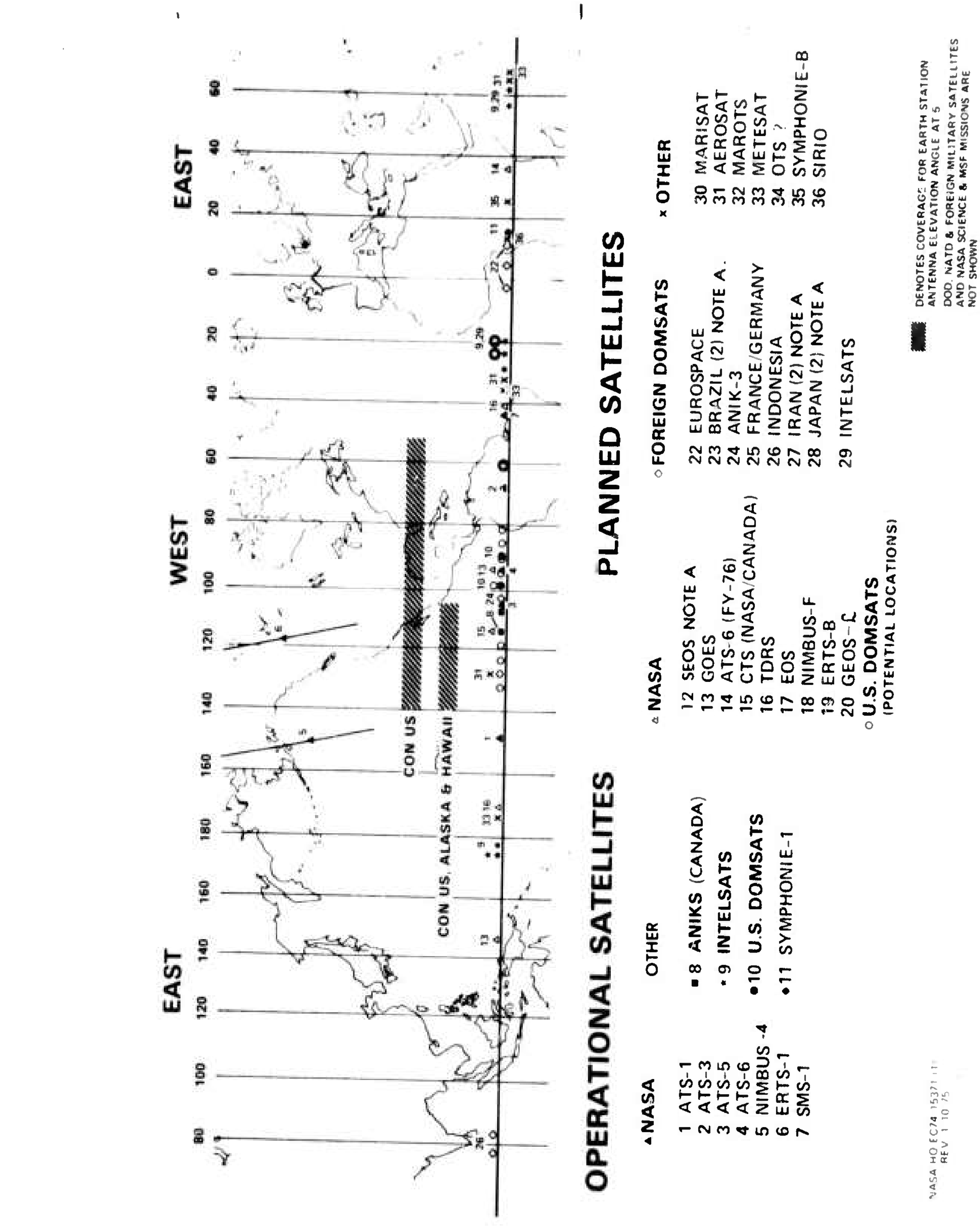


Figure 8 Satellite Spacing and Positioning

Potential Benefits for the Future

By 1985, the capability of satellites to furnish real-time weather, pollution, earth resource, energy management, and disaster warning information is expected to attract a host of additional industrial users, plus new space communications customers such as the airlines and shipping companies. The value of reliable and accurate meteorological data to farming, food, and other industries may be derived from a recent University of Wisconsin study, which found that the average annual agricultural loss due to weather from 1951 through 1960 came to more than $1 million each year. In a similar vein, the Department of Agriculture estimates that a third of US crops are destroyed each year due to disease, insects, and weeds. In another example, the staff of the Summer Applications Study stated that each dollar invested in a space-assisted world wheat survey could return two dollars in benefits.

Air pollution is responsible for direct annual costs of $6 billion per year in human health and another $10 billion in material and property damage. Water pollution, including oil spills and inadequate sewage treatment, also accounts for multibillion-dollar losses. Opportunities for water resource management are evident in the fact that a third of the total US rainfall is now employed for industrial, agricultural, and domestic purposes. By 1985, two-thirds of the US water supply will be needed by these users unless this nation is able to manage its fixed rainfall and other resources much more efficiently.

The above data suggest some of the representative areas in which industry can benefit from satellite-derived information, either in the conduct of ongoing business or in development of marketable technology and products. The agriculture, construction, transportation, and export-import industries, which in 1972 together produced $155 billion in revenues, seem logical candidates to follow the lead of telecommunications. The degree and timing of their space involvement will depend on competition, cost-effectiveness, managerial foresight, and funding.

In conclusion, the United States and other governments, as well as national and international industry and commerce, are moving into space for peaceful purposes on many fronts. This move into space has been fostered by technological breakthroughs and by opportunities to realize new knowledge and benefits. The employment of space by governments and commerce already has produced multibillion-dollar investments and a growing reliance upon the new medium for services and products. In the future, the availability of the Shuttle and the pressing need to deal with economic, energy, environmental, and social problems undoubtedly will place much greater emphasis upon the peaceful uses of space.

Footnotes

1. It is interesting to note that Dr. Theodore von Karman's impressive 1945 study for General Arnold, "Toward New Horizons," in assessing the future potential of liquid rockets, observed that "the satellite is a definite possibility." Contrast the vision of that statement of 30 years ago with the disparate 1957 comment of a Business Week reporter, "...there's a long theoretical gap between making an unmanned satellite circle the earth and building a spaceship in which man can travel through outer space—with a reasonable expectation of living to tell about it," and the even more incorrect prediction in 1956 by the British Royal Astronomer that "space travel is utter bilge."

2. NACA, as the Advisory Committee was known, was established on 3 March 1915 as a rider to the Naval Appropriations Act, "...to supervise and direct the scientific study of the problems of flight, with a view to their practical solution." The sum of $5,000 a year was appropriated for 5 years. Total appropriation for naval aeronautics that year was $1 million.

3. The number of Shuttle missions and payloads will differ in that some missions will carry multiple payloads. For example, the 1973 Payload Model calls for 725 Shuttle flights carrying 986 payloads. In September 1974, a 572 flight traffic model was developed, which also envisages multiple payloads on some missions. Under the 572 mission model, the number of annual Shuttle flights would be reduced to 50 to 60 rather than 70 to 80.

4. The Landsat or ERTS satellites are launched to pass over the same location on the earth every 18 days, from an orbit of 560 nautical miles. Each satellite is comparable in size and weight to a Volkswagen and completes 14 orbits daily. Landsats-1 and -2 carry two remote sensing systems, a multispectral scanner, and a return beam vidicon camera, which record photographic images in visible and invisible bands of the light spectrum.

5. Some 70 high-ranking specialists from government, industry, and academia were organized by the Academy into user panels, studying various application areas such as weather and climate, land use planning, environmental quality, and space manufacturing. The panels included the chairman of a state land use commission, the director of the Great Lakes

Basin Commission, the vice president of a large agricultural business, the president of the American Institute of Merchant Shipping, and others of this caliber.

6. In 1964, Lawrence Lessing, writing in Fortune, expressed the value of space science as follows: "The purposes of this exploration are no clearer to many men in this age than they were in Galileo's, so it is not strange that there is opposition. In this economic age, however, the opposition is not so much theological as budgetary. Both seem equally mistaken in the context of their times, for the earlier astronomical discoveries did not diminish man's spirit but rather enlarged and ennobled it, and space discoveries should have the same uplifting and enlarging effect. After all, a budget is only money, but new knowledge is a dukedom whose great wealth and resources cannot even begin to be estimated or exhausted. Already the new knowledge acquired in space exceeds by far the value of funds so far spent. For knowledge, more than guns and butter, is the true power of modern states."

7. A region of the upper atmosphere surrounding the earth, extending out thousands of miles and dominated by the earth's magnetic field so that charged particles are trapped in it.

8. For example, 39 principal investigators from 13 countries accomplished scientific studies under the NASA Lunar Sample Analysis program.

9. Like Canada, Australia probably will build two ground stations, one on the west coast and the other in the east.

10. Each synchronous satellite covers about 40 percent of the earth's surface, so that a network of as few as three satellites can cover the entire globe.

11. Comsat, which is partly a publicly owned company and partly owned by the US Government, earned $3[illegible].3 million in 1973, up 45 percent from the year before.

12. Communications had the highest percentage of growth of any major industry in the United States during the period 1950-1969. In that timeframe, the contribution of communications to national income increased by more than 500 percent, compared with the average growth of all industries of about

300 percent and slightly less than 150 percent for agriculture. From 1961-1970, sales of the communications-electronics industry in the United States contributed $196.3 billion to the GNP.

13. The Wisconsin report estimated that the average annual loss from weather damage in corn farming to be $351 million (8 percent of total crop); in wheat farming, $118 million (5 percent of crop), and in peanuts, $38 million (10 percent of crop).

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18. SUPPLEMENTARY NOTES

Basis for inputs to New Horizons II

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Space trends (nonmilitary)
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International interests

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This note is a summary of the growing national and international use of outer space for peaceful purposes by government and commercial activities. Emphasis is placed on: (1) the coming use of the Space Shuttle as a lower cost, more efficient space transportation system; and (2) the real and potential benefits that civilian space applications represent in meeting domestic and global economic, energy, and environmental needs. Of special significance are programs incorporating remote sensing systems, such as earth resources and meteorological (cont on p 1473 B)

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satellites. The highlights of scientific knowledge obtained from space also are covered. The study concludes by examining the industrial and commercial employment of space now and in the future. This note was prepared to furnish background information in projecting future military exploitation in the space medium.

1473B

SUPPLEMENTARY

INFORMATION

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To: Recipients of Distribution List for DDN 75-3

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Please make the following changes in your copy of subject document:

1. Bottom line of p. 29 and first three lines of p. 30 should read,

"tion (Comsat) serves as the management-services contractor in behalf of Intelsat and owns approximately one-third of the international communications cooperative, which launched its first satellite in December 1968."

2. Item 11. on p. 36 should read,

"11. Comsat, which is a publicly owned company, earned $36.3 million net income in 1973, up 45 percent from the year before."

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