72-137

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Washington, D. C. 20546
202-755-8370

NEWS

FOR RELEASE:

THURSDAY,
July 20, 1972

PROJECT: ERTS-A

NASA EARTH RESOURCES TECHNOLOGY SATELLITE

PRESS KIT

contents

- more -

TABLE OF CONTENTS (Continued)

- more -

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D. C. 20546
Phone: (202) 755-8370

FOR RELEASE:
THURSDAY,
July 20, 1972

Joseph J. McRoberts
(Phone: 202/755-3680)

James Lynch (GSFC)
(Phone: 301/982-5565)

RELEASE NO: 72-137

ENVIRONMENTAL AND EARTH RESOURCES SATELLITE TO BE LAUNCHED

A major step will be taken toward the establishment of a comprehensive information base about the Earth's resources and its surface environment with the launch of the first Earth Resources Technology Satellite (ERTS-A).

NASA is scheduled to launch ERTS-A (ERTS-1 in orbit) aboard a two-stage Delta rocket from the Western Test Range, Lompoc, Calif., no earlier than July 21.

The 891-kilogram (1,965-pound) ERTS-A will not only be a first step in the merger of space and remote sensing technology to more efficiently manage the Earth's resources, but it will greatly aid in assessing and understanding the changes taking place in our environment.

- more -

July 10, 1972

While this is an experimental mission, many use-oriented organizations believe that experiments of this type will lead to operational systems which will benefit all of mankind.

Charles W. Mathews, NASA's Associate Administrator for Applications, commented, "The environment and resources of the Earth's atmosphere, its continents, its coastal shelves, and its oceans, seas, and lakes have rightly become of great concern to people everywhere. This concern is in recognition of the closed ecology and finite resources of spaceship Earth, just as in the spaceships we build.

"In one sense, the world has become small with complex interactions between activities of nations, continents and hemispheres. In another sense, the world is still large, involving tens of billions of acres of land area and with oceans many times larger. We know humans have impacted much of this immense area, but how do we establish a baseline and how do we measure changes and differentiate between man-caused and natural changes? To accomplish this end, large amounts of data must be sensed and gathered from the various regions of the world -- in many cases, on a global basis."

The butterfly shaped observatory flying in a 920-kilometer (570-mile) circular, near-polar orbit will carry imaging systems which will provide data that could produce breakthroughs in the efficiency of user-oriented activities in agriculture, forestry, geology, geography (land use management), hydrology, pollution control, oceanography, meteorology, and ecology.

To carry out the research required to evaluate satellite techniques for resources survey and management, NASA is working with user agencies including the Departments of Agriculture, Commerce, Interior, the Environmental Protection Agency, and the U.S. Army Corps of Engineers, as well as regional state and local organizations.

In addition to the domestic programs, extensive cooperative Earth resources projects have been established with Canada, Brazil and Mexico involving ERTS and NASA Earth observations aircraft.

There are some 300 investigators from 43 states, the District of Columbia and 31 other foreign nations and two international organizations expected to participate in this program. NASA and the other government agencies fund the domestic investigations while the non-domestic investigations are funded by the foreign nations involved.

To handle this large group of investigators, NASA has assigned 25 specialists to help organize results submitted by each investigator.

Unlike previous unmanned programs where a principal investigator had his own instrumentation aboard the spacecraft and was responsible for analyses of resulting data, all investigators have access to all data from the ERTS instruments.

The main purpose of this first mission is to demonstrate the usefulness of remote sensing of conditions on the Earth's surface on a global scale and on a repetitive basis. These conditions are of economic, social and cultural interest to humanity.

In broad terms, the ERTS-A objectives are:

1. Determine those natural and cultural resource and environmental data which can be acquired best from spacecraft.

2. Test and demonstrate a combination of data acquisition procedures and interpretive techniques for application of the data in discipline areas such as agriculture, forestry, geology, geography, hydrology, oceanography, and ecology.

3. Determine how repetitive, synoptic, multispectral observations by spaceborne instruments can be of economic or social value to commercial, scientific, and governmental interests.

Ultimately, ERTS-A and planned follow-on systems are expected to provide widespread benefits in such areas as:

** Agriculture -- Information gathered will aid in land use planning, range management, identification and combatting of crop diseases and improved irrigation planning.

** Geology -- Information for use in the study of glaciers and volcanoes, earthquake fault systems, and in identifying terrain features associated with oil and mineral deposits.

- more -

** Hydrology -- Information for use in detecting water pollution trends; providing an inventory of surface water in lakes, reservoirs, and rivers; determining snow levels; and measurement of factors needed to predict the potential of floods and the location of water reserves.

** Oceanography -- Observation of environmental sea surface conditions which can be related to fish location, sources of pollution, behavior of major ocean currents, changes in shorelines and shores due to storms. Maritime commerce can benefit from better charting of sea conditions, ice field observation and iceberg warnings.

** Geography -- ERTS data can be used to produce a constantly updated map showing the various changes in the Earth's surface, natural and man-made, of interest to such groups as urban planners and the transportation industry.

During the ERTS-A mission, much of the early image analysis will be devoted to obtaining sequential information or "signatures" on surface features such as vegetation. soil and water.

All objects, living or inanimate, absorb, transmit or reflect visible and invisible lightwaves. All energy coming to Earth from the Sun is either reflected, transmitted, or absorbed by objects on Earth, each in its own way.

Sensing in a variety of wavelengths increases the possibility of identification of every feature in a particular area. The greater the number of spectral bands used the more complete and reliable becomes the identifying response pattern radiated by each individual resource. This radiation pattern is referred to as a "spectral signature."

To many in the scientific community, especially those concerned with ecology, the ERTS-A launch is one of the most widely anticipated events of the space age. Dr. Robert N. Colwell, Associate Director, Space Sciences Laboratory, University of California, Berkeley, an ERTS-A investigator and expert on remote sensing of agricultural, forest and range resources, earlier this year told the Committee on Science and Astronautics, House of Representatives:

"Agriculturists, foresters and range managers deal primarily with <u>renewable</u> natural resources, including agricultural crops, timber, forage and livestock. If such resources are wisely managed they can provide mankind with a sustained yield of food and fiber not merely for a few generations to come but perhaps, as some resource managers claim, 'in perpetuity'. If however, these resources are not managed wisely, man's very survival may soon be threated."

He went on to say, "Since the face of the land looks to the sky, it often is the 'bird's eye' view as obtained from an aircraft, together with the 'God's eye' view as obtained from a spacecraft which will best provide the resource manager with the information that he needs."

It will take about 500 pictures to cover the United States from ERTS-A versus 500,000 from high altitude aircraft.

The spacecraft will photograph large areas in a fraction of a second. Each picture will cover 34,000 square kilometers (13,000 square miles) or an area 185 by 185 kilometers (115 by 115 miles). For many scientific investigators, a single picture will provide a large enough field of view for disciplinary analysis.

ERTS-A will circle the Earth every 103 minutes or 14 times a day viewing a 185-kilometer (115-mile) strip of Earth running north/south at an angle to the equator of 80.0 degrees retrograde. In this type of orbit the surface coverage, with a slight overlap, will proceed westward until global coverage is completed once every 18 days.

The satellite's sun-synchronous, near-polar orbit was selected for the Sun angle. So the equatorial crossing occurs at the same time each day, about 9:30 a.m., local time. In other parts of the world the same conditions will be true, with the spacecraft crossing various points on the Earth at about the same time of day (9:30) local time.

The spacecraft's sensors, along with their associated communications and electronic equipment, weigh 220 kilograms (485 pounds).

Onboard instrumentation includes:

-- Return Beam Vidicon Television Cameras (RBV). These three cameras will view the same 185 by 185 kilometers (115 by 115 miles) square area in three different spectral bands, the green, red and near infrared portion of the spectrum.

-- Multispectral Scanner Subsystem (MSS). The MSS will return images in four spectral bands, the green, red and two near infrared bands. It will cover a continuous video strip corresponding to the RBV coverage.

-- Data Collection System (DCS). The DCS will collect information from some 150 remote, unattended instrumented ground platforms and relay the information to NASA ground stations for delivery to the user. The ground platforms will monitor such things as stream flow, snow depth, soil moisture and volcanic activity.

-- Wideband tape recorders. The two Wide Band Video Tape Recorders (WBVTR), will be able to record data in the form of images from areas outside of the area of direct data reception in North America for later playback to U.S. ground stations.

The three main tracking and data acquisition facilities which can receive video information from ERTS are at Fairbanks, Alaska; Goldstone, California and Greenbelt, Maryland. Canada has a ground data acquisition station for ERTS at Prince Albert, Saskatchewan and data processing facilities in Ottawa.

The spacecraft will be controlled from an Operations Center at NASA's Goddard Space Flight Center, Greenbelt. Data received from the satellite at the three data acquisition facilities will be sent to the NASA Data Processing Facility (NDPF) at Goddard. NDPF can handle some 1,300 scenes a week covering 45 million square kilometers (17 million square miles).

Data will be distributed in the form of high quality film images or digitized data on computer-readable magnetic tape. Information from the data collection platforms will be in digital form.

Copies of the data and photos processed at Goddard will be forwarded to the Department of Interior's Earth Resources Observation Systems (EROS) Data Center at Sioux Falls, South Dakota. On receipt at Sioux Falls the data are in the public domain and copies can be purchased by anyone. The Department of Commerce will also have data available at its National Oceanic and Atmospheric Administration (NOAA) Center at Suitland, Md.

Through its EROS program, administered by the U.S. Geological Survey, the Interior Department expects the ERTS missions to offer an opportunity to evaluate the use of multi-spectral space sensors together with the associated data processing techniques. The program will permit research on feasibility and cost effectiveness and contribute to the design of any future operational systems.

Dr. V. E. McKelvey, Director, USGS, Washington, D.C., said, "Based on findings to date, we are confident that the Earth resources satellites will live up to expectations. The Earth science community is eagerly awaiting the opportunities to apply space technology to the solution of many complex land resource and environmental problems."

The Department of Commerce through its NOAA and Bureau of the Census is responsible for developing and executing programs involving environmental and oceanic phenomena and population statistics.

The Earth Resources Survey Program is an important contribution to this effort, offering an opportunity to NOAA to evaluate the use of repetitive, multi-spectral obserations from aircraft and satellites, together with associated data processing techniques.

- more -

The U.S. Army Corps of Engineers will conduct seven experimental projects to test the feasibility of collecting water resources information by satellite.

Corps experts hope to obtain information and data on snow cover, precipitation, stream flow, sediment transport eutrophication, beach erosion, changes in vegetation, water quality, detection of chemicals and solids, drainage and general characteristics of selected waterways.

Experimental projects are in New England river basins, Chesapeake Bay, coastal areas of the Pacific Ocean in California, Cook Inlet area, Alaska, North Carolina barrier islands, Lower MIssissippi Valley and a proposed reservoir site in Illinois.

The U.S. Department of Agriculture expects its participation in the experimental ERTS-Satellite to identify areas where remote sensing could significantly benefit agriculture and related natural resources.

This would involve testing the practicality of including space-acquired data with other data to inventory and make predictions of the food and fiber resources of the nation, to evaluate the productivity of the land and to monitor changes affecting the quantity of production or quality of food and fiber.

The remotely sensed data is expected to permit identification of major agricultural crop types and forest species, insect damage, crop disease, soil salinity and moisture differences, mapping of surface water, snowpack, soil and water temperatures and changes in land use.

Other organizations working with NASA on the ERTS program include the Environmental Protection Agency as well as state and local governments, industry, universities, and foreign governments.

Overall ERTS program responsibility for NASA rests with the Office of Applications, Earth Observations Programs, Washington,

Project management for the ERTS spacecraft, the Delta launch vehicle, the Ground Data Handling System (GDHS) and the world-wide tracking network rests with the Goddard Space Flight Center, Greenbelt, Md.

Launching of the Delta is supervised by the Kennedy Space Center's Unmanned Launch Operations team.

Prime contractor for the ERTS spacecraft, the data collection system aboard the spacecraft, as well as the Ground Data Handling System at Goddard is the General Electric Company, Space Division, Valley Forge, Pennsylvania. Hughes Aircraft Company, Culver City, California is prime contractor for the multi-spectral scanner and RCA, Astro-Electronics Division, Princeton, New Jersey, is prime contractor for the return beam vidicon camera. RCA, Government and Commercial Systems Division, Camden, N.J., is prime contractor for the wide-band video tape recorders. The McDonnell Douglas Astronautics Company, Huntington Beach, Calif., is prime contractor for the Delta launch vehicle.

NASA costs for the ERTS program are $174 million. This includes two spacecraft, $28 million for the data handling facility at Goddard and $34 million for investigations. In addition, the Delta launch vehicle for ERTS-A costs $4.2 million.

(END OF GENERAL NEWS RELEASE; BACKGROUND INFORMATION FOLLOWS)

ERTS-A FACT SHEET

Launch Information:	
Date	No earlier than July 21, 1972
Launch Window	Opens at 10:54 AM PDT; closes about 30 minutes later.
Launch Vehicle	Two stage Delta, Model 0900
Launch Pad	SLC-2 West, Western Test Range
Orbital Elements:	
Circular	920 kilometers (570 statute miles)
Period	103.2 minutes
Inclination	Nearly polar, sun-synchronous, inclined 80.9 degrees retrograde to the Equator.
Spacecraft:	Butterfly shaped, 3 meters (10 feet) tall, 3.4 meters (11 feet) wide (with solar paddles unfolded) weighing 891 kilograms (1,965 pounds). Sensors and electronics are housed inside a 1.5-meter (5-foot) diameter sensory ring.
Stabilization Subsystem:	Earth oriented and three axes stabilized to less than 0.7 degrees, w/rates less than 0.4° sec exclusive of orbital rate.
Mission Objectives:	Define those practical Earth resources management problems where space technology can make beneficial contributions; conduct research on sensors and establish their utilities in Earth observation; and develop handling and processing techniques for Earth resources survey.
Spacecraft Designed Lifetime:	One year.

ERTS-A Sensors:

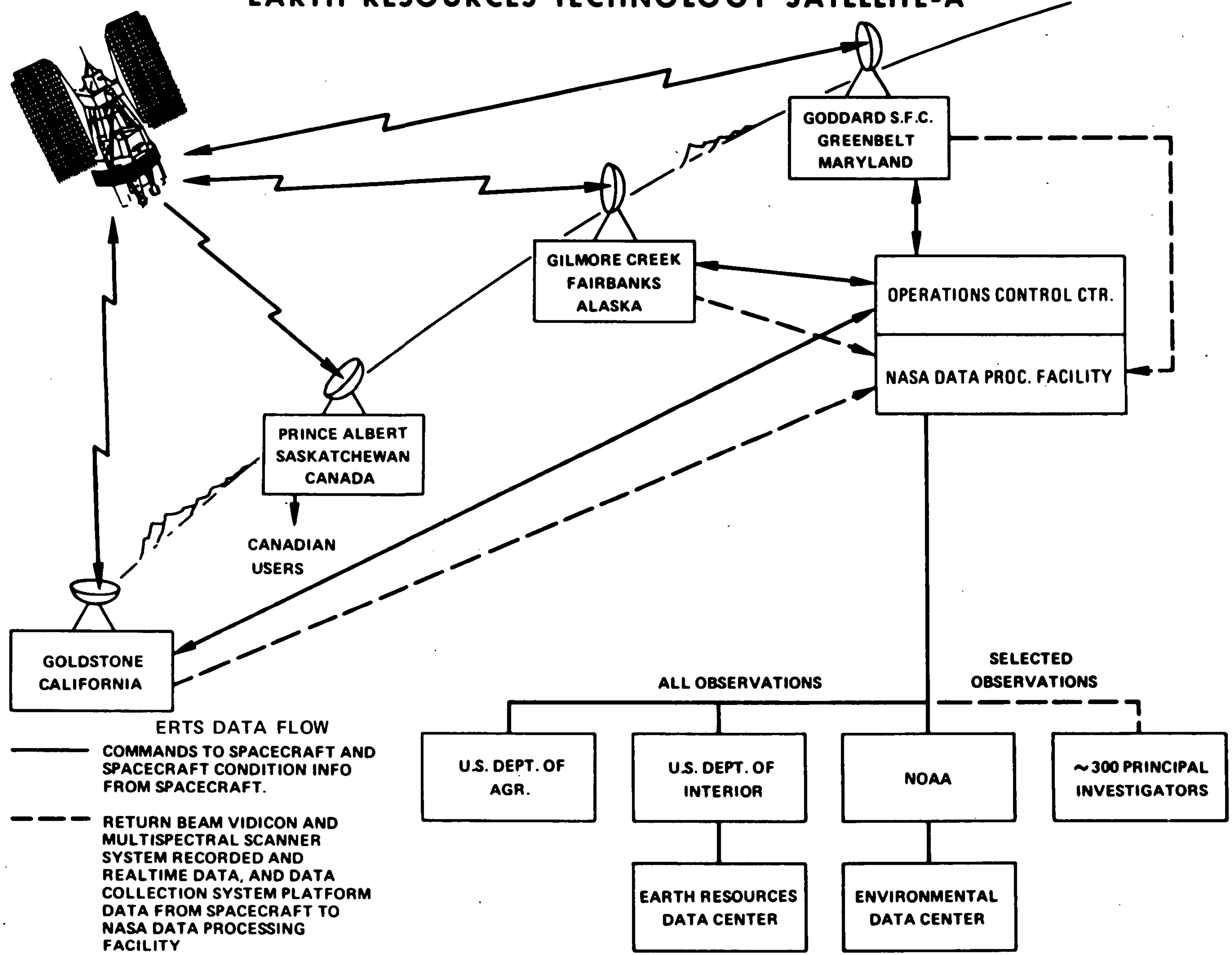
Multispectral Scanner Subsystem (MSS)	The MSS will collect data by continually scanning the ground directly beneath the observatory. The width of the strip will be identical to the coverage of the Return Beam Vidicon Camera, 185 kilometers. Optical energy will be sensed by an array of detectors in four spectral bands, two in the visible spectrum and two in the near infrared part of the spectrum.
Return Beam Vidicon Subsystem (RBV)	Three 4,125 line RBV cameras will view the same 185 kilometers swath as the MSS. Cameras will be reshuttered simultaneously every 25 seconds to produce 185 x 185 kilometers overlapping images of the ground along the direction of the satellite motion. The RBV will photograph two bands in the visible and one in the near infrared.
Data Collection System	Remote platforms for measuring soil, water and air, quality and other environmental data, and transmitting the data to ERTS as it passes overhead. This system can be expanded to global coverage by incorporating additional remote receiving sites. This system will provide in-situ measurements to be used to assist in the interpretation of data from the other two sensors.

Wide Band Video Tape Recorder (WBVTR)	ERTS-A will not be within range of one of the three ground stations, much of the time, so a tape recorder system is required to store images for later playback. ERTS-A has two WBVTRs and two transmitters. The system can record both sensors simultaneously and can transmit two channels of wideband data at once. The WBVTR has a digital bit rate of 15 million bits per second and a storage capability of 3×10^{10}. The normal tape recorder used in space employs a tape head speed of 30 inches per second while the WBVTR has a head and tape speed of 2,000 inches per second.
Tracking:	
Orbit	Stations of NASA's world-wide Spaceflight Tracking & Data Network (STDN)
Data Acquisition Facilities	Fairbanks, Alaska; Goldstone, Calif.; and Goddard Space Flight Center, Greenbelt, Md; Prince Albert, Sasketchewan, Canada.
Program Management:	Office of Applications, NASA Headquarters, Washington, D.C.
Project Management:	NASA/Goddard Space Flight Center, Greenbelt, Md.
Prime Spacecraft Contractor:	General Electric Company Valley Forge, Pa.
Prime Launch Vehicle Contractor:	McDonnell Douglas Astronautics Company, Huntington Beach, Calif.
Prime Sensor Contractors:	
Data Collection System	General Electric Company, Space Division, Valley Forge, Pa.

Multispectral Scanner Subsystem	Hughes Aircraft Company, Culver City, Calif.
Return Beam Vidicon Camera Subsystem	RCA Astro-Electronics Division, Princeton, N.J.
Wide Band Video Tape Recorder	RCA Government & Commerical Systems Division, Camden, N.J.
Principal Investigators	300 from 43 states, the District of Columbia and 34 foreign countries.

- more -

EARTH RESOURCES TECHNOLOGY SATELLITE-A



DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY

EROS AND ERTS

In preparation for the data to be acquired by ERTS-A, the Department of the Interior has, since 1964, been doing research in testing the applications of a broad spectrum of remote-sensing data from aircraft and spacecraft to Departmental programs.

Results of early studies in the basic fields of cartography, geography, geology, and hydrology, were sufficiently encouraging that in 1966, the Secretary of the Interior established the EROS (Earth Resources Observation Systems) program as a departmental effort under the management of the U.S. Geological Survey.

Through its EROS program, the Interior Department represents the largest single recipient and user agency of data to be obtained from NASA aircraft and spacecraft designed to gather repetitive information related to a wide variety of Earth science and natural resource disciplines.

Resources inventory and management applications have since become an important part of the research program with participation by 10 bureaus of the Department: the Geological Survey, Bureau of Indian Affairs, Bureau of Land Management, Bureau of Mines, Bureau of Outdoor Recreation, Bureau of Reclamation, Bureau of Sport Fisheries and Wildlife, the Bonneville Power Administration, National Park Service, and the Office of Trust Territories.

The EROS program has submitted 70 experiment proposals to NASA to evaluate the applications and use data from the ERTS-A satellite. Of these, 40 have been accepted by NASA for participation in the experimental program. The proposed investigations are categorized into five areas of research that correspond to working groups of the EROS program:

* Cartographic Applications and Mapping Requirements;
* Geology, Mineral, and Land Resources;
* Water Resources;
* Marine Resources; and
* Geography, Human, and Cultural Resources.

- more -

As part of gearing up for making the best possible interpretations and uses of data -- much of which will be obtained from a variety of remote sensing devices, such as infrared, ultraviolet, and radar devices carried in the satellites -- the U.S. Geological Survey will manage the EROS Data Center, being constructed at Sioux Falls, South Dakota. Processed data on terrain features will be stored in retrievable and reproducible form at the Center.

Eros

The $5 million facility, designated the EROS (Earth Resources Observation Systems) Data Center, will be constructed on a 315-acre site about 12 miles north and east of Sioux Falls.

When completed in the spring of 1973, the Center will be a key installation as a national central repository for processing, interpretation, and dissemination of thousands of images per year of a wide variety of land and water features of the United States obtained from aerial photography and spaceborne television and other remote sensing equipment.

Principal source of data to be stored at the Center will be NASA's ERTS (Earth Resources Technology Satellite) satellites.

The EROS Data Center will be a one-story steel frame structure with facilities, and will contain about 116,000 gross square feet of floor space, designed to house photographic and reproduction equipment and, in addition, special purpose hardware for picture rectification and color negative generation. During the ERTS experiments, space data will be delivered to the Center from NASA's Goddard Space Flight Center, Greenbelt, Md.

The facility, according to plans and specifications of the U.S. government, will be constructed by the Sioux Falls Development Foundation, Inc., a nonprofit organization of Sioux Falls businessmen which donated the site. Construction will be under a 20-year lease agreement with an option for the United States to purchase at any time within the period. If the option is not exercised, the facility will become the property of the Federal government at the end of the 20-year period.

The EROS Data Center, designed by Spitznagel Partners, Inc. in joint venture with Fritzel, Kroeger, Griffin, and Berg, both of Sioux Falls, is being constructed by Lueder Contruction of Omaha, Nebraska, with construction and permanent financing by the First National Bank, St. Paul, Minnesota.

DEPARTMENT OF COMMERCE

The Department of Commerce (USDC), through the National Oceanic and Atmospheric Administration (NOAA), is responsible for developing and executing programs to assure that the ocean environment and its resources are wisely used in a balanced way to enable their development as well as conservation for the national economic and environmental well-being. NOAA is also charged with developing and operating systems to monitor and predict environmental conditions such as weather, ocean, Earth and solar events, and with exploring the feasibility of beneficial modification of environmental conditions and understanding the consequences of inadvertent environmental modification. Through the Bureau of the Census, USDC is also responsible for providing a continuous statistical profile of the population of the Nation, measuring significant social and economic developments in each geographical area. Fulfilling these essential public functions requires a very large amount of data of many sorts over wide geographical areas, including global data in some cases. To meet these objectives, USDC is evaluating the feasibility and cost effectiveness of various types of in-situ and remote sensing techniques. The Earth Resources Survey Program will make an important contribution to this effort, offering an opportunity to evaluate the use of repetitive, multi-spectral observations from aircraft and satellites, together with associated data processing techniques, for this purpose. While many potential applications would require the availability of data in near real-time for operational purposes, the current program, while lacking that capability, will permit research on feasibility and cost effectiveness to be done and contribute to the design of future operational systems.

In addition to attempting to meet its own mission objectives, USDC will operate an ERS Data Center at Suitland, Maryland, to meet the needs of secondary users, including the public, in the disciplines of oceanography, hydrology, and meteorology.

DEPARTMENT OF AGRICULTURE

The U.S. Department of Agriculture looks to remote sensing as a very necessary and welcome tool in the intensifying war against waste. Remote sensing can help save time, save manpower and save resources.

Sensors now detect the subtlest of stresses in living plants and accordingly have a great potential value for identifying stress in the environment -- crops, forests and range. Such identification will, in some situations, like pest control efforts, lead to corrective action.

Corrective action may not be practical or possible in other instances, but the information gained by remote sensing can be used as a factor in crop estimates and forecasts. The information is essential to production, resource and inventory management.

As the world population increases, demands upon the capacity of exporting nations to produce more will become heavier. It will be increasingly important that available resources are managed with the least possible waste.

Local, state, national and global data, on a nearly real-time basis, would be of great usefulness in making reliable production forecasts. Such forecast information, translated into acres, pounds and bushels, would be of obvious value in reproduction, resource and inventory management decisions and the design of sound production adjustment, price support and environmental programs involving billions of dollars annually. The related merchandising and transportation industries vitally concerned with the availability, location and movement of food, fiber and materials, can benefit from early decisions based upon timely and accurate information.

Decisions of management of soil, forest, water, range and cropland and on management of commodity inventories will be better because they will be based on more accurate and more current information.

Specifically, USDA expects remote sensing to develop as an additional resource for estimating acreage and production of various crops and possibly for livestock inventories; inventory of forest resources, classifying and delineating commerial forest land; forest land; forest fire command and control; land use classification; soil type mapping; detection of water and air pollution; soil and water conservation, including monitoring snow accumulation and making water supply forecasts.

USDA will handle the imagery requirements of its own agencies through the facilities of its Western Aerial Photography Laboratory at Salt Lake City, where it will be reproduced and distributed to USDA users.

- more -

ARMY ENGINEERS

The U.S. Army Corps of Engineers will conduct seven experimental projects to test the feasibility of collecting water resources information by utilizing the Earth Resources Technology Satellite, the Office, Chief of Engineers announced.

Corps of Engineers experts hope to obtain information and data on snow cover, precipitation stream flow, sediment transport, eutrophication, beach erosion, changes in vegetation, water quality, detection of chemicals and solids, drainage and general characteristics of selected waterways.

Two imaging systems -- a television camera called a Return Beam Vidicon and a Multispectral Scanner -- and a data relay system aboard the Satellite are expected to provide multispectral imagery and data which the Corps will use in performance of its water resource mission. Corps investigators will use surface measurements together with high, medium, and low altitude aircraft remote sensing information to aid in the interpretation of the satellite imagery.

The experimental projects will provide data and imagery of the New England river basins areas, Chesapeake Bay, along the coastal areas of the Pacific Ocean in California, in the Cook Inlet area in Alaska, the barrier islands off North Carolina, the Lower Mississippi Valley and at the site of a proposed Corps reservoir in Illinois.

In the New England experiment, 25 data collection platforms will be placed along waterways from Stamford, Conn., to Fort Kent in northern Maine. The platforms will collect data such as stream flow, precipitation, temperature, soil moisture, tide changes, snow depth and water quality. This will be transmitted twice a day to the satellite's data collection system which will relay it to a receiving computer at the Goddard Space Flight Center in Beltsville, Md. An interfacing computer at the New England Engineer Division at Waltham, Mass., will receive the relayed data almost simultaneously. This experiment will test the feasibility of using satellite data relay in lieu of expensive "hard wire" or microwave data collection systems.

It is anticipated that the Chesapeake Bay studies, which will be conducted by the Corps' Waterways Experiment Station, Vicksburg, Miss., will provide information on how seasonal changes affect the water as river water mixes with the bay, changes in vegetation that occur, sediment movement, detection of solids and other foreign matter including chemicals, and other ecological changes in the area.

The Corps will also coordinate 11 investigations in the Chesapeake Bay area which are to be conducted by six agencies. The Corps will organize the aircraft remote sensing of the area and the collection of ground truth and enhance the flow of information among the investigators.

In the other experiments:

The Cold Regions Research and Engineering Laboratory, Hanover, N.H., will study ice cover, circulation patterns and sediment transport in Cook Inlet in Southern Alaska, and the effects of steam rings and permafrost changes in the Fairbanks and Eagle Summit areas in central Alaska.

The Coastal Engineering Research Center, Washington, D.C. will study beach buildup and erosion as well as dune patterns of the Barrier Islands off North Carolina's Atlantic Coast.

The Waterways Experiment Station will have a second project in the Lower Mississippi Valley to study drainage and vegetation characteristics and to obtain data for flood plain mapping.

The South Pacific Division, Corps of Engineer, plans to monitor coastal processes around San Fransisco Bay, Humbolt Bay, and the southern California coast from Morro Bay to Mission Bay. It will study sediment transport, estuarine exchange -- the changes in the estuary where the rivers discharge into the bay -- and the dispersion of chemical and biological wastes dumped into the water flowing into the bay and the bay itself.

The Construction Engineering Research Laboratory, which is located near the campus at the University of Illinois, Champaign-Urbana, will evaluate the feasibility of monitoring the environmental impact and vegetation changes resulting from construction, filling, and operation of the Oakley Reservoir on the Sangamon River in Illinois.

- more -

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency will participate in joint research programs with the University of Michigan and the Bendix Corporation to detect pollutants and monitor the general environment using ERTS data. The planned studies will employ low altitude aircraft, surface observations and measurements for verification purposes, and data from the ERTS system itself. Each study seeks to determine the feasibility of using ERTS type systems for ambient monitoring, the detection of effluents and outfalls and the mapping of dispersion currents.

EPAs regional officers have expressed an interest in over 40 of the scheduled ERTS experiments. This regional interest extends to plans for actually monitoring 15 of the proposed experiments.

EPA's Office of Monitoring is also experimenting with the use of data collection platforms, in estuarian, coastal and river environments.

- more -

REMOTE SENSING

What is remote sensing? Very simply, it is the measuring of an object from a distance. For example, a camera is a remote sensor in that it measures reflected light without touching the object being photographed. Other examples of remote sensors are human eyes, microwave radiometers, photomultiplier tubes, solid state detectors and spectrometers.

Remote sensing is a rapidly advancing technology. Unlike some technologies, remote sensing does not pollute. On the contrary, the use of remote sensing may help to preserve quality of the environment by detecting pollution early and improve the standard of living for Earth's increasing population by better utilization of our agricultural resources. It has the potential for revolutionizing the detection and characterization of Earth's natural resource phenomena.

Humans collect information through the five senses of sight, sound, taste, touch and smell. Most of the information that the Earth reflects or radiates can't be seen by the human eye. For example, in the near infrared, which is just slightly longer in wavelength than red, healthy vegetation is even brighter than the green radiance which our eyes can see. This near infrared information can be particularly valuable to farmers and agriculturists because it can reveal whether crops are healthy or sick.

Since objects have different physical and chemical properties, they tend to radiate different amounts of energy in the form of electromagnetic waves. Thus, a scene is made up of many small radiating elements, and every object could conceivably radiate different kinds and amounts of reflected and emitted energy.

The wavelengths of the electromagnetic spectrum used in remote sensing range from about 0.1 micrometers (x-rays) to 10,000 micrometers (radio waves). Only a small portion of the total spectrum can be seen with the human eye. The visible portion of the spectrum is from 0.4 to 0.7 micrometers. These wavelengths, or frequencies, quantify the colors of the rainbow -- violet, indigo, blue, green, yellow, orange and red.

No single instrument is capable of sensing and measuring energy at all wavelengths of the electromagnetic spectrum. Therefore, several devices are necessary if all the energy radiated by an object or scene is to be measured.

- more -

A sensor which measures the amount of energy being radiated as a function of frequency or wavelength is called a multi-spectral sensor. It measures the spectral characteristics of energy radiating from a scene or object.

The Department of Agriculture has been using remote sensing in the form of black and white aerial photography since the 1930s to measure crop and land use acreages for timber inventory and management, recreation and urban planning, as a base for soil maps and as a tool for crop estimates and yield predictions.

NASA and the Department of Agriculture have been working closely since the mid-1960s on high altitude tests of the necessary multispectral sensors and techniques necessary for an efficient inventory of Earth's natural resources. The choice of sensors for ERTS-A was influenced heavily by this work.

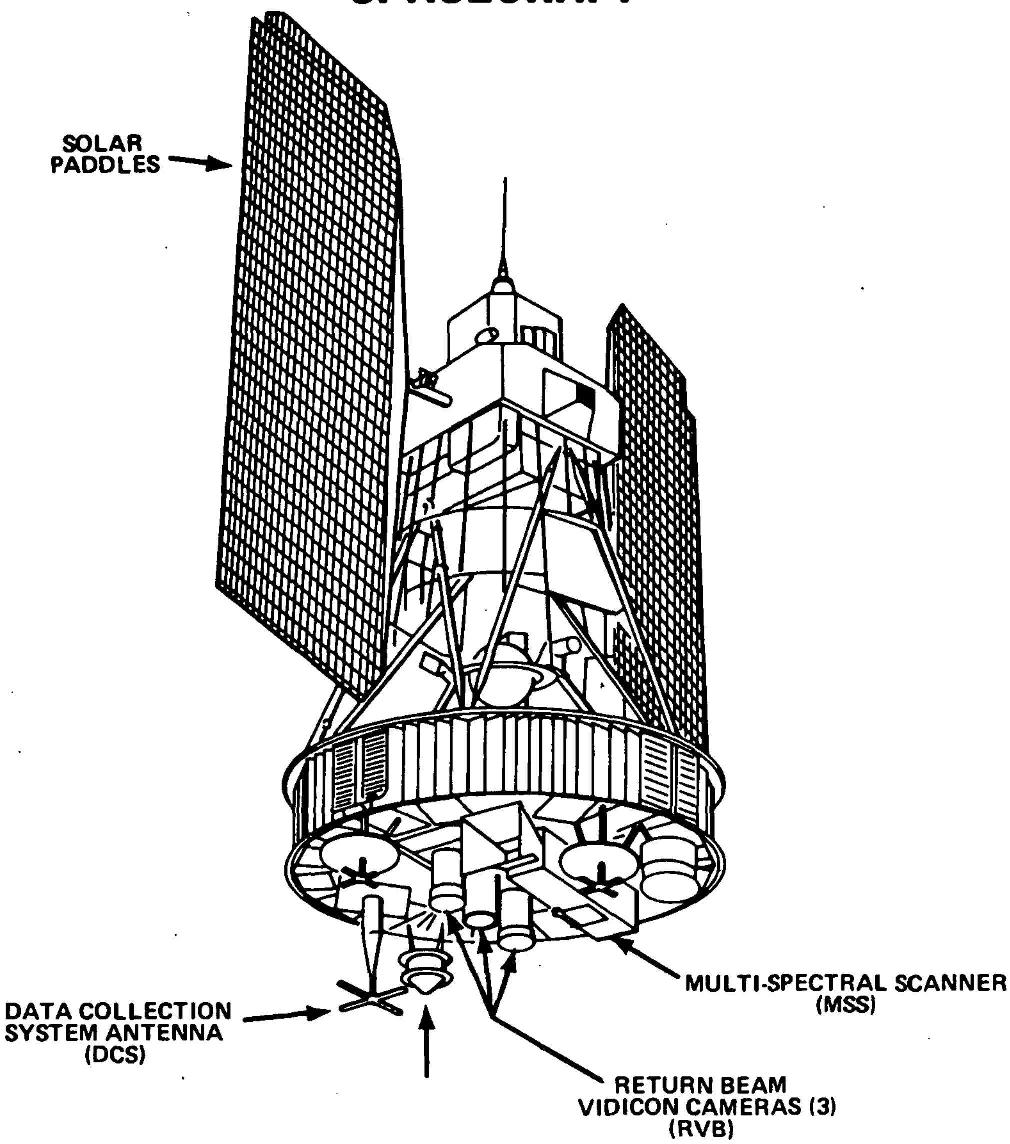
Since early in the history of aviation, remote sensing devices in the form of aerial photography have played an increasingly significant role in military and geographical investigations. With the possible exception of the seismograph, aerial photography has become the most successful mineral exploration tool in the history of mankind.

In Canada airborne electromagnetic, magnetic and gravity methods have been combined with aerial photography to achieve perhaps the greatest airborne usage of remote sensing for mineral exploration objectives. Hundreds of thousands of miles of surveys have been carried out, resulting in such finds as the Manitoba nickel deposits of International Nickel and the base metal discovery of Texas Gulf Sulphur in the Timmins, Ontario, region.

In 1964, the U.S. Geological Survey, long a lead agency in airborne surveys, entered into a cooperative agreement with NASA to investigate the feasibility and applications of remote sensing from space, relative to geologic studies.

Remote sensing won its "photographic wings" with the advent of the airplane and advanced rapidly during World War II because of military reconnaisance requirements. Multispectral scanning came into existence in the 1960s, and remote sensing advanced with space age technology.

ERTS SPACECRAFT



THE ERTS-A SPACECRAFT

The ERTS-A spacecraft design is based on the flight-proven Nimbus series of experimental meteorological satellites, first launched in 1964. Four Nimbus satellites built for NASA by General Electric, have been orbited in the past eight years and all have logged technological and meteorological firsts.

ERTS and Nimbus share the same basic design for the structure and thermal subsystem, power subsystem, attitude and control subsystem, telemetry, and tracking and command subsystem.

Unique ERTS requirements include an orbit adjust subsystem, a dual telemetry tracking and command subsystem and a wideband telemetry subsystem for sensor data transmission.

Structure and Thermal Subsystem

The spacecraft configuration packages payload equipment centrally in a ring structure at the base of the spacecraft, providing proximity between the payload sensors, their electronics, and wideband communications equipment.

The three Return Beam Vidicon (RBV) camera heads are mounted to a common baseplate, structurally isolated from the spacecraft, to maintain accurate alignment.

A superinsulation blanket surrounds equipment on the ring structure except for specified radiator areas where heat is rejected from the camera section. During minimum operating periods heaters are used to maintain temperature levels.

An active louver system around the ring maintains the overall structure and bay electronics very close to the nominal 20 degrees Celsius (68 degrees Fahrenheit).

Power Subsystem

Electrical power is generated by two independently driven solar arrays developed by RCA, with storage for eclipse periods and launch provided by eight individually controlled battery modules with a capacity of 36 ampere hours. Total capacity of the regulated power bus is nearly 1,000 watts.

The solar arrays are canted to a fixed angle when they are deployed in orbit to obtain maximum solar conversion efficiency for the mid-morning equator crossing for ERTS-A.

Attitude and Control Subsystem

Precise attitude control with an Earth pointing accuracy of less than 0.7 degree in all three axes (pitch, yaw and roll) is accomplished by a three-axis attitude control subsystem using horizon scanners for pitch and roll control and a gyrocompass for yaw orientation.

An independent passive attitude measurement sensor operating over a narrow range of about two degrees provides pitch and roll attitude data accurate to within 0.07 degree to aid in image location.

Orbit adjustment capability is furnished by a monopropellant hydrazine subsystem employing one-pound force thrusters. This system removes launch vehicle injection errors and provides periodic trim to maintain a precise orbit.

THE SENSORS

ERTS-A will carry two multispectral sensors, the multispectral scanner subsystem (MSS) and the return beam Vidicon (RBV) subsystem, and a data collection system (DCS).

The two sensors will repetitively take photo-like images of the Earth while the DCS will collect environmental data of various types from ground-based remote platforms. A high performance tape recorder, the wide band video tape recorder (WBVTR) will store photo images from the RBV and MSS as needed when the satellite is out of range of a direct readout data acquisition station.

The development of the MSS and RBV to meet the demanding performance requirements of the ERTS-A mission with its' stringent spacecraft weight and power constraints is considered a major technological achievement by NASA engineers.

The MSS and RBV will obtain images in two visible wavelength bands, 0.475-0.575 micrometers and 5.80 to 6.80 micrometers for the RBV, and 0.5-0.6 micrometers and 0.6-0.7 micrometers for the MSS. The third band in the RBV is 0.690-0.830 micrometers and in the MSS 0.7-0.8 micrometers. Both of these bands are in the near infrared. The MSS has a fourth band at a longer wavelength also in the near infrared, 0.8-1.1 micrometers, which will provide data of great interest to hydrologists and agriculturists.

First Band (0.5-0.6 micrometers)

Light of this spectral range appears green to the eye. Water is more or less transparent in this band which enhances features within the water, like sedimentation. The ocean bottom, such as shallow areas of the Bahamas, might be seen in this band.

This band has some limitation because scattering of light in the atmosphere makes "seeing" conditions difficult.

Second Band (0.6-0.7 micrometers)

This band appears red. Unlike the first band, this band is excellent for seeing through the atmosphere from space. It is especially good for land use mapping where regional population patterns need to be observed against vegetation patterns. A large group of principal investigators, about 20-25, are interested in such investigations.

The red band shows a good contrast between natural surface cover, like vegetation and soil, against man-made structures. Many man-made structures appear very bright while vegetation shows up very dark. Soil which has become exposed due to a man-made activity (a new housing development for example) can be seen in this band.

Study of desert related phenomena is excellent in this band because of the high contrast between vegetation and soil.

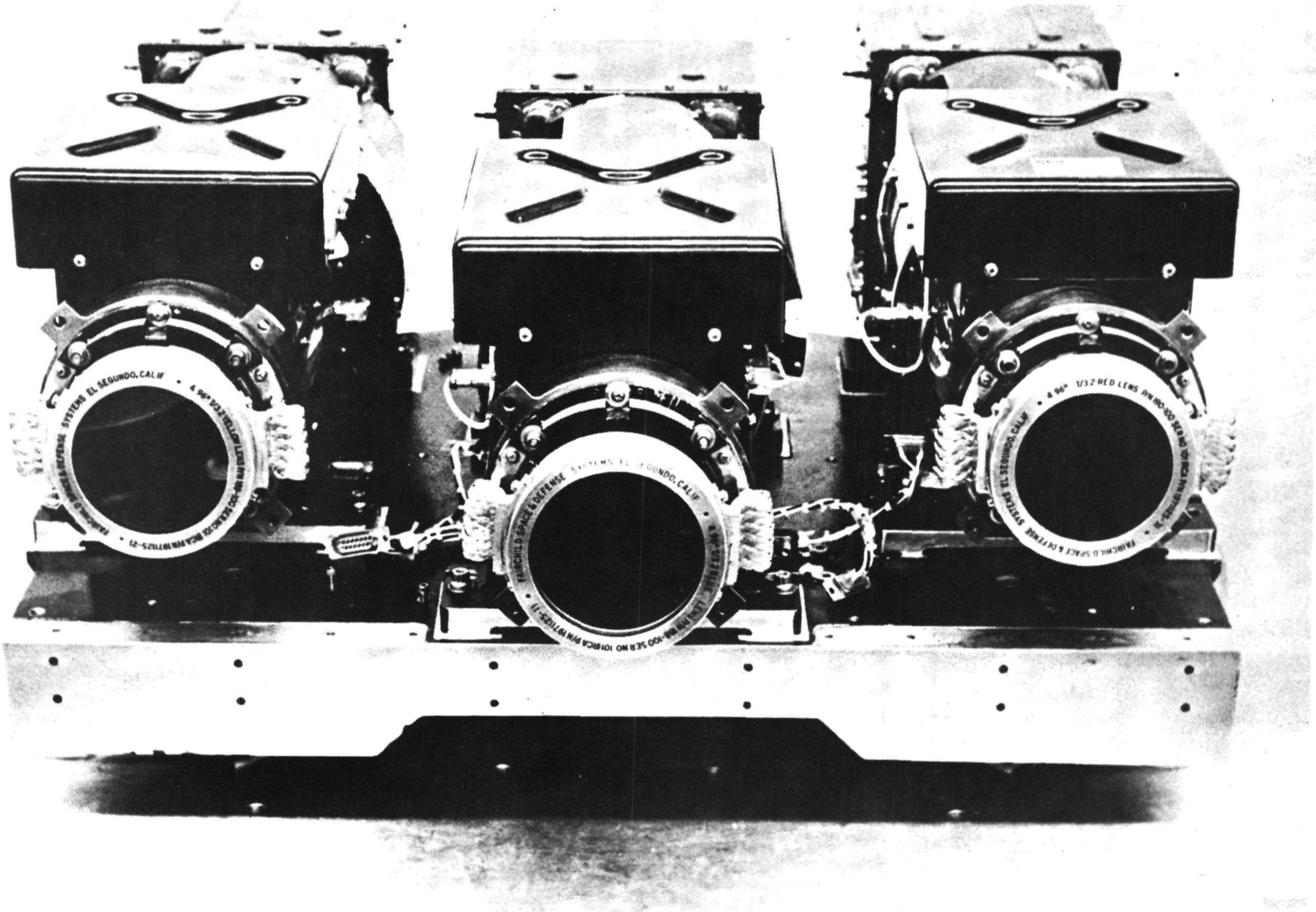
Third and Fourth Ba.ıds (0.7-0.8 and 0.8-1.1 micrometers)

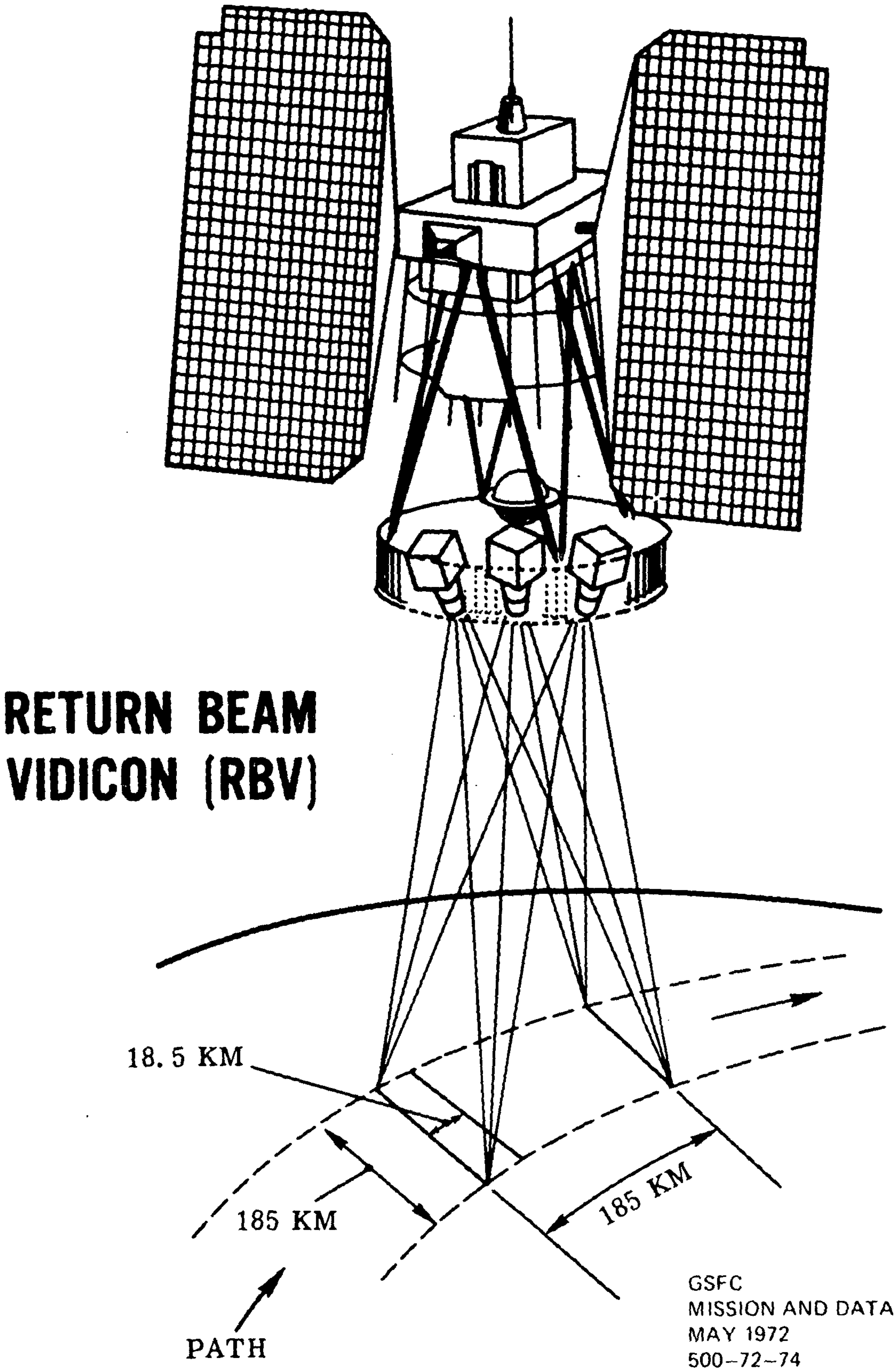
These two bands are in the near infrared (invisible to the human eye) portion of the spectrum. The fourth band, 0.8-1.1 micrometers, involves only the multispectral scanner. Water will be black in both of these bands because water almost totally absorbs the radiant energy in these frequencies.

Things look different to instruments in the infrared as compared to the visible. The most significant characteristic about infrared bands is that vegetation appears bright, and water appears dark. As a comparison, vegetation is as bright in the infrared as snow is in the visible.

Wheat in the first band (green) reflects about 20 per cent of light from the Sun. In the second band (red) approximately 95 per cent of the energy is absorbed by the plant and in used in the photosynthesis of carbohydrates in chlorophyll. This band is in fact called the chlorophyll absorption band. In the third, and particularly the fourth band, wheat reflects about 80 per cent of the radiation. It stands out in the infrared somewhat like snow does in the visible.

RETURN BEAM VIDICON





GSFC
MISSION AND DATA OPERATIONS
MAY 1972
500–72–74

Vegetation brightness depends on several things. For one, it depends partly on the type of vegetation -- big leaves will be brighter than small leaves. So, hard wood trees will show up brighter than pine trees. Tobacco, because of the texture of its leaves, will be brighter than wheat. Secondly, crop brightness depends on plant health. Healthy crops, in the infrared, will be much brighter than diseased vegetation.

Band three on the MSS (0.7-0.8 micrometers) was selected because it is in this band that the earliest detection of disease will be possible.

On any single photograph it would be difficult or impossible to detect a diseased condition in a mixed forest stand. ERTS however will provide repetitive coverage permitting the pathologist to compare sequential pictures and observe that abnormal changes have occurred.

Return Beam Vidicon Subsystem

The 5.08-centimeter (2-inch) RBV three-camera subsystem, built for NASA by RCA Astro Electronics Division, Princeton, N.J., will survey the Earth via three co-aligned camera sensors, each viewing the identical scene but in a different spectral band.

When the separate images from the three cameras (similar to TV picture tubes) are processed and superimposed in their respective colors, they provide a single full-color image containing the radiometric and cartographic information required for the ERTS system. The RBV has a much higher sensitivity than the normal vidicon camera.

The three spectral regions covered by the three-camera subsystem are the blue-green (0.475-0.575 micrometer); red (0.580-0.680 micrometer); and near infrared (0.690-0.830 micrometers).

The three cameras are exposed simultaneously to facilitate registration of the three separate images into the final color composites.

The cameras do not carry film. When their shutters are operated, images are stored on photosensitive surfaces within each vidicon camera tube and then scanned by an internal electron beam to produce a video picture. It requires about 11 seconds to read out all three tubes and transmit the pictures directly to Earth. If desired, the pictures can be stored on the wideband video tape recorder.

The cameras will be shuttered every 25 seconds to produce overlapping pictures of the ground scene below the spacecraft.

Each photo processed by the camera subsystem covers an Earth area 185 kilometers (115 miles) by 185 kilometers (115 miles). These individual photographs can be collated to provide a continuous swath along the spacecraft orbit subtrack.

The overall three-camera subsystem is comprised of the following electronic units:

Three camera sensors;

Three camera electronics units; and

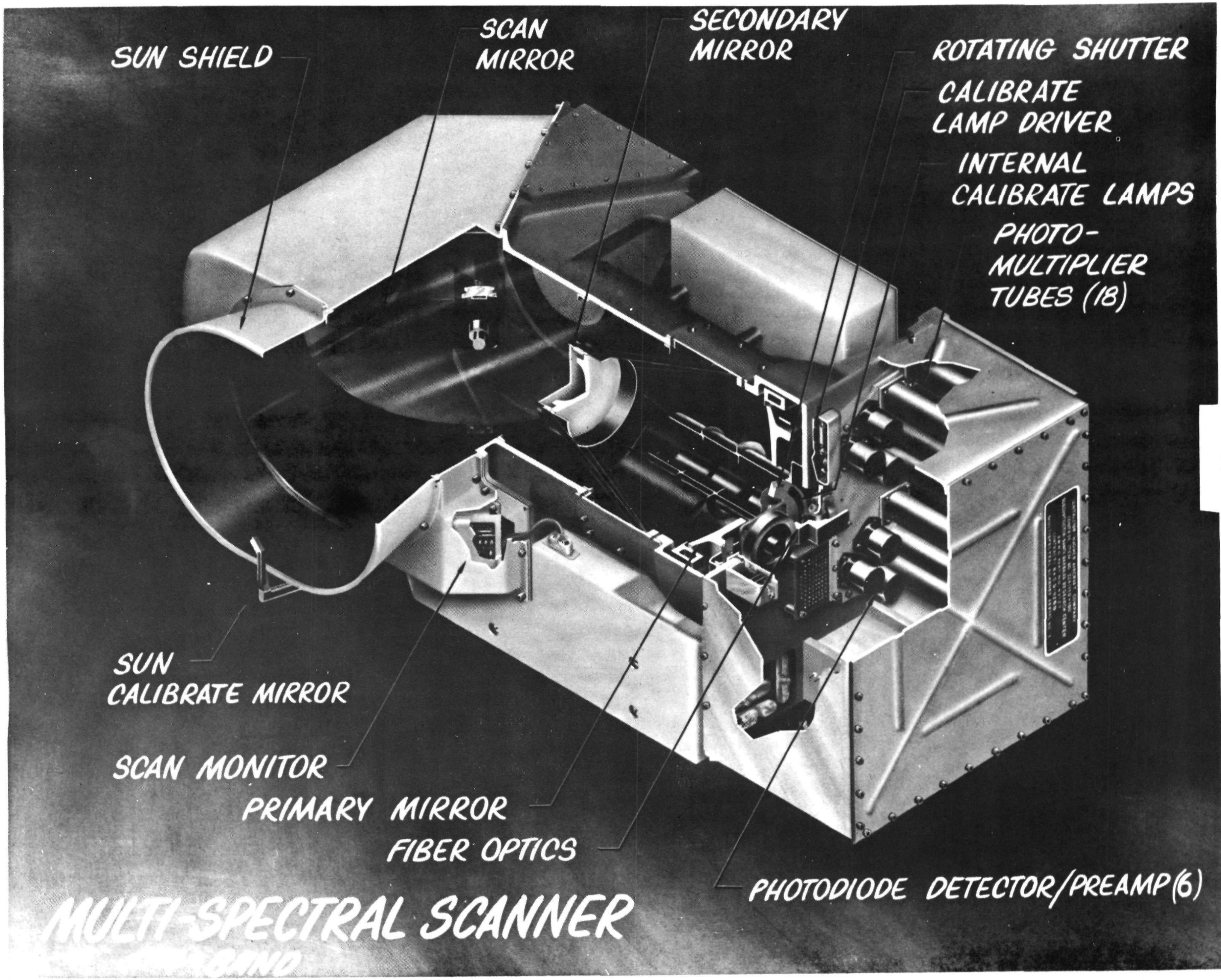
A common camera controller and combiner.

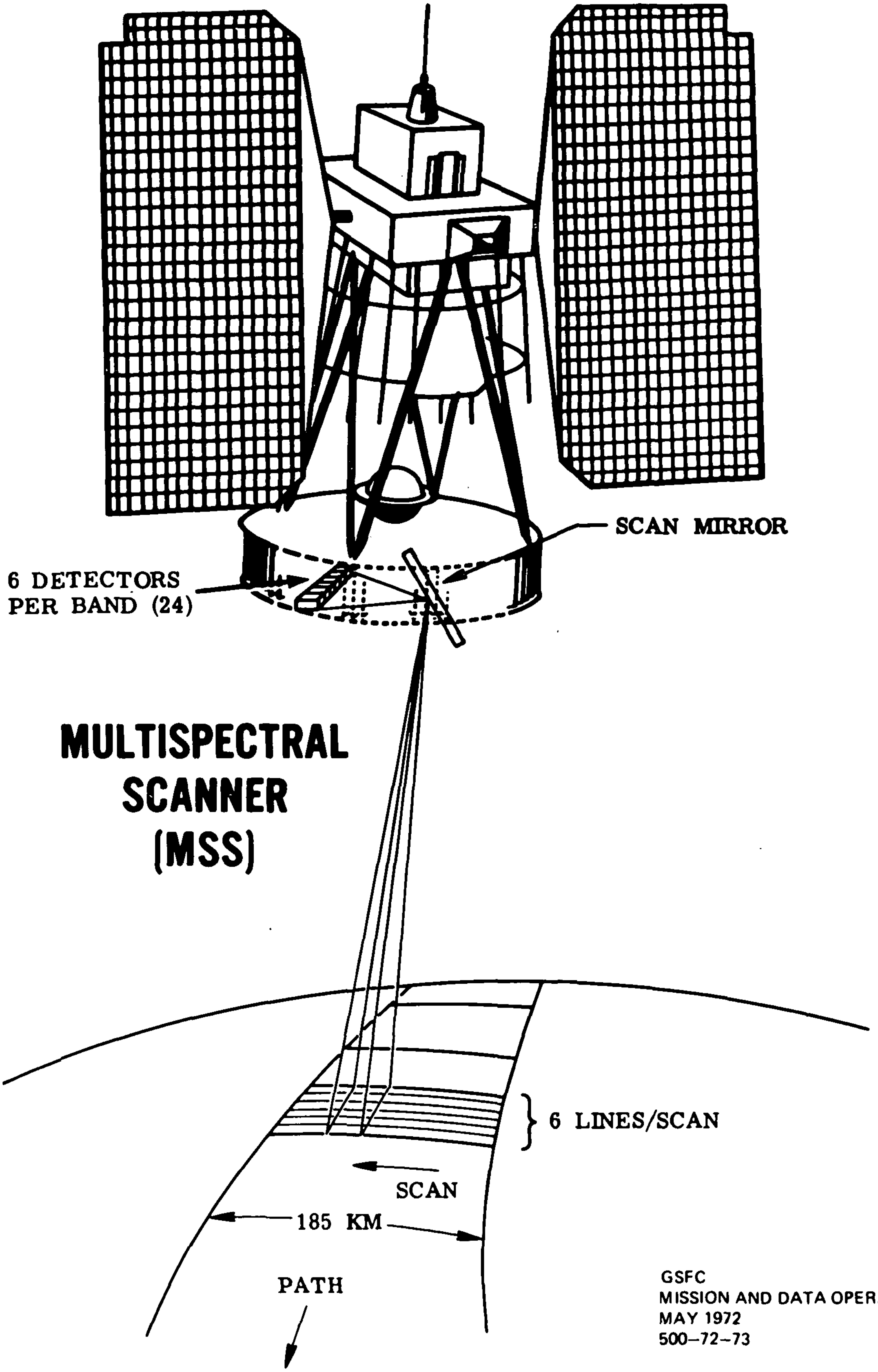
A base plate serves as a precise alignment reference plane and thermal control element. Each of the three camera sensors includes a return-beam vidicon, electron optics, electromagnetic deflection circuitry, electromechanical shutter, lens and thermoelectric cooler.

The vidicon imaging tube is a magnetically deflected, magnetically focused device with a 5.08-centimeter (2-inch) diameter face plate. Optical filters in the lens assembly of each camera sensor determine the different spectral range allocations for each.

The lens assembly provides a 15.9-degree field of view across the diagonal portion of the 2.54-centimeter (1-inch) square usable format of the vidicon face plate. A deposited reseau pattern on the face plate establishes a geometric reference for the later registration of the three separate images to make a color picture. The shutter provides for exposure of the vidicon, and it can be programmed for one of five exposure times to accommodate variations in scene illumination. The thermoelectric cooler controls the thermal environment of the vidicon face plate.

Each camera goes through four operational modes -- erase mode, prepare mode, expose mode and read mode -- in taking a picture of a scene. The duration of a picture-taking sequence is 25 seconds, with the erase, prepare, and expose modes being simultaneous for the three cameras and the read mode being sequential.


SUN SHIELD
SCAN MIRROR
SECONDARY MIRROR
ROTATING SHUTTER
CALIBRATE LAMP DRIVER
INTERNAL CALIBRATE LAMPS
PHOTO-MULTIPLIER TUBES (18)
SUN CALIBRATE MIRROR
SCAN MONITOR
PRIMARY MIRROR
FIBER OPTICS
PHOTODIODE DETECTOR/PREAMP (6)
MULTI-SPECTRAL SCANNER



GSFC
MISSION AND DATA OPERATIONS
MAY 1972
500-72-73

Multispectral Scanner Subsystem

The MSS, built by Hughes Aircraft Co., is an optical-mechanical sensing system which will simultaneously detect optical energy in four spectral bands, including the near infrared. It weighs about 54 kilograms (118 pounds).

The four bands are the visible green and red bands (0.5-0.6 and 0.6-0.7 micrometers) and two near infrared bands (0.7-0.8 and 0.8-1.1 micrometers).

The MSS will scan a swath of Earth 185 kilometers (115 statute miles) wide during each orbital pass. The width of the stip of Earth scanned by the MSS will be identical to the swath of the RBV camera subsystem.

The scanning will be achieved by means of a mechanically oscillating flat mirror which will flip-flop from side-to-side about 13 times a second during the orbital trace around Earth.

The images made from the MSS data will be of excellent quality and will be photograph-like in appearance.

Sensing in a variety of wavelengths to be obtained by the MSS increases the possibility of identification of important features in a particular area. The greater number of spectral bands used will make the identifying of resources more complete and reliable.

The purpose of the scan mirror assembly in the MSS is to reflect light from the Earth's surface into the optical system of the scanner. In operation this is how the MSS will work:

The Earth will be scanned by the moving mirror, which is elliptical in shape with a minor axis of approximately 23 cm (9 in.) and a major axis of 33 cm (13 in.). It is oriented at 45 degrees with respect to the scene and the double reflector telescope type of optics. As the mirror oscillates nearly 3 degrees about its nominal 45-degree position it will scan an 11.5 degree field of view.

During the actual scan period the mirror coasts inertially with only a soft spring force acting upon it. This is composed of a flexually suspended rotating segment which permits the mirror to strike bumpers or stops that reverse the rotation of the mirror during each cycle. An electromagnetic torquing device restores the energy lost during mirror impacts against the bumpers during each cycle.

During the orbital sweep, the scan mirror mechanism scans a 185-km (115-statute-mile) swath from side-to-side as the satellite progresses southward above the Earth path being scanned. The mechanism has a nearly symmetrical scan pattern, the oscillations in both directions requiring the same amount of time. Contact of the impacting springs against the mirror occupies only a brief time (4 milliseconds) during each oscillation.

Six scan lines are imaged in each of the four spectral bands during each orbital sweep. The scan lines are defined by fiber optics which transmit energy from the imaged spot through a spectral filter to a detector for that specific spectral band.

During the scan retrace, a rotating shutter blanks out the scene and sweeps the image of a calibration lamp across the fiber ends to measure radiometric levels. Once each orbit, sunlight is flashed across the fiber ends to check the accuracy of the calibration lamp.

To transfer the video signals to the ground receiving stations a multiplexer electronics unit encodes the 24 scan data signals into a single signal suitable either for realtime transmission or storage aboard one of the tape recorders for delayed transmission.

DATA COLLECTION SYSTEM

The ERTS-A data collection system (DCS) will provide users of the space data with near real time environmental information collected from ground based sensor instruments. The ground base instruments are connected to electronic units called platforms.

The platforms are remote data gathering units which accept sensor data such as measurements of soil, water, air and other parameters, convert the data to a convenient form and transmit the data by telemetry to the ERTS-A. The satellite immediately relays the platform data to the receiving site, which in turn relays it to the ground station at Goddard.

The ERTS-A DCS provides data retrieval from platforms situated within the continental United States and has capability for coverage of platforms situated in the near Pacific, off-shore Atlantic and parts of Canada and Mexico. The platform and receiving station must be in view of the satellite.

Some examples of how the DCS platforms can be used are:

Water Resources -- Detect water pollution trends, provide an inventory of lake and reservoir levels, show rainfall and snow levels and allow quicker prediction of potential floods.

Agriculture -- Monitor crop conditions and by means of precipitation and soil moisture measurements, contribute to drought predictions.

Forestry -- Measure precipitation, soil moisture, temperature and wind to aid in fire hazard prediction.

Wildlife and Fisheries Management -- Can provide for biological and ambient environmental measurements.

Meteorology -- Aid forecasting by making available information on air and water temperatures, barometric pressure, and snow, ice and glacier conditions.

-more-

Pollution Control -- Monitoring the contamination of the Earth's environment including ozone and pollutant concentrations in air, the distribution of water pollutants, noise levels and radiation levels and traffic counting both on land and water.

Geology -- Improve earthquake prediction and warning, monitor glaciers and volcanoes.

The platforms transmit on a random time basis with messages of tens of milliseconds duration being transmitted every few minutes. When ERTS-A is in view of a transmitting platform and one of the ground receiving sites, the platform data are relayed to the receiving site via the satellite. Equipment at the receiving sites recover the messages transmitted from individual platforms and sends them to Goddard over NASA ground communications facilities.

Operating in this repetitive manner, data from every remote platform can be obtained at least once every 12 hours.

The Data Collection Platforms (DCP) are designed to be rugged, easily-installed, field deployable units to which user-provided sensors can be connected. DCP's are designed to operate in the field for as long as six months without attention. During a portion of the ERTS-A mission, approximately 150 platforms will be in operation.

Wide Band Video Tape Recorder (WBVTR)

Worldwide coverage from space via imaging sensors requires either many ground receiving stations or an on-board tape recorder system. It is much easier to put tape recorders aboard the spacecraft than to install the many expensive ground receiving stations which would be needed to have the satellite in view by at least one station at all times. In the future geosynchronous data relay satellites can replace the tape recorder function completely.

ERTS-A carries two identical wide band video tape recorders (WBVTR), built by RCA Government Commercial Systems Division, Camden, NJ. The WBVTR is the largest tape recorder ever flown in space (35 kilograms - 76 pounds), and it has the highest storage capacity of any recorder ever orbited. The WBVTR has a digital bit rate of 15 million bits per second and a storage capability of 3×10^{10} (3 followed by 10 zeroes) bits. The normal tape recorder used in space employs a tape to head speed of 76 centimeters (30 inches) per second while the WBVTR used a tape to head speed of 5,080 cm (2,000 in.) per second.

The WBVTR subsystem consists of two recorders either of which can record and reproduce image data from either the RBV or the MSS. Two recorders allow simultaneous operation. The WBVTR has a designed lifetime of from 500 to 1,000 hours of operation which is sufficient to support a one-year spacecraft lifetime.

-more-

DATA PROCESSING WORKLOAD SIZING FOR ERTS-A

- 18 MIN/DAY OF REAL-TIME COVERAGE OVER U.S. (44 185 X 185 Km SCENES)
- 60 MIN/DAY OF TAPE-RECORDED COVERAGE (144 SCENES)
- 188 SCENES/DAY (24% OVER U.S.)
- 1,316 SCENES/WEEK IN 7 SPECTRAL BANDS
- 9,212 SPECTRAL IMAGES/WEEK

GSFC
MISSION AND DATA OPERATIONS
MAY 1972
500–72–103

NASA G-72 -8234

GROUND DATA HANDLING SYSTEM

The ground data handling system (GDHS) is at the NASA/Goddard Space Flight Center, Greenbelt, Md. The GDHS includes an operations control center (OCC) for operating the spacecraft, and the NASA Data Processing Facility (NDPF) for processing and distributing film images from the ERTS sensors to users around the world.

The General Electric Company is prime contractor for the GDHS. The Bendix Corporation and the Wolf Research and Development Corporation are major subcontractors for the NDPF subsystems.

Systematic repeating Earth coverage under nearly constant observation conditions will provide for maximum usefulness of the multispectral images collected.

Operations Control Center

The OCC is the hub of ERTS daily command and control activities. Operating 24 hours a day, the OCC will command the spacecraft as well as the observatory sensors. The OCC will be in touch with ERTS-A through the Alaska, California or Goddard data acquisition facilities on 12 or 13 of the 14 daily orbits.

The OCC computers will process spacecraft and sensor "housekeeping" data, command generation, displays, system scheduling as well as pre-processing of Data Collection System experiment information.

Operations in the OCC will interact with the computer and its software by means of operations consoles; each console will have a cathode ray tube display and other status and alarm indicators. The consoles will provide the operations personnel with all the information required to assess the health of the spacecraft and payloads, and to make and rapidly implement command and control decisions.

The NASA Data Processing Facility (NDPF)

The NDPF has been designed to produce controlled quality data and photographic images telemetered from ERTS and to distribute them to user agencies and principal investigators.

-more-

The NDPF has the capability of handling 10,000 images a week. Film products available are black and white positive and negative transparencies, black and white and color prints and color transparencies. Magnetic taped image data will also be duplicated and distributed.

The NDPF is composed of an image processing area and a data services laboratory. Each week in the image data processing (IDP) area, over 9,000 taped images will be converted to film in the Initial Image Generating Subsystem (IIGS) and about five percent of these are precision processed to generate orthophotos.

About 10,000 color composites are made and about 750 images are generated on computer readable tape during the same period. The Data Services Laboratory (DSL) has the capacity to service the ERTS users weekly. The DSL also provides library services and a browse file for the users as well as production control to efficiently operate the NDPF in response to requests for data.

The NDPF is capable of handling 188 RBV or equivalent MSS operations per day. This loading yields 1,316 scenes per week each of which produce seven spectral images to give a total of 9,212 spectral images 185 x 185 km (115 x 115 miles) per week.

These data, received on video tape are converted to high quality film images on 70 mm film by an electron beam recorder. This conversion requires about 80 hours per week, including maintenance.

In this conversion, radiometric corrections are made to the MSS data and the MSS data is framed to correspond to RBV images. Both the RBV and MSS data are geometrically corrected using error data acquired from satellite attitude telemetry and from the Scene Correcting Subsystem.

Copies of all ERTS images will be forwarded to the Department of Interior's Earth Resources Observation Systems data center in Sioux Falls, SD, the National Oceanic and Atmospheric Administration, Sutiland, Md, the U.S. Department of Agriculture, Washington, D.C. and the selected ERTS investigators. Public access to the ERTS-A data will be primarily through the Department of Interior's EROS facility at Sioux Falls. Cost of the data will be, essentially the expense of reproduction and handling. Ocean and coastal data will be available from the NOAA.

-more-

NDPF SUBSYSTEMS

Initial Image Generating Subsystem (IIGS)

The IIGS produces corrected 70mm images of video data from either the RBV video tapes, MSS video tape, or from special processed sensor data.

It also produces a tape record of either the RBV (converted to digital) or MSS data in a format acceptable for digital subsystems. Only one percent of the RBV and five percent of the MSS data is digitized. This element records annotation data regarding image location and time and a grey-scale for calibration of subsequent processing steps on its output images. The IIGS also applies initial radiometric and geometric corrections to the image video. The corrections performed here on all bulk data will allow registration so that good color composites may be generated from bulk data.

The 70mm images produced by IIGS are developed in the NDPF photographic processing subsystem and inspected for quality and cloud cover. At this stage the images defined by users as being useful in the NDPF information system will be enlarged, printed and distributed to ERTS users; the necessary 70mm images will be submitted to the Scene Correcting Subsystem and enlarged black and white or color composites will be produced, printed and distributed to ERTS users.

In addition to the ERTS data that will be made available to investigators by NASA, the Department of Agriculture, the Department of Interior and the Department of Commerce will make ERTS data available to the respective user communities on a reimburseable basis. The Agricultural Stabilization and Conservation Services (ASCS), Western Acrial Photography Laboratory at Salt Lake City, Utah will receive positive and negative film from the NDPF and make photographic reproductions for USDA agencies and its normal user community on a reimburseable basis.

Scene Correcting Subsystem (SCSS)

The SCSS accepts the 70mm images produced by IIGS and through a hybrid processing system produces corrected film images on a 24-centimeter (9 1/2-inch) format.

This element removes geometric distortions and performs precision location, 91 to 244 meters (300 to 800 feet) and scaling of the corrected video relative to map coordinates.

Automated research and ground control point processing is used to perform these corrections.

Digital Subsystems (DS)

The Digital Subsystem reads the high density digital tapes prepared from IIGS and SCSS and edits and formats this data on computer-readable digital tapes for distribution to ERTS users. An output tape is produced which when processed by the SCSS, will produce an annotated image showing the location of the encoded region; a selected section of an image will be produced on 24 cm (9 1/2-inch) format film.

User Services

All data entering the NDPF will be categorized, logged and stored. Users will have access to this information through several files maintained by User Services.

Subscribers to the User Services will be supplied with 16mm microfilm files, data abstract catalogs, and coverage catalogs on regularly scheduled service.

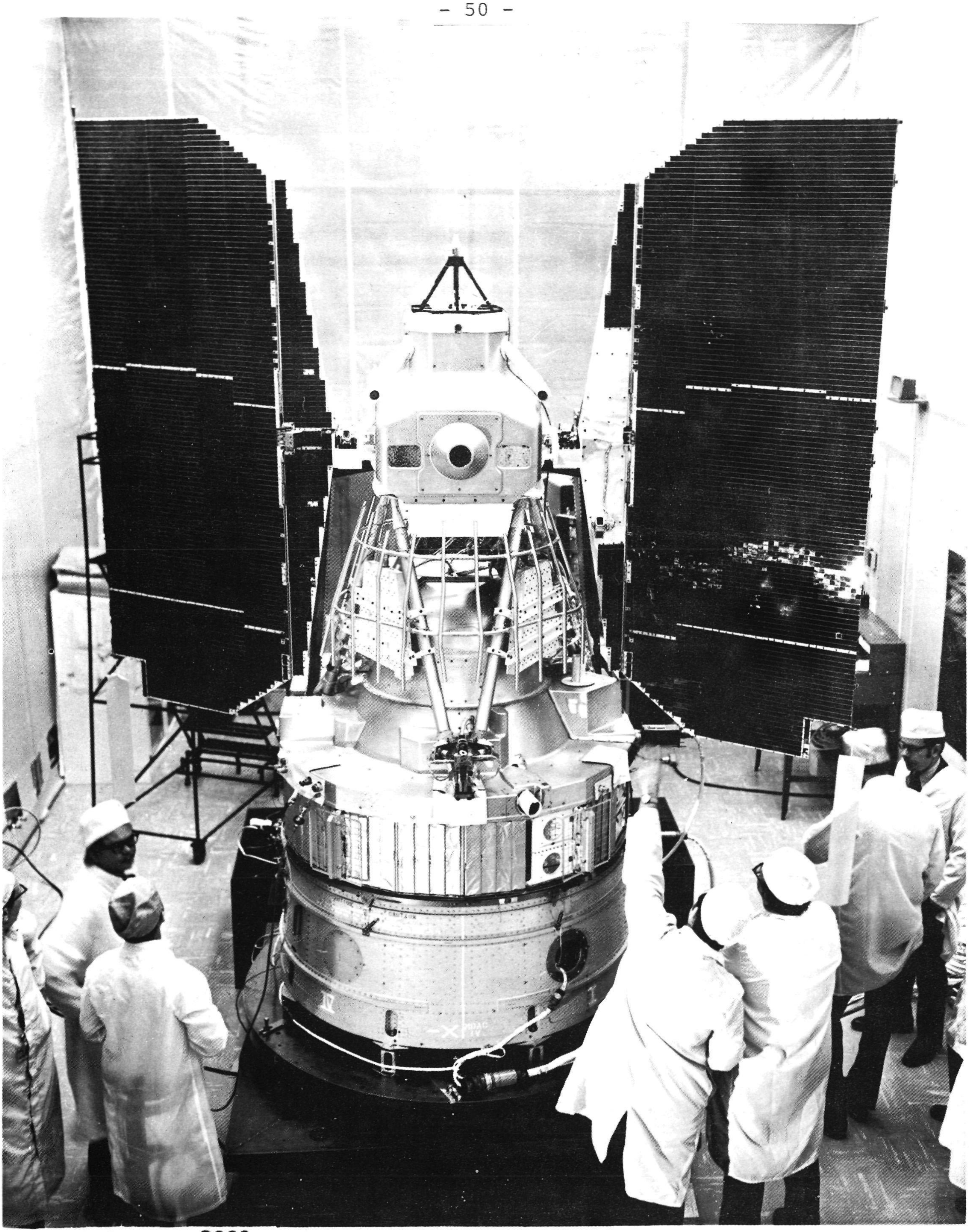
The RBV images are nominally 185 x 185 km (115 x 115 statute miles) in size and will be at 1:1,000,000 scale when presented in a usable 18.5 cm (7.3-inch) square format on a standard 24-cm (9 1/2-inch) paper format. The MSS data consists of successive scan lines cross-track and is put into a frame format by the NDPF.

When the RBV and MSS sensors are operated simultaneously, the frames will be made so the data cover the same area.

The annotation will list sensor, time of exposure, orbit number, subsatellite point, picture center location, Sun azimuth and elevation angles, spacecraft heading, spacecraft attitude and ground receiving site identification.

The spectral band identifiers in the annotation block are arranged so they show through without obscuring each other when a color composite is made. Therefore, the spectral bands used to make each color composite can be readily identified.

-more-



NASA G-72-8203

SCIENTIFIC DISCIPLINE AREAS OF ERTS-A INVESTIGATIONS

The general research areas to be addressed by ERTS-A are:

Discipline	Number of Investigations
Agriculture/Forestry	49
Environmental Quality/Ecology	60
Geography/Demography/Cartography	27
Geology	74
Hydrology	36
Interpretation Techniques Development	22
Meteorology	5
Oceanography	30
Sensor Technology	2
Total	305

The actual number of investigations finally approved may vary somewhat from the number listed above. As of July 5, 1972, contracts or agreements have been executed for investigations.

AGRICULTURE

Agriculture economists estimate that every $1.00 spent on remote sensing research promises to return $5.00 in benefits. These global benefits over the next two decades are forecasted to total $45 billion if the proper investments in control techniques are made.

The Department of Agriculture has been using remote sensing since the 1930s, in the form of black and white aerial photography to measure crop and land use acreages, for timber inventory and management, recreation and urban planning, soil mapping, etc. - Is also used in connection with other information to make crop yield estimates and other predictions vital to the management of the nation's agricultural programs.

Farm census is now taken every five years. Scientists anticipate that an Earth resources satellite may ultimately make it possible to take the census annually with a corresponding improvement in the accuracy of agricultural statistics and management.

Some of the types of crops which scientists will attempt to identify from ERTS-A data includes wheat, sugar beets, alfalfa, corn and grain sorgum, mixed grain, fields beans, potatoes, cotton, soy beans and spring wheat.

One of the proposals for ERTS-A is #049. The scientist in charge of this proposal is Dr. David A. Landgrebe from Purdue University. Dr. Landgrebe's proposal involves the study of the Wabash River Basin, an important agricultural area common to Ohio, Indiana and Illinois. It covers about two thirds of the State of Indiana, less than one third of the State of Illinois and a small part of Ohio.

"The largest land area in the Wabash River Basin is in agriculture," Dr. Landgrebe said. "This general area is part of the great corn belt. But we also grow a lot of soy beans and even some wheat and oats. Much of the area is still in the natural state. And we have a sizeable urban area. So we have a good mixture of land to study. ERTS photos will be a big help in providing us with the first good map of the vegetation of the Wabash River Basin."

While a lot of our time in this area has been devoted to agriculture, we've also spent a lot of time looking into the fields of geology, geography, hydrology, and general land use.

"We have an interesting activity going with the Marion County Division of Zoning and Planning (Marion County includes Indianapolis). We hope to work with the city and country urban planners in using ERTS imagery to help them determine the ways ERTS data can be useful in their planning activities.

"With most urban areas you always have the problem of trying to determine the best use of land--residential, industrial or agricultural. And even if you do have a well thought out plan for the best use of land, it's always a problem of keeping track of what's happening. With ERTS imagery we expect to show that the job can be done routinely and relatively inexpensively when you consider that the coverage will be every 18 days," said Dr. Landgrebe.

-more-

"Possibly the biggest achievement of ERTS-A will be its ability to repeatedly map large areas, more quickly and economically than in the past," Dr. Landgrebe concluded.

Remote identification of most crops can now be accomplished with multispectral aerial photographs. It also is possible to determine whether a crop is healthy or under severe stress.

Most experts predict that it may soon be possible to detect the stages of some plant diseases so that remedial action can be taken in time to save a crop. And, they expect someday to be able to use sequential images of a field in its various growth periods as a tool to assist in predicting yields.

During the 1971 growing season in the United States, several grovernmental agencies and selected corn belt states conducted a cooperative study of southern corn leaf blight. In 1970, about 15 percent of the U.S. corn crop, were destroyed because of this fungus disease, combined in some areas with severe drought.

Together with ground studies, high-altitude aircraft repetitively photographed about 116,000 square kilometers (44,787 square miles)of the corn belt, using special infrared and color film. Results of that study show that a disease such as corn blight can be successfully monitored through remote sensing.

FORESTRY

The Forest Service was directed by Congress in 1928 to maintain an inventory of the nation's forest resources on both private and public lands. Because of sheer size, more than about 2 million square kilometers (500 million acres) it has been difficult to keep an up-to-date inventory, and to stay abreast of the rapid changes in America's forests.

The northern temperature zone produces about 85 percent of the industrial wood consumed in the world. Yet it is the tropical forests (the Amazon Basin) which contain the largest share of the world's reserve of wood. The extent and productitivy of species or species groupings in tropical forests is largely unknown because man has never seen much of that area. ERTS-A will provide man with his first global reconnaissance inventory of timber.

"Not related to forestry, but an area where ERTS-A will play a great role is hydrology," said Dr. Colwell, Professor of Forestry at the University of California. "The snow line--where the line builds up in the winter and where it is when it starts to melt in the spring--will be of tremendous value in preparing reservoirs to handle the spring run-off without having a big flood.

"Another importance of ERTS-A will be the mapping of large areas that are being cleared of wildland to be put into suburban developments or agriculture," Dr. Colwell added. "ERTS imagery will show an area change on a seasonal basis. This will permit us to determine whether a pioneer who tried to establish agricultures in a previously uncultivated area made a go of it or had to fold his tent and leave.

"There is another area of importance to ERTS-A and that is cloud cover. While many people say that one of the disadvantages of space imagery is the fact you can't see certain areas of the Earth because of clouds, I think that clouds can be advantageous to a somewhat cooperating extent.

"By observing the amount of cloud cover over a given area, man can determine the annual amount of sunlight that is hitting the terrain below. This in turn will help him determine the best type of crop to be grown in any one given area," Dr. Colwell concluded.

Scientists working on the earth resources program predict that, ultimately, satellite imagery will provide information necessary for better forest management. For example, it will identify those forest areas being attacked by insects and disease in time to save them and be capable of providing early detection of forest fires.

-more-

OCEANOGRAPHY

The oceans, covering 70 percent of our planet, are the breeding grounds for many of our weather systems, are a source of food, a means of transportation, potential source of minerals, and an important indicator of the health of life-sustaining processes on Earth.

Oceans absorb carbon monoxide (CO) and carbon dioxide (CO_2), and provide oxygen, heat energy, and water vapor for the atmosphere. Photosynthesis in the ocean's surface layer is the key life process of the marine ecosystem. The effect of marine pollution on these life-sustaining processes is poorly known.

Because of the vastness of the seas many of these features from an economic standpoint, can be observed best from satellites.

Currently, technology is struggling with the problem of separating atmospheric effect from the ocean color signals. Visible sensing in the blue-green portion of the spectrum appears to have the greatest potential. While sensor technology is nearly adequate, much more understanding of fundamental phenomena will be required before ocean color sensing can be profitable used.

The health of the oceans can be assessed through their color. Blue oceans imply an absence of chlorophyll and, thus, low food productivity. The greener the ocean the greater its productivity. Measurements of "greeness," together with water temperature--a known factor in the feeding habits of fish--can provide valuable information for the fishing industry. Global surveys of ocean color and chlorophyll contour maps could provide insights into the health of the ocean, its ability to absorb CO and CO_2, rate or production of oxygen and release to the atmosphere and its implications to marine productivity.

One of the ERTS-A investigations concerned with oceanography is Proposal 172 under the direction of Dr. Karl Szekielda from the University of Delaware.

"We hope to get some idea of the distribution and the behavior of chlorophyl in the ocean and the dynamics of phytoplankton. We are especially interested in the relationship of phytoplankton with very small organisms having a diameter of about five microns because they are very important for the whole life cycle in the ocean.

"The big advantage of ERTS is going to be its ability to measure large areas, rapidly, which you ordinarily cannot do from ships. The concentration of chlorophyll changes very rapidly, in just a few days. If you take these same measurements from ships, it may take you a week or two to move from one region to another. By the time you reach your new destination, the whole picture might have changed. You would also need many ships. It just wouldn't be economical," Dr.Szekielda concluded.

Another oceanographic study is ERTS-A Proposal 063 directed by Dr. Fabian C. Polcyn of the University of Michigan.

"We are going to use ERTS photographs to locate underwater features hazardous to navigation with an accuracy better than what is now available," Dr. Polcyn said.

"The second problem we plan to look into with ERTS imagery is a way to measure water depth in this same geographical area. We have achieved about 10 percent accuracy of measuring water depths through aerial photography.

"We have been working with several techniques to measure water depth through remote sensing. One of the techniques involves the diffraction of waves over the shallow features by looking at the change in water wave length. The second technique involves computer processing of two light wavelengths from the ERTS multispectral scanner. The depth will be computed based on the selective transmissions of two different wavelengths.

"Color shading in ERTS photographs will display valuable information," said Dr. Polcyn. "The shallow areas will appear blue/green as opposed to darker blue shades for deeper water.

"Our results should be most helpful to navigators using these waters and similar waters around the world. Our findings will go to the National Oceanic and Atmospheric Administration and to the International Hydrographic Bureau in Monaco so that current navigation charts can be changed and updated," Dr. Polcyn concluded.

GEOLOGY

As a professor once said, "Unlike orchards, mines bear no second crop." The known mineral reserve of the world is not great when compared to the rapidity with which man uses it. However, things look better considering the new discoveries which might be available through remote sensing. Man's known reserves of oil, gas and minerals generally have increased rapidly during the past 20 years, due mainly to improvements in remote sensing.

ERTS-A is expected to improve the geologist's map of the distribution of rocks and structures exposed at the Earth's surface, which is one of his principal tools for discovering new mineral deposits.

It will be possible with satellite imagery to locate faults, and other anomalies which frequently indicate valuable mineral deposits, even when they are buried under sand.

"Contrary to what anyone says, we are not going to detect minerals from space," said Dr. Paul Lowman of the Goddard Space Flight Center. "It just can't be done." Dr. Lowman has been a leader in remote sensing the past several years as a principal investigator of space photography from the manned Gemini and Earth-orbiting Apollo spacecraft.

"What you will find from ERTS imagery are areas which look promising. Then you can go in there and further investigate these areas from the ground or through aerial photography.

"A good example of this is several previously undetected faults which I discovered near San Diego as a result of Apollo 9 photography of that area. As a result of a structural feature I noted after thoroughly analyzing Apollo 9 pictures, I decided to go and investigate. So after a five-hour plane ride and an hour and a half drive in a car I was there. After two days of field work I had it 'nailed down.' I had discovered several new faults. Without space photographs I could have spent years looking for those features in these peninsular ranges near San Diego.

"That's what is going to happen with mineral exploration from ERTS. You'll be able to pick the big structural features and that is the big thing geologically. If you know an area and you know what kind of structure is associated with ore deposits, this will enable you to pick the most promising areas for follow-up aerial photography or for drilling," Dr. Lowman concluded.

ERTS-A experiment proposal number 103 is interested in geology and will be run by the Argus Exploration Company, a research subsidiary of Cyprus Mines Corp., Los Angeles.

"Our proposal will cover quite a large area," said Mark Ligett, an Argus Exploration Company scientist.

"The area we are interested in crosses the Great Basin Province something like 77,970 sq. km (30,000 sq. miles). It covers a strip which goes from the eastern Sierra Nevada mountains in California to the Colorado Plateau in northern Arizona and western Utah.

"We are interested in this area for several reasons. We have some limited Apollo imagery (color photos from the early Earth-orbiting Apollo missions) that is oblique, which covers the lower portion of the southwestern United States. And we have studied some of this area with ground-based geological maps made during the past 100 years. And, we were immediately aware that many large regional structures show up in space imagery which aren't apparent in ground-based map geology," Ligett said.

"We are going to be interested mainly in the origins of structures. Some structures may be shear zones and others may be dike swarms.

"These structures form belts which are quite long and linear. They might be too subtle to recognize on maps and therefore we are enthusiastic about looking at them through remote sensing," said Ligett.

"Image enhancement of ERTS photos will help us determine if we can identify the anomalies that we see in some space imagery, and then try to assess their importance to geology and the significance they have as far as tectonics," Ligett said. Tectonics has to do with regional geologic structures -- the study of regional structural patterns and dynamics of the movement of the Earth's crust.

"We think some of these structures may have a lot to do with Volcanic activity and earthquakes. And they might also play an important role in mineral exploration and hydrology," Ligett concluded.

The general store of structural geologic information is expected to be upgraded through the acquisition of much data that would be impossible, difficult, or economically impractical to obtain by repetitive routine field mapping methods, or by similar low altitude aerial surveys.

Other possibilities, include: locations of mineral bearing fluids that form ore deposits; location of thermal anomalies in the surface which indicate the existence of subterrain geothermal power sources; location of rock fractures which leak lethal gases from underground fires into populated areas; and, a means of warning of volcanic eruptions.

- more -

HYDROLOGY

Many of the problems which face hydrologists will be somewhat helped by ERTS-A photos and the data collection system which will include remote platforms in streams.

For instance, one of the problems hydrologists face is the capacity of soil to store rainfall. They now must go into the field, examine the soil in a few selected spots an then make an estimate of a large area.

This is the current method used to develop mathematical models of water-sheds for dams and the volume of water they must hold. Hydrologists estimate that the estimates are often often incorrect by 50 per cent. With large dams costing hundreds of millions of dollars, large savings are possible by improving these estimates. Aircraft tests indicate that ERTS-A data can lead to a considerable improvement.

In many parts of the world fresh water is a precious commodity and ERTS-A imagery will facilitate its discovery. Water will be especially "photogenic" in the two near infra-red bands (0.7-0.8 and 0.8-1.1 micrometers). Water will show up very dark in this band and will contrast with vegetation which will appear very bright.

One of the hydrological experiments of ERTS-A is Proposal 114. Dr. Fabian C. Polcyn is the principal investigator from the University of Michigan.

"This experiment deals with mapping of terrestial features in the Lake Ontario Basin. ERTS results will be coordinated with the International Field Year on the Great Lakes (IFYGL) program. The program will try to determine how much water is running off and how much is naturally sinking into the land, what happens to it when it enters the lake, the amount of sediments entering the lake and the amount of beach erosion. Results from ERTS should provide a valuable input to the IFYGL terrestial water budget program, the water movement program and the biological chemical and fisheries program.

"We plan to put together a space picture of the entire Lake Ontario basin from about eight ERTS-A photographs. The montage will include not only the lake but the land area from which water drains into the lake. We are especially interested in obtaining the total standing water in the basin, the general land use practices and knowledge about soil moisture content.

"The United States faces a tremendous water management problem. Do you let the water being stored by our dams be used for recreation, keep it stored for electrical power, or use it for irrigation? ERTS imagery should give us many new inputs in these areas which should be of tremendous value," Dr. Polcyn concluded.

Efficient management of water requires maps of drainage patterns and good estimates of snow cover in mountain areas. ERTS information could improve this management in all parts of the world. And in many regions, it will provide the first solid information ever available, at a small fraction of the cost of conventional surveys.

GEOGRAPHY, CARTOGRAPHY AND DEMOGRAPHY

Almost four billion humans live on less than 20 per cent of the Earth's surface.

Remote sensing from ERTS-A will be a big step forward in man's ability to plan and use the land.

The sensors aboard ERTS-A will make the first systematic surveys of land use patterns over most of Earth's 151 million square kilometers (58 million square miles).

With all of the great technological advances, such as the use of aerial photography, and in spite of the tremendous resources which are expended yearly by the combined cartographic capabilities of all the advanced nations, the world remains less than 50 per cent adequately mapped.

Due to the vastness of our planet's surface and the rapid changes wrought by man, it has been impractical to keep abreast of even the gross surface patterns reflecting man's activities on a yearly, or much less for seasonal increments of time.

Yet, such measurements are needed to inventory cultural and natural resources and to evaluate man's potential for further land development.

Presently, only about 40 per cent of the nation is covered by the standard topographic map. Each quadrangle map now takes approximately four years to complete.

While ERTS-A photographs will not have the resolution of aerial photographs, they will cover very large areas and will be repetitive. ERTS photography will let mappers look for trends and changes over short periods of time, heretofore not possible.

A land use experiment for ERTS-A is Proposal 101, land use of northern megalopolis in the New England area. The investigator is Dr. Robert B. Simpson, a geographer from Dartmouth College in Hanover, New Hampshire.

"Our particular interests with ERTS-A photography," said Dr. Simpson, "are the problems of urban development, the spread of cities, the conversion of unused land into urban land in the New England area.

"We have selected two areas, Boston and New Haven, to study the problems of megalopolis, particularly the northern end. We have been using aerial photographs from about 15,000 meters (about 50,000 feet) which is a step-up from the old days of aircraft flights of around 3,300 meters (10,000 feet). It takes several hundred pictures from the lower altitude flights to cover a city while only a few pictures are required from the higher flights. For absolute detail in photointerpretation and for local planning purposes, photographs from the 3,300-meter (10,000-foot) level are ideal. But the trend for planning purposes is to go from the very detailed low-level photography to the more generalized larger area. A basis for this trend is that while community planning is important, regional planning is even more important over the long term," said Dr. Simpson.

"If we would have had ERTS imagery 25-30 years ago," said Dr. Simpson, "we probably would have much more green space between Washington, D.C., and the Boston area than we now have. The zoning practices around the cities along the Eastern Seaboard probably would have been a lot different also. ERTS pictures should hep us to better plan urban areas over large regions.

"We are interested in urban sprawl, particularly, how cities spread out and what types of land are most wanted. With ERTS-A imagery, we will look at four stages. The first stage will be to determine where the urban landscape is. The next step will be to determine why this imagery looks the way it does. The third step will be to predict future trends. The final step will be to take the necessary action required for the best use of the land.

"We plan to have the first ERTS-A mosaic of the region we are studying about two months after launching," Dr. Simpson concluded.

Another use of land involves the availability of grazing areas for livestock, ERTS-A proposal 147. This study is in charge of Gordon Bentley of the Department of Interior's Bureau of Land Management in Denver, Colo.

- more -

"I'm concerned with that property which is still considered public domain (those areas which have not gone into state ownership, private or into forest reserve)," said Bentley. "This is the land, much of it is in the Far West, which is left over from the original acquisitions of properties from other countries -- like the Louisiana purchase, and properties we obtained from Spain. This area today covers several thousand square kilometers," Mr. Bentley said. "My agency is in charge of administering just about everything that happens on this land such as recreation areas, timber and grazing areas. ERTS-A photography should be extremely helpful to us in the latter of these areas, grazing," said Bentley.

"The grazing areas we are concerned with include the southwestern portion of the United States, eastern Oregon and Alaska," said Bentley. "We lease large regions of these areas to livestock ranchers for grazing their herds."

"We are required to operate under the Taylor Grazing Act for managing this grazing land. Under this act, we can't license more forage than we can produce on the range. While this doesn't pose too much of a problem in most northern latitudes where forage is perennial, it can become a problem in the southwest where our grazing conditions may be good only two out of five years or even three years out of ten," said Bentley.

"Due to the lack of rain in the southwest, much of the area is desert shrub country and livestock makes very little use of desert shrubs. They are just not edible. But if we should get good moisture conditions in the area then we have good forage and ranchers from Arizona and California will want to truck in their herds for short term grazing.

"Our site in Alaska is north of Nome. Because Alaska is so large, much of the land has not been inventoried and we're hoping to use ERTS-A as an inventory tool to help us map the different types of vegetation.

"The area we plan to monitor in Oregon is the eastern part which is pretty dry. We want to monitor the effects of grazing management in that part of the state. Grazing is detrimental to plants. They need a rest on a yearly basis. So we plan to rotate our grazing areas from year to year and watch the results from ERTS photographs.

"Because we are talking about such large areas," said Bentley, "it's almost impossible to take an accurate vegetation inventory over a short period. We should be able to obtain good vegetation photos on a routine basis from ERTS-A," Bentley concluded.

ENVIRONMENTAL QUALITY/ECOLOGY

Environmental monitoring, from a pollution and health-of-the environment point of view, is still in its infancy. If man is going to improve his ecological system over the long term, then he must begin to monitor the health of his planet's air, water and land more accurately.

Water pollution is well suited for monitoring from space. Direct monitoring of pollution across all the Great Lakes, the Gulf of Mexico and major estuarian systems such as the Chesapeake Bay would be both time consuming and very expensive.

Pollution of the open oceans is of increasing concern. The vast expanses of oceans, which are a major source of heat, oxygen and water vapor in our atmosphere, can be most economically observed from space.

Oceans, which absorb carbon monoxide and carbon dioxide, are a valuable source of food. Yet, they have become a dumping place for many pollutants.

One of the ERTS-A proposals, 081, is concerned with water pollution. The scientist in charge is Dr. C. T. Wezernak from the University of Michigan.

"Out studies will be concerned with water pollution, water masses, color anomalies and pollution anomalies in several geographic locations. These locations are southest Florida, Tampa Bay, Lake Michigan, and Lake Erie, southern California and New York Harbor.

"We have a number of problems in these areas and there is something unique about each one. In the southeast Florida and California areas we are concerned with ocean outfalls, effluent fields and coastal processes. The Tampa Bay area is a good example of an estuary and the New York Harbor is a prime barge dumping area of chemicals and sewage sludge. And finally the Great Lakes, Lake Michigan and Lake Erie, where there is a great deal of public interest about water quality and water resources management.

"With ERTS-A imagery we will be looking for color anomalies and changes in suspended solids and in some cases oil slicks. The ERTS photos will be compared with aerial imagery of the same areas. While oil pollution is not one of our primary concerns we do plan to monitor it.

"Pollution will stand out well in the near infrared bands. There should be evidence of turbidity in ERTS photos over polluted areas.

"We want to study the movements and dispersion of pollutants, and maybe even discover some we didn't know about. We need ERTS imagery so we can plan remedial action. In the case of Lake Michigan and Lake Erie, we have never had the large picture look. ERTS photos will help us map pollution in the lakes and should be useful for planning corrective action where necessary," Dr. Wezernak concluded.

ERTS-A proposal 309 is concerned with detecting and monitoring strip mining in eastern Ohio. The proposal is in charge of Dr. Wayne Pettyjohn of Ohio State University.

"Our state has a tremendous population for its size and it possibly has more water pollution than any state in the union," said Dr. Pettyjohn. "Lake Erie and the Ohio River are good examples.

"The main interest we have in ERTS imagery is the eastern part of Ohio. Much of this area is underlaid with coal so a lot of mining has been carried out over the past 100 years."

"The last 30 years or so the technique of removing coal through underground mining techniques has changed to strip mining. This has disrupted huge areas and has had an effect in the long run on the quality of water in the streams drained from these areas. Mineralization increases astronomically in these streams, sulphate and iron become very high and very few types of aquatic life can live. In fact some streams are entirely barren of life," said Dr. Pettyjohn.

"One of the big problems is that we don't know how much area on a day-to-day, month-to-month or year-to-year basis has been stripped. In other cases we don't know where some of the old mines are. So I visualize that ERTS-A photographs will help us to map those areas which were mined years, many years ago, between 1935-1945 so we can evaluate the recovery of vegetation. I suspect that we will find some areas where vegetation can take over naturally and others where normal re-forestation techniques won't work," said Dr. Pettyjohn.

"I feel that if we can find those areas which have created the least water quality problem, then the state will be more inclined to issue more permits in those areas, for mining. However, if we can find those areas where there is a high iron sulphite content and a lot of acid generated, a different approach will have to be taken," Dr. Pettyjohn said.

"We already realize that we can't manage our area on a small basin-to-basin point of view, but must do it regionally," Dr. Pettyjohn concluded.

- more -

METEOROLOGY

To date, space technology and remote sensing from space have been applied to environmental monitoring primarily in the meteorological field.

The Earth's cloud cover has been routinely observed by remote sensors (cameras) from space since the world's first weather satellite, TIROS-1, was launched in 1960. Although TIROS-1 was an experimental weather satellite, the cloud-cover pictures it produced were gradually fed into daily weather forecasts of the U.S. Weather Bureau. Several TIROS developmental satellites followed TIROS-1 and in the short span of six years (1966), weather satellites became operational by the Commerce Department.

More recently, cloud motion, cloud top temperatures and moisture profile measurements have become operationally useful.

The 12-hour prediction which was possible more than 10 years ago has expanded to 36 hours, with an 80 per cent reliability. Meteorological satellites have played a big role in improving this weather forecasting capability.

ERTS-A Proposal 220 involved meteorology and is being directed by Dr. Walter A. Lyons from the University of Wisconsin, Milwaukee. The test site is in the general Lake Ontario and Lake Michigan area.

One of the goals of this experiment is to develop the total energy budget for Lake Ontario, of which incoming solar radiation is a most important term.

Research has shown that with few exceptions only convective clouds and stratus are affected by a large lake, like Lake Ontario. During the cold months, formation of convective snow squalls is a well known phenomena. "Heat and moisture from the lake surfaces causes bands of violent conventive snow storms to form over several thousand square kilometers in this area," said Dr. Lyons. "When these bands hit the lee shore, massive amounts of snow can fall, sometimes in excess of two feet in a day, typical areas include South Bend, Ind., and Oswego and Buffalo, N.Y.

"During the summer, the lake appears to likewise influence convective cloud distributions in a very regular manner. For instance, during periods of general warm advection across the cold lakes, cumulus clouds will slowly dissipate within a few kilometers of the shore leaving the lake and an 8 to 32 km (5 to 20 statute mile) strip of the downwind shore free of convective clouds.

"This ERTS-A experiment includes making a thorough census of cloud types and amounts over and around Lake Ontario. While the ERTS-A pictures will only be available over the Lake Ontario basin on two days per month, they still can serve a vital purpose in the daily cloud climatology program of that area."

Another meteorological experiment, ERTS-A Proposal 113, involves the freezing and thawing patterns of lakes in central North America. The principal investigator is Dr. Allan Jelacic of the Wolf Research and Development Corp., of Riverdale, Md.

In a detailed study of the physical limnology of several meromictic lakes in 1970, Dr. Jelacic found freezing and thawing of the surface waters to be closely interlinked with deep water circulation. An even closer relationship exists in the case of lake ice phenology. Climatic factors, such as wind and solar radiation, govern the thermal regime of any natural water body.

"Although a wealth of records on the freezing and thawing dates of lakes have existed for many years," said Dr. Jelacic, "no truly regional investigation was attempted until an aerial survey of lake freezing was carried out in the fall of 1961. This limited reconnaissance effort, called Operation Freezeup, covered south-central Canada and parts of Minnesota and Wisconsin," said Dr. Jelacic.

One of the principal results of Operation Freezeup was the definition of the boundaries of a transition zone, called the lake freezing zone, south of which all lakes were open and north of which all lakes were closed. Shallow lakes have less heat to give up to the atmosphere in comparison with deep lakes. Therefore, shallow lakes respond more readily to weather perturbations and freeze over sooner than deep lakes. As a result the northern boundary of the transition zone has been termed the deep lake freeze line while the southern boundary has been called the shallow lake freeze line.

ERTS-A imagery will be used to study the lake freeze/thaw transition zone over an entire year in mid-continent North America, between 40-70 degrees North Latitude and 85-110 degrees West Longitude.

This experiment is aimed at being able to predict the relative mean depth of lakes by observing their freezing sequence. It is hoped that this experiment will be able to forecast the freeze/thaw dates of numerous lakes and possibly other water bodies as well.

"A secondary objective of this experiment is to correlate weather patterns with migration of the transition zones (freezing and thawing patterns of lakes). John Martin, a meteorologist with Wolf is in charge of this experiment," Dr. Jelacic concluded.

- more -

THE DELTA LAUNCH VEHICLE

ERTS-A, weighing 891 kilograms (1965 lbs.), or 934 kg,(2,075 lbs.)including the adapter), will be the heaviest spacecraft ever launched by a Delta Rocket. The launch vehicle is Delta 89.

Delta has been a work horse booster for NASA for 12 years. It first orbited the Echo-1 communications balloon in August of 1960. Since then, Delta has orbited 81 major spacecraft in 88 attempts.

Delta has grown over the years to handle bigger spacecraft for more demanding space missions at a relatively low cost. The various stages of the Delta have grown longer and fatter, the engines have become more powerful, and solid motors have been added to the first stage. In 1960, Delta was capable of orbiting 136 kg (300 lbs) in a low Earth orbit of 805 km (500 statute miles). Today's Delta can boost 1,134 km (2,500 lbs.) into the same 805 km (500 statute miles) orbit.

Several changes have been included in the Delta 89 vehicle. They include:

A new inertial guidance system named Delta Inertial Guidance System (DIGS);

A new second stage engine, an adaptation of the Air Force Transtage used on the Titan-3 rocket;

A new spring separation technique for the first and second stages; and

A new S-Band telemetry system

Also, Delta 89 will carry nine solid motors strapped around the base of the Thor for the first time (the rocket has previously carried six solid motors). Six of these motors will ignite on the launch pad and three at altitude, about 6 kilometers (four statue miles).

-more-

The all inertial (DIGS) guidance system, consisting of an Inertial Measurement Unit (adapted from the Apollo Lunar Module) and digital guidance computer (adapted from the Centaur launch vehicle program), control the vehicle and sequence of operations from lift-off to spacecraft separation. The sensor package provides vehicle attitude and acceleration information to the guidance computer. The guidance computer generates vehicle steering commands to each stage to correct trajectory deviations by comparing computed position and velocity against prestored values. This system will permit more accurate orbits and will be more flexible than the radio command guidance system used by the earlier Delta rocket.

The new second stage engine will increase the thrust from 3,402 kg (7,500 lbs) to 4,309 kg (9,500 lbs). The new engine will also have a higher specific impulse, which means the engine runs more efficiently.

The general characteristics of the Delta 89 for the ERTS-A mission are:

Total Height:	33 m (107 ft.)
Total Weight:	About 113,400 kg (250,000 lbs)
Maximum Body Diameter: (Not including solids)	2.44 m (8 ft.)

The Delta first stage is a modified Thor booster incorporating nine strap-on solid fuel rocket motors. The booster is powered by an engine using liquid oxygen and RJ-1 Kerosene. The main engine is gimbal mounted to provide pitch and yaw control from lift-off to main engine cut-off (MECO). Two liquid propellant vernier engines provide roll control throughout the first stage operation, and pitch and yaw control from MECO to first stage separation.

The second stage is powered by a liquid-fuel pressure-fed engine which is also gimbal mounted to provide pitch and yaw control through second stage burn out. The second stage propellants are Nitrogen Tetroxide (N_2O_4) for the oxidizer and Aerozine 50 for the fuel. A nitrogen gas system using eight fixed nozzles provides roll control during powered and coast flight as well as pitch and yaw control after second stage cutoff.

-more-

The Delta program is managed for NASA's Office of Space Science by the Goddard Space Flight Center. Launch services are provided by the Kennedy Space Center of NASA. The Delta prime contractor is McDonnell Douglas, Huntington Beach, Calif.

The Flight

The Thor main engine and six of the solid motors are ignited at lift-off, and the remaining three solids are ignited later at altitude. Between T plus 100 and 105 seconds the vehicle is yawed approximately 2.1 degrees to achieve the desired inclination of the transfer orbit.

The ERTS-A flight plan calls for the second stage to undergo two burns. The first burn will place the vehicle into an elliptical transfer orbit with a perigee (closest point to Earth) of 185 km (115 statute miles) and an apogee (farthest point from Earth) of about 890 km (553 statute miles).

The orbiting second stage will be restarted (about 57 minutes after lift-off) over the Indian Ocean near Tananarive to circularize the ERTS-A orbit. This second burn will last for 11 seconds.

About 13 minutes after the second stage shuts down for the second time, the ERTS-A separation sequence will begin. Gas jets aboard Delta will turn it, and ERTS-A, to an attitude of 80 degrees of the local verticle of the Earth. A spring system will then separate or push ERTS-A away from the Delta. The ERTS-A attitude and control subsystem will then be activated so the spacecraft becomes Earth oriented and stabilized in all three axes.

About seven minutes after spacecraft separation (about T plus 77 minutes) the Delta second stage will be ignited for the third time in a special test related to the restart capability of the new second stage. This third and final burn will place the Delta second stage into a perigee of 604 km (398 statute miles) and an apogee of 908 km (564 statute miles).

MAJOR DELTA 89/ERTS-A FLIGHT EVENTS

Event	Time	Altitude	Velocity (Kilometers Per Hour)
First Solid Motors Burn-out (six solids)	T plus 39 sec.	6 km (4 s.m.)	1536 km/HR (955 mph)
Three Solid Motors Ignite	T plus 39 sec.	6 km (4 s.m.)	1536 km/HR (955 mph)
Second Solid Motor Burnout (three solids)	T plus 1 min. 18 sec.	21 km (13 s.m.)	3072 km/HR (1909 mph)
Solid Motor Separation (all nine solids)	T plus 1 min. 25 sec.	27 km (16 s.m.)	3511 km/HR (2182 mph)
Main Engine Cut Off (VECO)	T plus 3 min. 40 sec.	101 km (63 s.m.)	17,150 km/HR (10,657 mph)
Vernier Engine Cut Off (VECO)	T plus 3 min. 46 sec.	102 km (63 s.m.)	17,157 km/HR (10,660 mph)
Stage I, Stage II Separation	T plus 3 min. 48 sec.	104 km (65 s.m.)	17,040 km/HR (10,588 mph)
Stage II Ignition	T plus 3 min. 52 sec.	108 km (67 s.m.)	17,128 km/HR (10,575 mph)
Jettison Fairing	T plus 4 min. 25 sec.	130 km (81 s.m.)	17,730 km/HR (11,016 mph)
1st Second Engine Cut Off (SECO)	T plus 9 min. 11 sec.	185 km (115 s.m.)	28,785 km/HR (17,887 mph)
Restart Second Stage	T plus 57 min.	909 km (565 s.m.)	25,928 km/HR (16,111 mph)
Second SECO	T plus 57 min. 11 sec.	909 km (565 s.m.)	26,635 km/HR (16,550 mph)
Spacecraft Separation	T plus 70 min. 35 sec.	907 km (564 s.m.)	26,636 km/HR (16,551 mph)

ERTS-A PROJECT OFFICIALS

NASA Headquarters, Washington, D.C.

Charles W. Mathews	Associate Administrator for Applications
Dr. John DeNoyer	Director, Earth Observations Programs
Dr. Arch B. Park	Chief, Earth Resources Survey Program
Bruton B. Schardt	Program Manager
Charles D. Centers	Program Engineer
Joseph B. Mahon	Director, Launch Vehicles and Propulsion Program
I. T. Gillam IV	Delta Program Manager

Goddard Space Flight Center, Greenbelt, Md.

Dr. John F. Clark	Director
Robert N. Lindley	Director of Projects
Harry Press	Associate Director for Earth Observation Satellites
Wilfred E. Scull	Project Manager
Stanley Weiland	Deputy Project Manager
Wilber B. Huston	Assistant Project Manager
Thomas M. Ragland	Assistant Project Manager
Gilbert A. Branchflower	Observatory Manager
Dr. William Nordberg	Project Scientist
Dr. Stanley C. Freden	Chief Scientist for Meteorology and Earth Sciences
Joseph Arlauskas	Multispectral Scanner Technical Officer

-more-

GSFC cont'd

Walter D. Bradley	Network Support Manager
Luis Gonzales	Ground Data Handling System Manager
John M. Hayes	Wide Band Video Tape Recorder Technical Officer
Earl Painter	Data Collection System Technical Officer
William R. Schindler	Delta Project Manager
Oscar Weinstein	Return Beam Vidicon Camera Technical Officer

Kennedy Space Center, Florida

Robert Gray	Deputy Director of Launch Operations
John Neilon	Director of Unmanned Launches
Henry R. Van Goey	Manager, KSC-WTR Operations
Joseph Schwartz	Deputy Manager, KSC-WTR Operations
Bud Thacker	Chief, Delta Operations
Gene Langenfeld	Spacecraft Coordinator for ERTS - KSC-WTR

Department of Agriculture

Joseph Clifton	Agricultural Stabilization and Conservation Service
Robert H. Miller	Agricultural Research Service
Robert Otto	Economic Research Service
Donald Von Steen	Statistical Reporting Service

Department of Commerce
National Oceanic and Atmospheric Administration

Dr. William O. Davis	Chief, Upper Atmosphere and Space Division
Douglas H. MacCallum	ERTS Coordinator, NOAA/NESS

General Electric Company, Valley Forge, Pa.

I. S. Hass	General Manager, Earth Observatory Programs
L. T. Seaman	Manager, Observatory Systems Program
R. H. J. King	Manager, Earth Observatory Program Ground System
D. J. DiGiovacchine	Deputy Manager, ERTS Program
W. D. Wood	Data Collection System Project Manager

Hughes Aircraft Company, Culver City, Calif.

John Housego	Multi-Spectral Scanner Project Manager

McDonnell-Douglas Astronatics Company, Huntington Beach, Calif.

E. W. Bonnett	Delta Project Manager

RCA, Princeton, New Jersey

Robert Miller	Return Beam Vidicon Camera Project Manager
C. R. Thompson	Program Manager, ERTS Wide Band Video Tape Recorder

EROS Program Officials

Dr. V. E. McKelvey	EROS Program Director, and Director, USGS
William Fischer	EROS Program Manager
Charles Robinove	Associate Program Manager
Edward Risley	Staff Assistant for Program Development
Raymond Fary	Assistant Program Manager for Technical Information Management
W. D. Carter	Assistant Program Manager for Applications Research
Glenn Landis	Chief, EROS Data Center Sioux Falls, S.D.
Gary North	Regional Data Center Albany, N.Y.
Janice Whipple	Regional Data Center
Stanley Addess	NASA Liaison
Alvin Colvocoresses	Research Coordinator, Mapping Requirements
Robert Alexander	Research Coordinator (Acting) Geography and Human-Cultural Resources
Wm. Hemphill	Research Coordinator, Mineral and Land Resources
Morris Deutsch	Research Coordinator, Water Resources

-more-

ERTS-A MAJOR CONTRACTORS

Company	Responsibility
General Electric Company Space Division Valley Forge, Pa.	ERTS-A spacecraft, Ground Data Handling System and Data Collection System
Hughes Aircraft Company Culver City, Calif.	Multispectral Scanner
RCA-Astro-Electronics Div. Princeton, NJ	Return Beam Vidicon Camera System
RCA Government and Communications Systems Division Camden, NJ	Wide Band Video Tape Recorder System
General Electric Company Space Division Valley Forge, Pa.	Prime Contractor
Bendix Corporation Navigation and Control Division Teterboro, NJ	Pitch and Haw Wheels
California Computer Products Anaheim, Calif.	Command Clock
Centralab El Monte, Calif.	Solar Cells
Fairchild Hiller Industries Germantown, Maryland	Attitude Control Systems Structure
General Electric Company Electronics Components Division Battery Products Section Gainesville, Florida	Storage Modules
Goodyear Aerospace Corp. Akron, Ohio	Substrate Platforms for Solar Arrays
Ithaco, Inc. Ithaca, New York	Attitude Control System Reaction Wheels Scanner Subsystem Magnetic Moment Compensation Assembly Dual Flake Bolometer

Contractors, Continued

Leach Corporation Control Division Azusa, Calif.	Narrow Band Tape Recorder
Motorola Government Electronics Div. Scottsdale, Arizona	Unified S-Band Equipment Flight and Ground
Northrop Corporation Electronics Division Norwood, Massachusetts	Yaw Rate Gyro Gas Bearing Gyro

- more -

ERTS-A Major Contractors

Company	Responsibility
Quantic Industries San Carolos, Calif.	Attitude Measurement System
Radiation, Inc. Melbourne, Fla.	Data Collection Systems Versatile Information Processor Airborne and Ground Station Equipment
RCA Astro-Electronics Division Princeton, NJ	Return Beam Vidicon checkout equipment, Command receiver spacecraft power supply
Rocket Research Corporation Redmond, Wash.	Orbit adjustment subsystem
SCI Electronics, Inc. Huntsville, Ala.	Pre-modulator processor (spacecraft electronics)
Sperry Rand Corporation Gyroscope Division Great Neck, N.Y.	Rate Measurement Package
TRW Systems Group Electronic Systems Division Redondo Beach, Calif.	Solar Array Drive Attitude Control Systems Pneumatics
Watkins-Johnson Company Palo Alto, Calif.	Wide-band power amplifier

Major Multi-Spectral Scanner Contractors

Hughes Aircraft Company Culver City, Calif.	Prime Contractor
Ampex Corporation Redwood City, Calif.	Ground Tape Recorder
Bendix Corporation Mosaic Fabrication Division Sturbridge, Mass.	Fiber Optics

-more-

Contractors cont'd

Company	Responsibility
International Telephone and Telegraph Electron Tube Division Fort Wayne, Ind.	Photomultiplier Tubes
Litcom-Division of Litton Industries Melville, N.Y.	Photo Recorder
Santa Barbara Research Center Santa Barbara, Calif.	Scanner
Speedring Systems Division of Schiller Industries Warren, Mich.	Beryllium Scan Mirror
United Detector Technology Santa Monica, Calif.	Silicon Photo Diodes

Major Data Collection System Contractors

General Electric Company Space Division Valley Forge, Pa.	Prime Contractor
General Electric Company Apollo Ground Systems Department Daytona Beach, Fla.	Data Collection Platform Production
Radiation Inc. Melbourne, Fla.	Systems Development

Major Return Beam Vidicon Camera Contractors

RCA Astro-Electronics Division Princeton, N.J.	Prime Contractor
Fairchild Camera & Instrument Corporation Space & Defense Systems Div. Syossett, N.Y.	Precision optics for the cameras
RCA Electronic Components Industrial Tube Division Lancaster, Pa.	Tubes for the camera

Major Ground Data Handling System Contractors

Company	Responsibility
General Electric Company Space Division Valley Forge, Pa.	Prime Contractor
Bendix Corporation Bendix Aerospace Systems Division Ann Arbor, Mich.	Image Generation System
Computer and Software Inc. Los Angeles, Calif.	Maintenance and Operation of the NASA Data Processing Facility (NDPF)
Eastman Kodak Rochester, N.Y.	Film and Automatic Film Processors
RCA Service Company Camden, N.J.	Maintenance and Operation of the Operations Control Center (OCC)
Wolf Research and Development Corp. Riverdale, Md.	Ground Data Handling Systems, Software
ODS Xerox Data Systems Rockville, Md.	Ground Data Handling Systems, Computers

Major Delta Launch Vehicle Contractors

McDonnell Douglas Astronautics Company Huntington Beach, Calif.	Prime Contractor
Aerojet General Corporation Sacramento, Calif.	Second stage propulsion system
Hamilton Standard Division of United Aircraft Corp. Farmington, Conn.	Inertial Measuring Unit Portion of the inertial guidance system

Contractors cont'd

Company	Responsibility
Rocketdyne, North American Rockwell Corporation Canoga Park, Calif.	First stage main engine and vernier engines
Teledyne Industries, Inc. Northridge, Calif.	Computer for inertial guidance system
Thiokol Chemical Corporation Elkton, Md.	Solid Motors

ERTS-A PRINCIPAL INVESTIGATORS
(under contract or agreement)

Investigators	Investigations
Abdel-Gawad, Dr. Monem North American Rockwell Corp. Science Center 1049 Camino Dos Rios Thousand Oaks, California	Identification and Interpretation of Tectonic Features from ERTS-A Imagery
Acosta, Carlos Del Campo Consejo des Recursos Naturales no Renovables Ninos Heros #139 Mexico 7, D.F., Mexico	Geomorphological Features & Location of Mineral & Nonmineral-Bearing Fault Systems
Aguilar, Silvino Anguiana Dept. of Agri. & Livestock Bur. of Geography & Meteorology Tacubaya, D.V., Mexico	Study of Natural Resources of the State of Chiapas
Amaral, Gilberto, Dr. Projeto Sere, Inpe Caixa Postal 515 Sao Paulo, Brazil	Regional Geological & Mineral Resources Survey
Anderson, Richard R., Dr. American University Dept. of Biology, Hurst Hall Washington, D.C.	Wetlands Mapping & Monitoring with ERTS
Bernstein, Ralph Federal Sys. Div. IBM Corp. 10100 Frederick Pike Gaithersburg, Maryland	All-Digital Processing of ERTS Images
Bodenlos, Alfred J. U.S. Geological Survey Washington, D.C.	Study of MSS Imagery ERTS-A, N.W. Saudi Arabia

- more -

Investigators	Investigations
Bremnes, Ole H. Norwegian Meteorological Inst. Oslo, Norway	Studies of Sea Ice in Spitzbergen Area, Formation of Convection Clouds
Brewer, William A., Dr. Earth Satellite Corp. 2150 Shattuck Avenue Berkeley, California	Evaluation of Potential ERTS-A Data for Mineral Exploration
Busuego, Fernando Director, Bureau of Mines Manila, Philippines	Use ERTS-A Images for Natural Resources Investigation in Philippines
Cabrera, Bulmaro Ruiz Bureau of Research & Labs Roads Div., Photogremmetry Br. Mexico, D.F., Mexico	Study of Orizaba-Veracruz Test Area
Calderon, Gustavo Riveroll Lighthouses & Hydrography Bur. Dept. of the Navy Mexico, D.F., Mexico	Oceanography Program
Campbell, P.I. Water Survey of Canada Inland Waters Branch Sir Charles Tupper Bldg. Ottawa, Ont. KIA OH3, Canada	Application for use of ERTS-A for Retransmission of Water Resources Data
Cast, Larry D. U.S. Bureau of Reclamation Region 7, Federal Center Denver, Colorado	Remote Sensing of Reclamation Projects
Collins, Robert, Dr. Eason Oil Company 5225 N. Shartel Avenue P.O. Box 18755 Oklahoma City, Oklahoma	An Evaluation of the Suitability of ERTS Data for the Purposes of Petroleum Exploration

- more -

Investigators	Investigations
Cooper, Saul N.E. Div. USA Corps of Engineers 424 Trapelo Road Waltham, Massachusetts	The Use of ERTS Imagery in Reservoir Management and Operations
Corao, Manuel J. Ministry of Public Works 427825 Caracas Venezuela	Investigation of Urban-Regional Planning in Venezuela
Daniel, James F. U.S. Geological Survey 2222 Schultz Road St. Louis, Missouri	Performance of the ERTS Data Collection System in a Total System Context
Danko, John M. RCA Astro-Electronics Div. P.O. Box 800 Princeton, N.J.	Meteorological Utility of High Resolution Multispectral Data
De Azevedo, Luiz Henrique, Dr. Ministry of Mines & Energy DNPM-Project RADAM 54 Avenida Portugal, URCA Rio de Janiero, Brazil	Analysis of Earth Resources & Factors Governing Environmental Quality in Amazon Region
De Mendonca, Fernando, Dr. Director General, I.N.P.E. C.P. 515 - Sao Jose dos Campos Sao Paulo, Brazil	Surveying Natural & Cultural Resources
Crew, James V., Dr. 412 Administration Bldg. University of Nebraska Lincoln, Nebraska	Mapping and Managing Soil and Range Resources in the Sand Hills Region

- more -

Investigators	Investigations
Edson, Dean T. U.S. Geological Survey 1340 Old Chain Bridge Road McLean, Virginia	Investigation ERTS-A Imagery for Application to Thermatic Mapping
Eibenschultz, Juan Federal Electric Power Comm. Res. Inst. of Electric Power Ind. Mexico, D.F., Mexico	Use of Remote Sensors for Locating & Defining Anomalous-Temperature Zones
Fletcher, Alvaro Gonzalez, Dr. C.I.A.F. Apartado Nacional 762 Chapinero Bogota, Columbia	ERTS Application Program for Lower Magdalena & Casca Valleys
Fryrear, D.W. USDA Big Spring Field Station P.O. Box 909 Big Spring, Texas	Erosion of Soils
Gama, Emmanuel Comissao Nat'l. de Atividades Espaciais C.P. 515 Sao Jose dos Campos Sao Paulo, Brazil	Develop Method of Bathymetric Studies from Satellite Imagery
Garcia, Luis, Dr. Instituto Geografico Nat'l. Av Las Americas 5-76 Zona 13 Guatemala City, Guatemala	Res. & Land-use in Soil Eros., Deficit, Deforest & Floods; Geologic Mapping & Tectonic Structure Delineation
Glover, Lynn III Dept. of Geological Sciences Virginia Polytechnic Institute Blacksburg, Virginia	Geological Landform Analysis in Central Piedmont

- more -

Investigators	Investigations
Goetz, A.F.H., Dr. 183-501 Jet Propulsion Lab Pasadena, California	Appl. of ERTS & EREP Images to Geol. Invest. of Basin & Range-Colorado Plateau Boundary in Arizona
Gramenopoulos, Nicholas Itek Corporation 40 Maguire Road Lexington, Massachusetts	Automated Thematic Mapping and Change Detection of ERTS-A Images
Haefner, Harold, Dr. Dept. of Geography University of Zurich Pluem Lisalpstrasse 10 Zurich, Switzerland	Snow Survey & Vegetation Growth in Swiss Alps
Hall, Dr. Ralph C. Natural Resources Mgmt. Corp. 2150 Shattuck Avenue Berkeley, California	Detection and Monitoring of Forest Insect Infestation in the Sierra Nevada Mountains in California
Hanson, Kirby J. NOAA, Atlantic O & M Labs Sea Air Interaction Lab 461 S. Miami Avenue Miami, Florida	Remote Detection of Oceanic Eddies in the Lesser Antilles
Harting, William Tri-State Regional Planning 100 Church Street New York, NY	Detect and Identify Development or Changes in Land Use Patterns for Regional Planning Purposes

- more -

Investigators	Investigations
Heller, Robert C. Pacific S.W. Forest & Range Station U.S. Dept. of Agriculture P.O. Box 245 Berkeley, California	Inventory of Forest & Rangeland Resources (Including Stress)
Hendrickson, J.R., Dr. The University of Arizona Biological Sciences Department Tucson, Arizona	The Study of the Marine Environment of North Gulf of California
Hepworth, J.V., Dr. Geo. Survey & Mines Dept. Private Bag 14 Lobatse, Botswana	Investigation of Geological Structure of Kalahar Basin
Hidalgo, John U. Eng. Sciences Environment Center Tulane University 6823 St. Charles Avenue New Orleans, Louisiana	Prelim. Study of Lake Pontchartrain & Vicinity Using Remotely Sensed Data from ERTS
Higuera, Hector R. M. Nat'l. Commission on Outer Space Zola & Ave. Universidad Mexico 12, D.F., Mexico	Nat'l. Program on Remote Sensors
Isachsen, Yngvar W. Geological Survey N.Y. State Museum and Science Service Albany, New York,	Evaluate ERTS-A Data for Usefulness as Geological Sensor
Jain, R. K., Dr. U.S. Army Corps of Eng. Research Laboratory P.O. Box 4005 Champaign, Illinois	Evaluate Effects of Construction & Staged Filling of Reservoirs on Environment & Ecology
Jelacic, Allan, Dr. Wolf R&D Corp. 6801 Kenilworth Avenue Riverdale, Md.	The Interdependence of Lake Ice & Climate in Central North America

- more -

Investigators	Investigations
Katili, John A. Indonesian Inst. of Science Tengku Tjhik Ditiro 43 Djakarta, Indonesia	Topographical Mapping and Remote Sensing Study of the Barito River Basin and Bali
Koopmans, Bastiaan N., Dr. C.I.A.F. Apartado National 762 Chapimero Bogata, Colombia	Program for the Llanos Orientales-Colombia
Kosco, William J. Topographic Division U.S. Geological Survey 1340 Old Chain Bridge Road McLean, Virginia	Man-Made Culture Interpretation & Culture Revision of Small-Scale Maps
Kuusela, Kullervo, Dr. Forest Research Institute Unioninkatu 40A Helsinki 17, Finland	Earth Resources Program in Finland
Landgrebe, David A., Dr. Lars/Purdue University 1220 Potter Drive West Lafayette, Indiana	A Study of the Utilization of ERTS-A Data from Wabash River Basin
Lee, Joung Hwan, Dr. Geological Survey of Korea Ministry of Science and Technology 125 Namyong Dong Seoul, Korea	Investigations of Geologic & Structural Features of Korean Peninsula
Lind, A.O., Dr. Univ. of Vermont Dept. of Geography Burlington, Vermont	Environmental Study of ERTS-A Imagery, Lake Champlain Basin

- more -

Investigators	Investigations
Lyons, Walter A. Dept. of Geography University of Wisconsin Sabin Hall, Room 301 Milwaukee, Wisconsin	Use of ERTS-A Satellite Data in Great Lakes Mesometeorological Studies
Mascanzoni, Bruno Mexican Petroleum Institute Av. Cien Metros #500 Esquina Calz Atzcapotzalco Mexico 14, D.F., Mexico	Establish Bases for Study of Geological & Structural Features
Maughan, Paul M., Dr. Earth Satellite Corp. 1771 N Street, N.W. Washington, D.C.	Improve Menhaden Fishery Detection & Prediction Using ERTS-A
Maul, George A. NOAA/ADML Miami, Florida	Remote Sensing of Ocean Currents
Mcewen, Robert B. U.S. Geological Survey McLean, Virginia	Cartographic Evaluation of ERTS Orbit & Attitude Data
Miller, William D. Geoscience Department Texas Tech. University Lubbock, Texas	Water Budget of Tex. High Plains Plaza Lakes
Mohr, Paul, Dr. Smithsonian Astrophysical Observatory 60 Garden Street Cambridge, Massachusetts	Mapping of the Major Structures of the African Rift System

- more -

Investigators	Investigations
Morley, L. W., Dr. Dept. of Energy, Mines & Res. Ottawa, Canada	Pilot Study to Provide Economic & Effective Info Sys to Respond Rapidly to Needs of Res. & Environment
Myers, Victor Remote Sensing Inst. South Dakota State Univ. Brookings, S.D.	Effective Use of ERTS Multisensor Data in the Great Plains Corridor
Odegaard, Helge State Power Board Oslo 3, Norway	Snow Surveying to Assess Risk of Spring Flood and Snow Storage in Areas of Hydropower Stations
Otterman, Joseph Dept. of Environ. Sciences Tel-Aviv University Tel-Aviv, Israel	Multidisciplinary Uses in Israel
Palosuo, Erkki, Dr. Institute for Marine Research Takitorninkatu 2 Helsinki 14, Finland	Application of Satellite Data to Hydrology & Ice Survey
Paulson, Richard W. Pennsylvania District Water Resources Division U.S. Geological Survey Harrisburg, Pa.	Near Real-time Water Resources Data for River Basin Management
Pettyjohn, Wayne, Dr. Ohio State University Columbus, Ohio	Determine Utility of ERTS to Detect & Monitor Area Strip Mining & Reclamation
Pilonero, Joseph T. USGS Topographic Div. McLean, Virginia	Investigation of ERTS RBV & MSS Imagery for Photomapping

- more -

Investigators	Investigations
Place, John L., Dr. USGS Washington, D.C.	Interpret ERTS Images to Produce a Land Use Map & Computer Model of Phoenix Quadrangle
Polcyn, Fabian C. Willow Run Laboratories University of Michigan Ann Arbor, Michigan	To Use Space Acquired Imagery for the Measurement of Water Depth
Pomalaza, Jose C. Instituto Geofisico Del Peru Lima, Peru	Study of Santa River Basin
Rehder, John B. Dept. of Geography Univ. of Tenn. Knoxville	Geographic Applic. to Rural Landscape Change
Reimnitz, Erk U.S. Geological Survey Menlo Park, Calif.	Studies of Inner Shelf & Coastal Sedimentation Environment of Beaufort Sea From ERTS-A
Rey, Paul Augustin Free Univ. of Berlin Lehrstuhl fur Angewandte Geo. 1 Berlin 33, Wichernstr 16 Germany	Management of Natural Resources through Automatic Cartographic Inventory
Rogers, Dr. Ernest H. The Aerospace Corporation Los Angeles, Calif.	Remote Haze Detection
Romero, Adolfo C., Dr. Direccion de Cartografia Nac. EDF, Camejo Centro Simon Bolivar Caracas - 101 - Venezuela	Venezuela Development of Techniques to Investigate & Estimate Natural Resources in Remote Areas

- more -

Investigators	Investigations
Saa, Rene Institute de Investigacion de Recursos Naturales Santiago, Chile	Changes in Rural Land Use in Central & North Chile
Schmidt, Robert G. USGS, Bldg. #10 Washington, D.C.	Analysis Study of Multispectral Data from ERTS-A in W. Pakistan
Shown, Lynn M. USGS Federal Center Bldg. 25, Rm. 1818 Denver, Colorado	Determine Utility of Imagery in Preparation of Hydrologic Atlases of Aridland Watershed
Simpson, Robert B. Dept. of Geography Dartmouth College Hanover, NH	Land Use of Northern 1/3 of Megalopolis & Create Appropriate Maps & Data Bank
Skulberg, Olav M. Royal Nor. Council-Sci. & Ind. RS Norwegian Inst. for Water Res. Oslo 3, Norway	Multidisciplinary Study
Spencer, Donald J., Dr. TRW Systems Group One Space Park Redondo Beach, Calif.	ERTS Image Data Compression Technique Evaluation
Stoeckeler, Ernest G. Maine State Highway Dept. Box 1208 Bangor, Maine	Detection and Monitoring Vegetation Damage Associated with Highways and Highway Facilities

- more -

Investigators	Investigations
Strong, Alan E., Dr. NOAA (NESS) Washington, D.C.	Evaluation of ERTS Data for Certain Oceanographic Uses
Swanlund, George D. Honeywell, Inc. St. Paul, Minn.	Automatic Photointerpretation for Land Use Management in Minnesota
Szekielda, Dark-Heinz, Dr. College of Marine Studies University of Delaware Newark, Delaware	Dynamics of Plankton Populations in Unwelling Areas
Thomas, Edwin L. Md. Dept. of State Planning Baltimore, Md.	Application of ERTS-A Data to Integrated State Planning in Md.
Thomas, Jean-Claude, Dr. Geography Dept. Catholic University Washington, D.C.	ERTS Data Analysis of Rhone Delta
Thomson, Fred J. Willow Run Laboratories The University of Michigan Ann Arbor, Michigan	Map Terrain Features in Yellowstone National Park
Thomson, Fred J. Willow Run Laboratories Univ. of Michigan Ann Arbor, Michigan	Determination of Atmospheric Effects on the Performance of Spectral Pattern Recognition Devices
Tuominen, H. V., Dr. University of Helsinki Helsinki, Finland	Major Crustal Fractures in Baltic Shield
Vaca, Jorge F. Hindjosa Bureau of Economic Studies Study Comm. of Nat'l. Terr. Photointerpretation Div. Mexico, D.F., Mexico	Comprehensive Study of Leon-Queretaro Area

- more -