PRELIMINARY DEMONSTRATION OF REMOTE SENSING AND OTHER DATA TO BE UTILIZED IN THE REGIONAL RESOURCES BASIC INVENTORY FOR THE GREAT SMOKY MOUNTAINS NATIONAL PARK (GSMNP) AND REGION

OCTOBER 29, 1973

NPS/MTF
Task 1
10/29/73

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This report, with the accompanying base mosaic (of satellite photographs) and thematic overlays, is prepared in accordance with MTF Technical Work Request No. NP-1001 to demonstrate the potential capability for display of Resources Basic Inventory data.

Figure 1 is a compact map of the GSMNP, and Figure 2 shows the eleven counties which constitute the GSMNP Region.

Appendix A describes the base mosaic (or photo mosaic). Appendices B, C and D give some detail concerning the overlays about land ownership, transportation and soils. Appendix E gives general information (including age) regarding the standard topographical maps which were used.

Appendix F is a reprint of the article "ERTS and EROS" written by the staff of EROS program in March 1972. ERTS is a acronym for the Earth Resources Technology Satellite. EROS is a acronym for the Earth Resources Observation Systems Program of the Department of the Interior and the U. S. Geological Survey.

The base mosaic (Appendix A) was compiled from one spectral band of the Earth Resources Technology Satellite (ERTS-1). When combined with the information contained in other spectral bands, and when processed by suitable computation equipment, a great variety of thematic maps can be produced. Because of the limited time available, it was not possible to present anything but the rudimentary information contained in one band.

FIGURE 1

COMPACT MAP OF GSMNP

FIGURE 2

11 COUNTIES IN GSMNP REGION

(Sept. 19 9)

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

DETAIL OF PROGRAM REQUIREMENTS

GPO 901-813

FUNCTION OR ACTIVITY (1)	AMOUNT $ (2)	NUMBER POS. PERM. (3)	MY PERM. (4)	NUMBER POS. TEMP. (5)	MY TEMP. (6)	AREA PRIORITY (7)	JUSTIFICATION DETAIL (8)	TYPE (9)
FY 1975	3,125,000	25	-	-	-	-	Resources Basic Inventory - The Resources Basic Inventory (RBI) is an inventory of the ecological, biological and geographical resources of an area and some of the factors that influence it from the outside. Information must be gathered and assembled on these resources in order to increase our knowledge of the complex ways the natural systems operate. The ability of an area to function as a natural system, with allowance made for human use, must be considered a function of atmosphere, hydrosphere, lithosphere and biosphere, together with cultural and social features. The relationships between these factors are highly complex and variable and all of the various processes comprising the systems and how they operate are not fully understood. Consequently, research and analysis need to be continued or undertaken in order to obtain required resources data. Likewise, the conflicts or impacts between man and the natural resources must be explored. Such information will be applied to increasing the quality of our management of park resources. The RBI forms the basis for Master Planning, EIS preparation, Carrying Capacity regulation and resource management planning. No positions are scheduled for WASO. (Coordination $625,000; RBI procurement for 10 parks $2,500,000.)	
FY 1976								
A01	2,875,000	15	-	-	-	-	Coordination $375,000; RBI procurement for 10 parks $2,500,000	
FY 1977								
A01	2,875,000	15	-	-	-	-	Coordination $375,000; RBI procurement for 10 parks $2,500,000	
FY 1978								
A01	2,500,000	-	-	-	-	-	RBI procurement for 10 parks	
FY 1979								
A01	2,500,000	-	-	-	-	-	RBI procurement for 10 parks	

Park: Office of the Chief Scientist (DDS)

Date: November 5, 1973

APPENDIX A

BASE MOSAIC OF ERTS-1 IMAGERY

The first Earth Resources Technology Satellite (ERTS-1, formerly ERTS-A) employs four distinct spectral bands in the multi-spectral scanner, and three cameras sensing different spectral ranges. Band 5 (0.6 to 0.7 micrometers) was chosen to photographically portray the Great Smoky Mountains National Park (GSMNP) and the surrounding area for the purposes of Task 1. More particularly, the photo-mosaic comprises ERTS-1 scenes 1084-15431 and 1084-15433, as recorded on October 15, 1972, by the multi-spectral scanner in the satellite. The images were provided by the regional office of the Earth Resources Observation Systems Program (EROS) at the Mississippi Test Facility (MTF).

The base mosaic shows more territory than is included in the National Park Service region associated with the GSMNP. The boundary of this region is therefore shown on an overlay. The uncontrolled base mosaic was constructed by personnel from the EROS/MTF office at a scale of 1:250,000.

The corresponding U. S. Geological Survey - U. S. Army maps were used to provide correct relative location of the photographs. The three map sheets (scale 1:250,000) used were (1) Chattanooga NI16-3, (2) Johnson City NJ17-10, (3) Knoxville NI17-1. Appendix E gives more details of these maps.

In addition to the GSMNP region, the base mosaic shows some clouds and, in the lower left corner, a large area without vegetation near Ducktown, Tennessee, due to the mining of copper and iron and the manufacture of sulfuric acid.

APPENDIX B

LAND OWNERSHIP

This overlay was constructed from the 1:250,000 and 1:24,000 USGS-USA maps described in Appendix E.

Among the Federal boundaries shown are national parks, wild life management areas, national forests and Indian reservations.

Undoubtedly most of the boundaries shown are valid for 1965. But in some few cases, boundaries may not have been revised since 1937 or 1940. The only way to obtain guaranteed 1973 information is not to rely on the maps of Appendix E, but to rely on the records of the NPS and of the eleven counties.

The maps of Appendix E also have some boundaries inadvertently omitted. Eight such omissions were found in preparing this overlay. Some omissions exist for wild life management areas (Harmon Den, Sherwood, Shining Rock, Tellico, Santeetlah, Standing Indian). Other omissions relate to a national forest (Pisgah) and land ownership related to the Foothills Parkway.

APPENDIX C

TRANSPORTATION

This overlay shows highways and railroads. The railroad tracks shown are single track and double track. The three classes of highways shown are (1) major paved public roads, (2) public roads subject to minor use within the Park, (3) management roads (usually gated and locked) within the Park.

Trails in the Park are not shown. Outside the Park there is no display of primitive and unimproved roads surfaced with gravel, soil or stone.

Much information was obtained from county highway maps and state highway maps. Such maps provide up-to-date information which only rarely is more than two years old.

APPENDIX D

SOILS

The information on this overlay was derived from the map "Soils in the Tennessee Valley - General Suitability for Agricultural Use," which is available from:

U. S. Tennessee Valley Authority
110 Pound Building
Chattanooga, Tennessee 37401

The map was prepared in 1968 by the National Fertilizer Development Center, Muscle Shoals, Alabama, in cooperation with the Soil Conservation Service, U. S. Department of Agriculture. Cartography was by the Maps and Surveys Branch of TVA.

In addition to giving soil association and parent material, the soils are categorized into the six categories of (a) Very Good, (b) Good, (c) Fair, (d) Poor, (e) Very Poor and (f) Unsuited. Definitions of these categories are as follows:

- Very Good (Symbols 3, 6 on the overlay) - Nearly level to rolling, mainly well-drained, productive soils. Most soils of this group are deep and inherently fertile, being derived from alluvium, loess, or easily weatherable limestone parent materials. This group of soils is very well suited to most row and pasture crops climatically suited to its region. Forests represent less than 20% of the land utilization on these soils. Many large prosperous farms are found in this very good commercial farm area.
- Good (Symbols 20, 21, 26, 29, 31, 44, 45) - The soils in this group are generally undulating to rolling, but include some on nearly level slopes. These soils are wlll suited to a variety of row and

pasture crops, but with slight limitations in productivity, such as low inherent fertility in the sandy-textured soils, restricted drainage and/or slight flooding hazard, presence of subsoil pans, or heavy textured subsoils. Also included are areas containing very fertile and productive soils interspaced with adjacent areas of less desirable soils. On the whole, this group of soils is well suited to agricultural crops, but demands a somewhat higher level of management to achieve the productivity of the first group. Forests occupy probably no more than 30% of the land in these areas. This is generally a good commercial farm area.

- Fair (overlay symbols 71, 72, 73) - These are mostly undulating to hilly, well drained soils which are only fairly suited to cropland use. Though generally suited topographically, these soils have certain limitations which decrease their productivity. Included are infertile soils derived from sandstones, cherty limestones, shales and Coastal Plain sediments. Other limitations of this group include poor drainage and/or moderate flooding hazard, presence of subsoil pans, heavy-textured subsoils and occurrence of beds containing gravels, stones and rocks at or near the surface. Some hilly areas of productive intermountain soils are also found in this group. Forests occupy nearly half of the land area. A higher level of management and a larger acreage is required for successful commercial farming than in the previous groups.

- Poor (overlay symbols 110, 112, 115, 122, 124) - Dominantly rolling to hilly infertile upland soils which are generally not well suited to cropland use. A few hilly and steep areas with deep, permeable, productive soils are included. Also included is a limited acreage of undulating to rolling land with fine-textured, very plastic subsoils. An estimated 10 to 15% also occurs as productive alluvial soils in areas too small to delineate with the scale of this map. Much of this land in the Ridge and Valley Province of East Tennessee, Southwest Virginia and North Georgia occurs as a series of narrow ridges and valleys containing both highly productive and unsuited agricultural land. Thus, some of these areas designated as poorly suited necessarily represent a compromise of contrasting suitability categories. Forest use is predominant in this group. Success of farms depends largely on the acreage of crop-adapted soils available to go with the adjacent larger areas of uncultivatable land. In general, this group is considered poor for commercial farming.
- Very Poor (overlay symbols 130, 131, 139) - These are mostly hilly to mountainous upland soils that are very poorly suited for cultivated agriculture. Most soils possess one or more of the following serious limitations: shallow rooting zone, infertility, excessive chertiness, stoniness of rockiness and susceptibility to erosion. As in the previous group, a small amount of productive alluvial soils (10% or less) occur as small areas within this category. Forests occupy 80% or more of the land in this group. Only in a very few places is there a

sufficient acreage of row crop and pasture adapted soils occurring together to support commercial type farming.

- Unsuited (overlay symbol 151) - Mostly mountainous shallow and stony soils. The minor alluvium in these areas are generally too stony and rough for cropland use. Although practically all this land is in forest, the soils vary greatly in their forest productivity. Very little of this land is in farms. The larger part is in National Forests and Parks.

APPENDIX E

STANDARD TOPOGRAPHIC MAPS

The subject of this appendix is the standard maps produced and sold by the U. S. Geological Survey in cooperation with the former U. S. Army Map Service (later the U. S. Army Topographic Command and the Defense Mapping Agency).

Such maps of two scales (1:24,000 and 1:250,000) were used. Map numbers are readily identifiable from the "Index of Topographic Maps of Tennessee" and the "Index of Topographic Maps of North Carolina." Xerox copies of appropriate areas of these indices are attached. Dates of map preparation and revisions (sometimes partial only) are given on the indices and maps.

Both indices and maps are available from:

Distribution Section
U. S. Geological Survey
1200 South Eads Street
Arlington, Virginia 22202

The status of the progress of mapping in Tennessee and North Carolina may be obtained from:

Topographic Division
U. S. Geological Survey
1109 North Highland Street
Arlington, Virginia 22210

or

Map Information Office
U. S. Geological Survey
Washington, D. C. 20244

The code name for a 1:24,000 map is a "7-1/2 minute QUAD." Notes on the 1:24,000 and 1:250,000 maps now follow.

TOPOGRAPHIC MAP
PRODUCED BY
U. S. GEOLOGICAL SURVEY

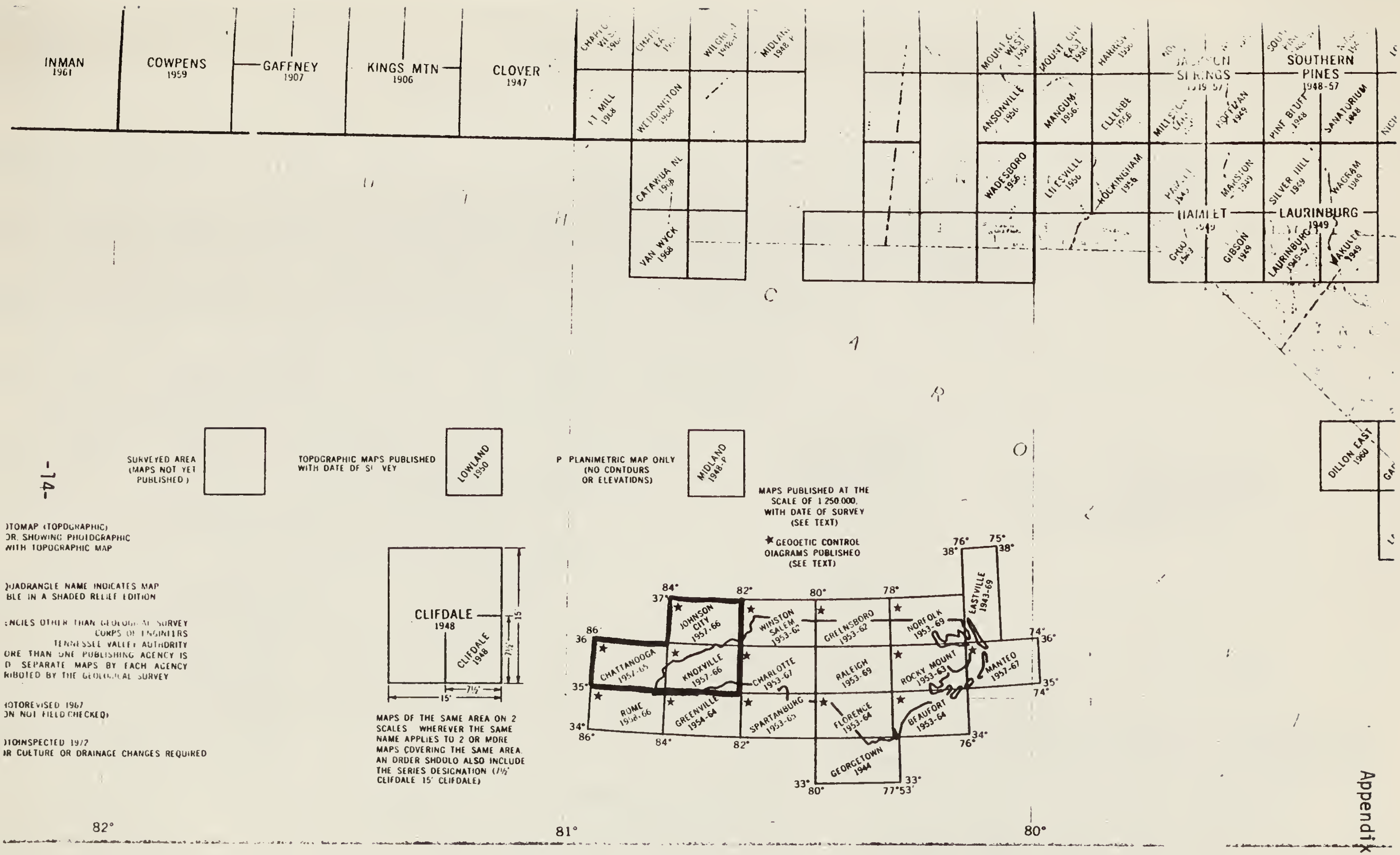
SCALE:	1:24,000 CODE: 7-1/2 minute QUAD (1 inch = 2,000 feet)
PROJECTION:	Polyconic
SIZE:	27" x 22"
PURPOSE:	For detailed small area planning and to accurately determine the location of specific features such as roads, railroads, cities and towns as well as hills, mountains, valleys, etc.
STYLE:	Full margin, multi-color, relief, ticks for UTM grid and geographic coordinate graticule.
INFORMATION SHOWN:	
RELIEF:	The contour interval varies according to the relief of the area covered.
CULTURE:	Detailed pattern of cities, towns, roads, trails and railroads. Includes miscellaneous cultural features, boundaries and power transmission lines.
HYDROGRAPHY:	Detailed drainage pattern.
VEGETATION:	Woodland overprint.
AERONAUTICAL:	Airfield locations by symbol.

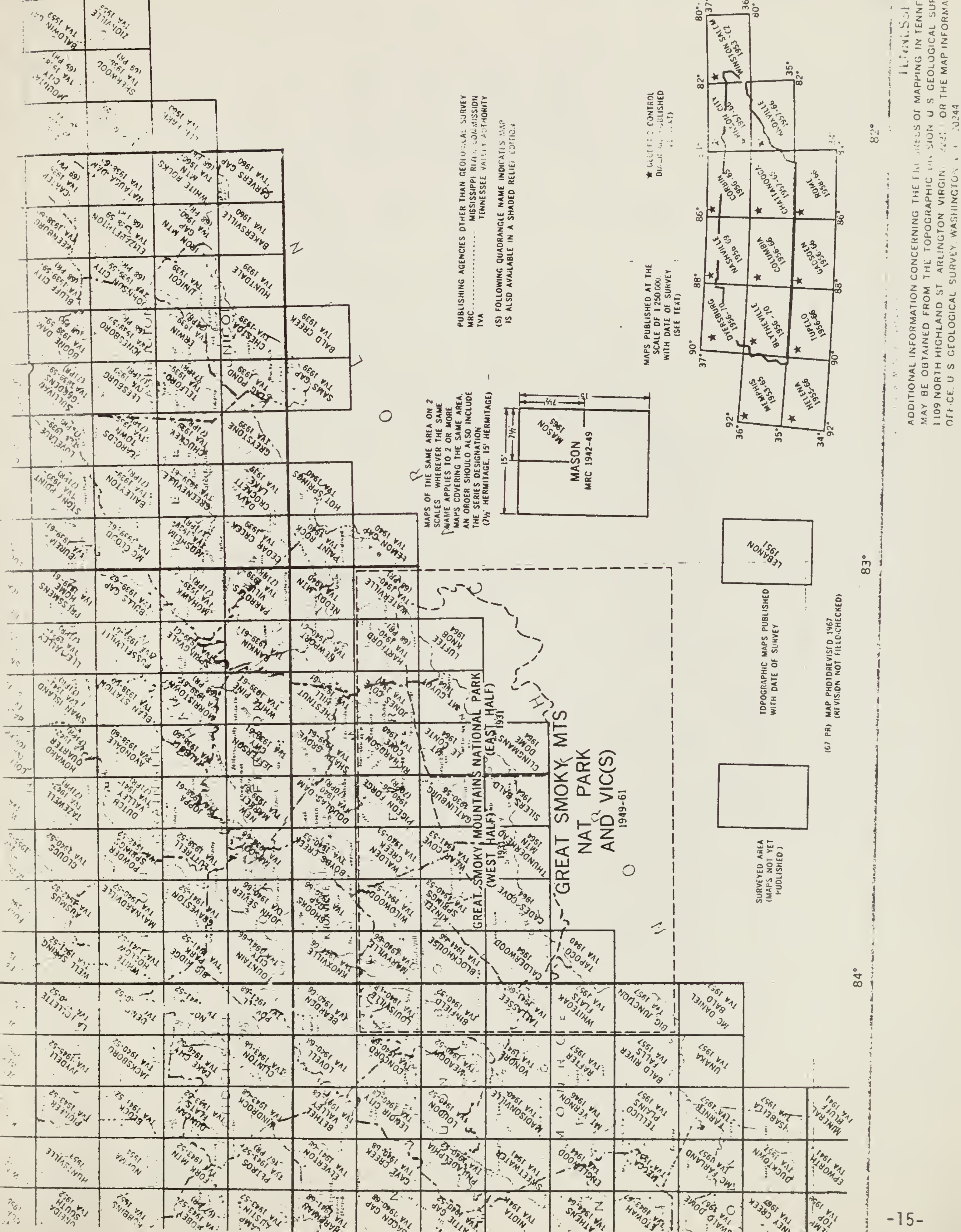
TOPOGRAPHIC MAP

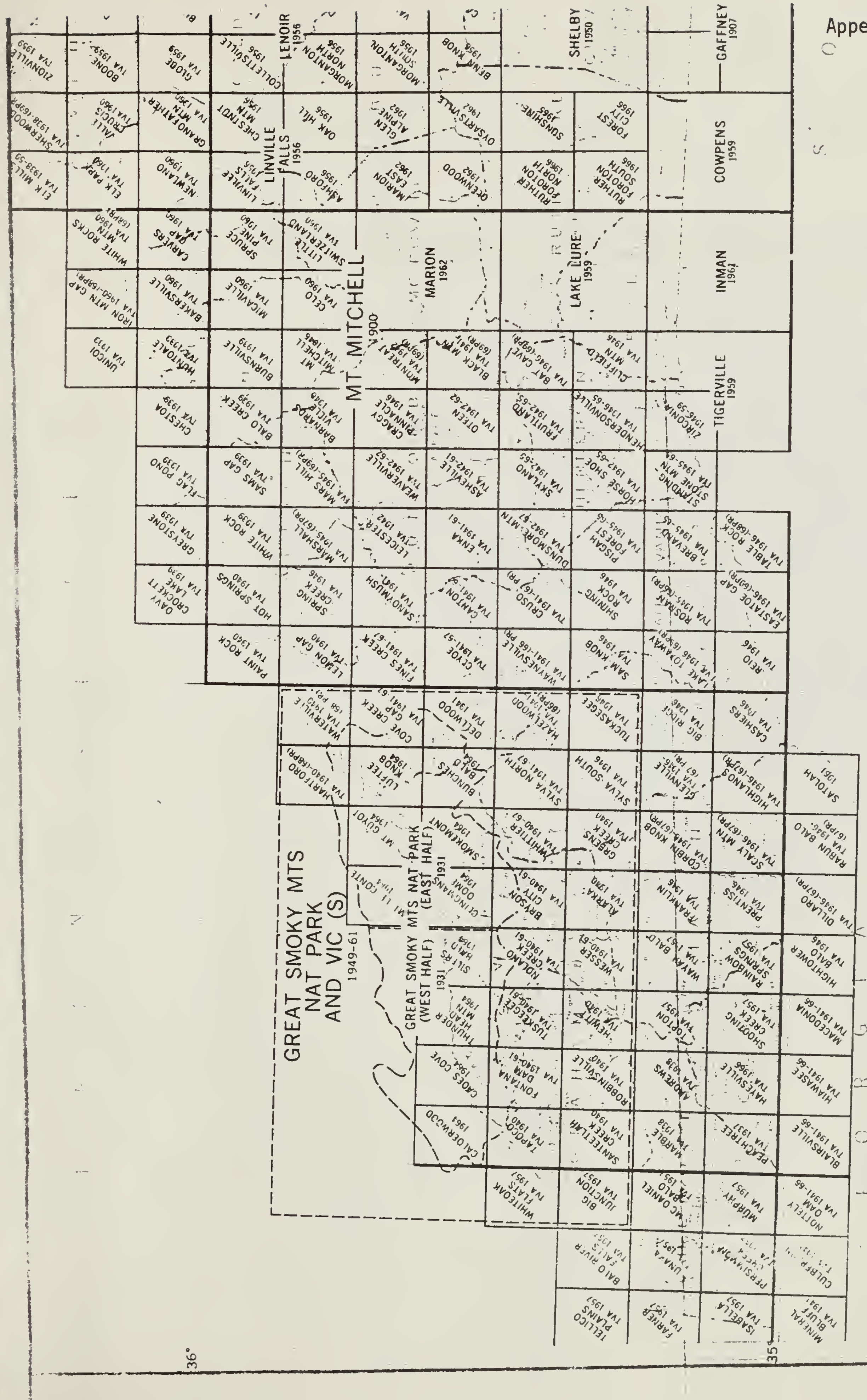
PUBLISHED BY

U. S. ARMY TOPOGRAPHIC COMMAND

SCALE:	1:250,000 (1 inch = 3.5 Nautical Miles)	CODE: None
PROJECTION:	Transverse Mercator	
SIZE:	29" x 22"	
PURPOSE:	For planning projects extending over large areas and to determine the location of features such as highways, trails, oil/gas pipelines, power transmission lines, drainage basins, etc.	
STYLE:	Full margin multi-color, relief, UTM grid and ticks for geographic coordinate graticule.	
INFORMATION SHOWN:		
RELIEF:	The contour interval ranges from 50 feet in relatively flat areas to 200 feet in mountainous regions. Supplementary contours at one-half the basic contour interval are sometimes added in areas of low relief to provide a more detailed representation of the terrain. Spot elevations.	
CULTURE:	Detailed pattern of cities, towns, roads, trails and railroads. Includes miscellaneous cultural features, boundaries and power transmission lines.	
HYDROGRAPHY:	Detailed drainage pattern.	
VEGETATION:	Woodland overprint.	
AERONAUTICAL:	Airfield locations by symbol.	


INMAN 1961
COWPENS 1959
GAFFNEY 1907
KINGS MTN 1906
CLOVER 1947
WEDDINGTON 1968
CATAWBA NE 1968
VAN WYCK 1968
MOUNT GILEAD WEST 1956
MOUNT GILEAD EAST 1956
ANSONVILLE 1956
MANGUM 1956
WADESBORO 1956
LILESVILLE 1956
ROCKINGHAM 1956
SOUTHERN PINES 1948-57
PINE BLUFF 1948
SANATORIUM 1948
SILVER HILL 1949
WAGRAM 1949
HAMLET
LAURINBURG 1949
GIBSON 1949
LAURINBURG 1945-57
WAKULLA 1949
DILLON EAST 1960
SURVEYED AREA (MAPS NOT YET PUBLISHED)
TOPOGRAPHIC MAPS PUBLISHED WITH DATE OF SURVEY
LOWLAND 1950
PLANIMETRIC MAP ONLY (NO CONTOURS OR ELEVATIONS)
MIDLAND 1948-P
MAPS PUBLISHED AT THE SCALE OF 1:250,000, WITH DATE OF SURVEY (SEE TEXT)
★ GEODETIC CONTROL DIAGRAMS PUBLISHED (SEE TEXT)
CLIFDALE 1948
CLIFDALE 1948
MAPS OF THE SAME AREA ON 2 SCALES: WHEREVER THE SAME NAME APPLIES TO 2 OR MORE MAPS COVERING THE SAME AREA, AN ORDER SHOULD ALSO INCLUDE THE SERIES DESIGNATION (7½' CLIFDALE 15' CLIFDALE)
JOHNSON CITY 1957-66
WINSTON SALEM 1953-62
GREENSBORO 1953-62
NORFOLK 1953-69
EASTVILLE 1943-69
CHATTANOOGA 1957-65
KNOXVILLE 1957-66
CHARLOTTE 1953-67
RALEIGH 1953-69
ROCKY MOUNT 1953-63
MANTEO 1957-67
ROME 1958-66
GREENVILLE 1954-64
SPARTANBURG 1953-65
FLORENCE 1953-64
BEAUFORT 1953-64
GEORGETOWN 1944
82°
81°
80°
QUADRANGLE NAME INDICATES MAP ... BLE IN A SHADED RELIEF EDITION
... CORPS OF ENGINEERS
TENNESSEE VALLEY AUTHORITY
... SEPARATE MAPS BY EACH AGENCY ... BUTED BY THE GEOLOGICAL SURVEY
... CULTURE OR DRAINAGE CHANGES REQUIRED


GREAT SMOKY MTS NAT PARK AND VIC(S)
1949-61
MASON
MRC 1942-49
PUBLISHING AGENCIES OTHER THAN GEOLOGICAL SURVEY
MRC .... MISSISSIPPI RIVER COMMISSION
TVA .... TENNESSEE VALLEY AUTHORITY
(S) FOLLOWING QUADRANGLE NAME INDICATES MAP IS ALSO AVAILABLE IN A SHADED RELIEF EDITION
MAPS PUBLISHED AT THE SCALE OF 1:250,000 WITH DATE OF SURVEY (SEE TEXT)
TOPOGRAPHIC MAPS PUBLISHED WITH DATE OF SURVEY
SURVEYED AREA (MAPS NOT YET PUBLISHED)
(67 PR) MAP PHOTOREVISED 1967 (REVISION NOT FIELD-CHECKED)


GREAT SMOKY MTS NAT PARK AND VIC (S) 1949-61
GREAT SMOKY MTS NAT PARK (EAST HALF) 1931
GREAT SMOKY MTS NAT PARK (WEST HALF) 1931
MT. MITCHELL 1900
MARION 1962
LAKE LURE 1959
SHELBY 1950
GAFFNEY 1907
COWPENS 1959
INMAN 1961
TIGERVILLE 1959
LENOIR 1956
LINVILLE FALLS 1956
36°
35°

ERTS & EROS

by staff, Eros Program
U. S. Geological Survey
Washington, D.C.

In June the National Aeronautics & Space Administration is to launch its first experimental satellite designed to view the Earth systematically with remote-sensing instruments that will provide new information about our resources and environment.

The launching will culminate more than 8 years of planning and research by resource agencies of the Federal Government in coöperation with NASA, state and local governments, universities, and industry. The first Earth Resources Technology Satellite, ERTS-A, will be followed a year later by ERTS-B. Analyses of data from them, it is hoped, will lead to design of operational satellites for Earth-resources investigations in the future. In the belief that satellite systems will be of significant assistance in meeting its responsibilities to map, monitor, and manage the vast resources and the public lands of the United States, the Department of the Interior assumed a major role in the ERTS-A Experiment.

The ERTS System can be most easily understood by considering it as composed of 3 subsystems—spacecraft, sensor payload, and ground-control and processing system. All are interrelated and all are necessary to demonstrate the use of space-acquired data in managing natural resources.

Before beginning the design of ERTS-A, NASA consulted the Department of the Interior, the Department of Agriculture, and other Federal agencies to determine their needs for observational coverage, type, resolution, and spectral characteristics of the data, and processing of the data. From these consultations came the guidelines that eventually led to the specifications for ERTS-A.

The spacecraft chosen for ERTS-A by NASA is a modified Nimbus, a choice influenced by the orbit, sensors, and ground-processing methods, as well as by the requirement that the spacecraft be a modification of an existing design in order to reduce development time and cost.

The orbit was chosen to fulfill the needs expressed by potential users for synoptic repetitive coverage, uniformity of observation times, sidelap of swaths and overlap of scenes of imagery, sensor fields of view, and ground resolution. Translated into an orbital specification, these requirements led to a Sun-synchronous, near-polar, near-circular orbit. With such an orbit, areas will be viewed every 18 days, scenes along the data swath will overlap by at least 10 per cent, the sidelap of adjacent swaths will be at least 10 per cent at the equator and greater at high latitudes. Consecutive swaths will be 25° apart at the equator. However, because of the angle of inclination, there will be no coverage of an 18° cone around the poles. ERTS-A will cross the equator on its north-to-south track at 0930 local time, and at increasing times northward so that the time of an observation at latitude 50°N will be about 1000 local time.

The ERTS-A spacecraft will be required to maintain an accuracy of attitude, or pointing, of 0.7°, with a rate of change of attitude of no more than 0.04°/second. However, it is hoped that the rate of change of attitude can be reduced to 0.015°/second. Corrections can be made during ground processing for any deviations from the vertical caused by a change in attitude of the spacecraft if the attitude during sensor operation is known. The system chosen in ERTS-A will determine or control the attitude with accuracies of 0.1° in pitch and roll and 0.8° in yaw. An onboard propulsion system will insure maintenance of the orbit during the life of the experiment.

The ERTS-A payload will consist of 3 return-beam-vidicon medium-resolution television cameras, a 4-channel multispectral scanner, 2 wideband videotape recorders, and a data-collection receiver & transmitter. Instruments will be mounted on a structure called the sensory ring, and all will be boresighted on the spacecraft's vertical axis.

The 3 television cameras are new to space projects and represent a great advance in television systems. They will view simultaneously an area 100 nautical miles on a side. Objects 100 m long should be recognizable if the contrast with the background is 2:1 or greater. The cameras will be filtered to record information in different parts of the visible and near-infrared parts of the spectrum. One, recording the green part (475-575 nanometers), will be used to provide information on the depth of bodies of water such as lakes, ponds, and reservoirs. One, recording in the red part of the spectrum (580-680 nm), will reduce atmospheric interference and provide information on the distribution of cultural features. The third camera will be filtered for only the near-infrared part of the spectrum (690-830 nm); it will be used to define the margins of water bodies and to determine the distribution and vigor of plant life.

The multispectral scanner, unlike other spaceborne scanners, does not require spacecraft motion for its function. ERTS-A will be stabilized on 3 axes, so the continuous motion needed to scan the Earth's surface normal to the spacecraft's velocity vector will be provided by an oscillating mirror. The orbital motion provides the necessary movement along the ground-coverage swath. 6 scanlines in 4 channels will be taken simultaneously; the radiance collected by the mirror will be passed through an optical system and then carried by fiber optics to a set of photomultiplier tubes.

The videotape recorders will provide coverage for parts of the Earth that are not in the direct view of the spacecraft at the times it is in communication with the NASA ground stations. They will be able to record as much as an hour of RBV and MSS data each day and play them back to a ground station during the night or during the pass when other data are not being collected.

The data-collection receiver & transmitter is designed to receive information from low-power transmitters attached to unattended ground sensors, such as stream gauges, water-quality monitors, precipitation gauges, and various devices for monitoring volcanic activity. Both the omnidirectional antenna and the formatting transmitter of this ground equipment can operate on a 24-volt battery pack for at least 3 months. Data can be transmitted from as many as 1,000 sites at approximately the same frequency and on approximately the same time schedule with a 95 per cent probability that one correct message can be received every 12 hours by the satellite's receiver. By using inaccurate transmitters and timers, a distribution of both frequency and time of signal is obtained. The relaxed criteria for those items reduce the cost of equipment and make it possible for such a system to function.

The Ground System consists of an Operations Control Center and the NASA Data-Processing Facility, both at the NASA Goddard Space Flight Center in Greenbelt, Md. The Operations Control Center assumes command of the satellite when it reaches orbit. It controls the attitude and position of the satellite, turns the sensors and tape recorders on and off and gives command to transmit data to reception centers in Alaska, California and Maryland. The Data Processing Facility will use specially designed equipment to convert the spacecraft's sensor data to images that are geometrically, photometrically, and radiometrically corrected, either in hard copy (as transparencies or paper prints) or as digital tape. It will maintain a storage & retrieval system to provide information on particular image frames or other aspects of the ERTS missions. It will also make a prime distribution to the Department of the Interior and other agencies as well as to scientists chosen as principal investigators for experiments sponsored by NASA. The Department of the Interior plans to redistribute the data to the public through the Eros Data Center being established on a 320-acre site near Sioux Falls, S.D.

Rapid access to the holdings of the Data Center will be provided by a computerized storage & retrieval system, working in concert with a microfilm reference system. The computer will enable Center personnel to respond to inquiries by telephone, letter, and personal visit, and to inform users of the availability of Data Center imagery for any geographic area of interest. People visiting the Center will be able to preview the images on microfilm records in a 'browse area' before ordering full-size reproductions. Copies of these microfilm browse files will be available for viewing in several regional data centers across the country, or may be purchased for reference. The microfilm files will enable the potential user to screen the images, determine the frames of coverage desired, and ascertain that the area of interest is cloud-free before ordering reproductions.

The opto-electronic laboratory in the Data Center will enable Center scientists to analyze images rapidly to determine the presence or absence of selected objects that have a characteristic spectral signature. Through a combination of electronic and photographic processing of the images, subjects such as snow cover, standing water, infrared reflective vegetation, and massed works of man will be mapped and analyzed for areal extent and seasonal changes.

Visitors to the Center can receive help in techniques for interpreting and applying the data through consultation with the Center's scientific staff. Special equipment such as densitometers, additive color viewers, and stereo viewers will be available for inspection and analysis of remote-sensor images. The scientific staff is to offer formal instruction in interpretation of remote-sensor data.

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 Earth Resources Observation Systems (Eros) Program as a departmental effort under the management of the U.S. Geological Survey. Resources inventory and management applications have since become an important part of the research program with participation by 10 bureaus of the department: the Bureaus of Indian Affairs, Land Management, Mines, Outdoor Recreation, Reclamation, and Sport Fisheries & Wildlife, the Bonneville Power Administration, National Park Service, Office of Trust Territories, and the Geological Survey.

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 tentatively or firmly accepted by NASA for participation in the experimental program. The proposed investigations can be categorized into 5 areas of research that correspond to working groups of the Eros Program: Cartographic Applications & Mapping Requirements; Geology, Mineral & Land Resources; Water Resources; Marine Resources; Geography, Human & Cultural Resources. Examples of proposed investigations are described below:

• **Cartographic applications** and mapping requirements: The Geological Survey has proposed 6 experiments designed to test the utility of Return Beam Vidicon (RBV) data for cartographic applications. It includes the production of experimental photomaps of selected parts of the U.S., foreign countries and polar areas, revision of standard maps, production of thematic maps, and an evaluation of the ERTS orbit and attitude data for positioning ERTS images.

• **Experimental photomaps:** NASA intends to produce both bulk and precision images from ERTS. The precision images will be controlled by identified points on the Earth's surface and will, in effect, be maps. The precision images will be cast on a specified map projection (Universal Transverse Mercator Projection) and will contain grid-reference information.

To save time and money, the cartographic processing will be kept as simple as possible; however, if the precision processor fails to remove enough distortion for cartographic products, rectification will be applied. For the most part, a cartographic product with a format based on the annotated image frame at 1:1,000,000 scale will be produced, but for experimentation a variety of products of other scales will be compiled, tested, and distributed to users for evaluation. Standard quadrangle formats with ERTS images mosaicked and the line map imagery overprinted on the enhanced photo-image are also planned.

1:1,000,000 has been decided on as the most appropriate scale at which ERTS images should be presented, but attempts will also be made to experiment with 1:250,000, 1:500,000 and smaller scales such as 1:5,000,000. In atlas-type map products, photomaps at even smaller scales may be found useful.

• **Foreign maps:** The Geological Survey proposes to help compile as many as 10 1:1,000,000-scale photomaps of foreign areas representing various terrain conditions. However, the foreign countries must supply photo-image ground control.

• **Polar mapping:** Although the satellite inclination precludes vertical coverage beyond latitude 82°N & S, there still exists a unique opportunity to cover much of the inaccessible Arctic and Antarctic regions, where large areas have never been properly photographed or mapped. An ambitious program has been proposed to investigate the use of RBV images: **(1)** in supplementing planimetric map data with information on features such as crevasse fields, sastrugi patterns, and glacier flow lines in mapping specific areas of the polar plateau at 1:1,000,000 scale and smaller; **(2)** for delineating and mapping gross ice features such as the Ross, Filchner and Ronne ice shelves: **(3)** for compiling planimetric sketch maps or photomaps of the poorly mapped Antarctic areas: **(4)** in compiling a 1:10,000,000-scale photomap of the entire continent: **(5)** in compiling small-scale maps of sea ice and record time-scale variations; **(6)** for detecting changes in glaciological features; and **(7)** for compiling maps of the entire Arctic coverage and Alaska.

• **Map revision:** Application of RBV images to revision of standard quadrangle maps at scales from 1:250,000 to 1:1,000,000 will be investigated, first by determining and categorizing the types of details on the RBV images that may be correlated to details on maps at various scales, and then by attempting a revision of maps of selected areas of the U.S. These maps will represent widely different terrain conditions such as found in the Far Northwest, the California Coast, the Mid-West and the East Coast. Repetitive coverage of these areas will be studied for its value in detecting change.

• **Thematic maps:** A system being developed by the Geological Survey will provide information from RBV data.

The themes to be extracted from ERTS data are water, snow, IR-reflective vegetation, and massed works of man. So far as possible, each theme will be represented on a binary-level graphic on which quantitative analysis of the data may be pursued, and will include changes as a function of time. The methods and techniques for using ERTS data are themselves an objective of the proposed research. The products generated are to include single black & white or color thematic-map overlays in binary form, multiple-color thematic-map overlays, a base-map series for thematic data analysis, and, in addition, a digitized version. The system will provide thematic area analyses, outlines of thematic regions and transformation parameters needed to relate thematic maps to data bases for specialized analysis.

• **Orbit and attitude data:** This investigation is to determine how much the ephemeris data can be used to rectify ERTS images for mapping purposes without conventional ground control. It includes development of procedures for cartographic use of satellite-derived position and attitude data and will determine the need for more accurate position and attitude sensors. This work could lead to reduction or elimination or the requirement for ground image points for photomap compilation and other cartographic products, depending on the accuracy of the orbit and attitude data.

• **Geology, mineral and land-resource** applications: The Bureau of Reclamation proposes to evaluate repetitive ERTS-A data over reclamation projects to monitor the changes during construction and to determine effects that construction and the resulting works have on local land, environment, and economics. The Bureau of Land Management plans to compare repetitive data from 3 areas in Arizona, Oregon, and Alaska to determine whether they can predict the quantity and quality of ephemeral and perennial range grasses during the normal grazing season. The success of such an experiment could help greatly in determining the number of cattle allowed to graze on public lands.

The Geological Survey has a large number of experiments ranging from studies of the distribution of permafrost and geologic hazards in Alaska to a study of the applications of multispectral imagery in geologic mapping of Saudi Arabia and West Pakistan. A study of the morphology, provenance, and movement of desert sand of sand seas in Africa, Asia, and Australia has been proposed.

2 proposals involving use of ground data-collection platforms in surveillance of U.S. volcanoes have been accepted. One aims at monitoring changes in thermal features such as hot springs and fumaroles with thermistor probes; the other will monitor earthquake tremors with seismic-event counters and tiltmeters Ground instruments connected to radio transmitters will send their data to the ERTS-A space vehicle throughout the year. The data will be transmitted to Goddard Space Flight Center, processed, and sent to the investigators along with multiband images of the area.

Other projects are to evaluate automatic terrain interpretation, soil and rock identification and geologic mapping techniques in Yellowstone National Park, parts of the Colorado Plateau, and the Basin & Range Province of Arizona. Soils mapping, erosion since 1890 in desert terrain of Arizona, and loess-buried glacial features of the Great Plains are the subjects of other experiments.

• **Geography and cultural resources:** In the course of preparing more than 700 special-subject maps for the *National atlas of the United States of America* (published in 1971), it became apparent that data collected by traditional means often differ too much in date, scale, categorization, and extent of coverage. Consequently, we urgently need to collect multispectral data on a nationwide basis by use of instrumented aircraft and satellites, process the returns quickly at relatively low cost, and to display the resulting information on request in either cartographic or computerized format. This need has led to establishment in the Geological Survey of a Geographic Applications Program and later to the Geography & Human-Cultural Resources Working Group, which includes the applications of remote sensing to people-oriented programs within the Department of the Interior.

Research efforts of the Working Group focus largely on land-use analysis and environmental complexes at national, regional, and urban scales Data from remote sensors in ERTS-A and from aircraft as well as from traditional sources are to be combined in these sequential activities: **(1)** thematic mapping of land use and environmental conditions; **(2)** mapping the dynamics of change in the land surface; **(3)** identifying environmental trends through surveillance and expediting remedial responses to disasters. The goals of the program are to develop a team of scientists with techniques and equipment capable of rapid and reliable prediction of national, regional, and urban developments and related environmental changes; to provide valid current information for policy formulation and administrative decisions; and to contribute to the improvement of land use and environmental quality throughout the country.

The Working Group has prepared a map of the forest-tundra ecotone (boundary zone) across Canada, based on weather-satellite photography; a land-use map of the southwestern U.S. from the Pacific Coast to central Texas, compiled from Apollo and Gemini space photos; a land-use classification that takes into account the practical features of many existing systems and is receptive to data from high-altitude airplanes and spacecraft; and studies of urban housing and neighborhood quality, transportation and traffic flow, and land-use changes and trends. Studies of water, air and land pollution through use of remote sensors, and of the potential economic development of a region around NASA's Mississippi Test Facility established patterns for other special studies in the future.

Projects now under way lead to use of ERTS-A data. Among these is a pilot project to make a land-use map on a rectified mosaic of 2 Apollo photos, on a UTM-gridded overlay with some 20,000 one-kilometer information cells. Land-use data will be digitized and taped along with information on a comparable scale on geology, soils, vegetation, climate, and other related environmental factors. Another project is a fully integrated multi disciplinary study of the Central Atlantic Regional Ecological Test Site, which covers about 30,000 square miles within 100 miles of the Atlantic Coast between Philadelphia and the Virginia North Carolina boundary. Approximately 50 Federal, state, regional and local agencies are involved in combining data from satellites and high altitude aircraft with information from traditional sources to provide an effective system for analyzing and interpreting land-use patterns in relation to their environmental complexes. A Census Cities Project is based on multisensor overflights of more than a score of widely distributed cities in the U.S. at the time of the 1970 Census. The resulting maps are being prepared in computer formats for eventual use in the Geological Survey's studies of *urban and regional change*.

• **Hydrology and water resources:** The Water Resources Working Group proposes several experiments to use repetitive information from ERTS, in detection and identification of water or water-related features on the surface. The information may then be interpreted in terms of water quantity or quality measurable on the surface. The size of the synoptic view and proposed ground resolution of ERTS instruments dictated that experiments in hydrology cover regional targets, such as large lakes, reservoirs, bays and estuaries, snow fields, soil-moisture distribution, or distribution of vegetation indicative of hydrologic conditions. The proposed ERTS experiments deal primarily with phenomena where twice-monthly, monthly, or seasonal observations are required. Because hydrologic conditions affect soil and vegetation as the seasons change, and requirements for hydrologic data are often seasonal, ERTS with its 18-day cycle will be an important source of hydrologic information.

Among hydrologic experiments proposed for ERTS are an interpretation of environmental changes resulting from projects of the Bureau of Reclamation; determination of the utility of ERTS imagery in preparation of hydrologic atlases of arid-land watersheds; transmission of water-quality and discharge data from surface monitoring system in the Delaware River Basin via ERTS to the Current Records Center at Philadelphia; use of ERTS-relayed ground data and evaluation of imagery to monitor environmental changes and evaluate hydrologic hazards along the Alaska Pipeline corridor; evaluation of data from the Chesapeake Bay region in delineating the gross boundaries of regional wetlands and ecological conditions in coastal wetlands; the relay of hydrological data from monitors at several so-called multidisciplinary test sites throughout the U.S. to aid in the interpretation of the ERTS imagery, but primarily to provide point-source quantitative data that may be extrapolated areally by density analysis of the imagery.

The Geological Survey, as co-investigator with Stanford Research Institute, has submitted a package of proposed experiments designed to study dynamic phenomena by using all repeat imagery of selected targets. The package includes studies on the rates of encroachment and changes in density of phreatophyte vegetation in Arizona, movement and fate of sediment plumes in Lake Ontario, change in snow cover over the Coast Range of the Pacific Northwest, changing surface conditions in one of the Potomac River drainage areas as they affect the quantity of runoff, and analysis of the ecological effects of the ever-changing distribution of land and water in the Everglades. The data will be fed into a 500-channel video console, permitting the phenomena to be viewed and analyzed on a time-lapse basis.

The Bureau of Sport Fisheries & Wildlife, the Bureau of Reclamation, and the Geological Survey have joined with the University of Michigan and South Dakota State University in a proposal designed to study the feasibility of making resources-management decisions based on ERTS data covering a large test site in the Northern Great Plains. A major facet of the study will be assessment of surface-water distribution throughout the year.

• **Marine resources:** The potential of ERTS data in support of the Department of the Interior programs involving marine geology and coastal studies is indicated by proposals to use ERTS imagery of the northeastern Pacific Ocean, including the Hawaiian Islands, the Texas Gulf Coast, and northern Alaska.

In the northeastern Pacific, knowledge of near-shore circulation patterns is based on insufficient and often poorly located recording stations. Especially neglected are areas where the water is less than 15 m deep. The green band in ERTS-A was selected for its water-penetration capability and should help map shallow-water areas. Better information about near-shore circulation and water quality is necessary for environmental planning. Repetitive small-scale ERTS-A imagery should make it possible to identify many water-mass boundaries in near-shore areas of the northeastern Pacific and to integrate oceanographic data acquired by vessels and buoys. The synoptic coverage from ERTS will make it possible to interpret the effects of marine processes over large areas of great economic importance. ERTS data will also be evaluated to determine the possibility of identifying principal sources and dispersal patterns of suspended particulate matter in the near-shore zone. These studies will aid in mapping long-shore movement of suspended sediments and general near-shore circulation and lead to a better understanding of coastal processes and morphology.

Repetitive multispectral imagery from ERTS will be analyzed to assess the possibility of tracing the source, movement, and dispersal of suspended sediment plumes, water masses, and any associated pollutants along the Texas Gulf coast. Changes in shoreline features caused by normal coastal processes and storm damage will also be studied, and the feasibility of mapping the sea-floor morphology of shallow-water areas will be explored.

ERTS data will also be used in conjunction with studies of the northern Alaska coast, our least-known marine environment. The problems involve transport regime of the inner shelf and associated sedimentary processes as well as relationships of sea ice to coastal morphology. The space imagery will supply information on environmental variables including distribution and movement of ice and water, freeze-thaw relationships, and sediment discharge.

• **Potential impact** on Department of Interior functions: Interior's mission is to inventory, map, monitor, manage and preserve the nation's natural resources. To fulfill this mission, it must have up-to-date and complete information on the status of our lands and resources. Development of the ERTS program comes at a critical time, when the need for resources and resource planning is accelerating. Space-collected data, with its advantages of broad coverage and timeliness, promises to be an important feature of resources information systems.

If the data are as useful as we believe they will be, the scientists and engineers will use them to determine the limits within which our land and resources can be used. Legislators and administrators will use them to determine policies for land and resource use, and the managers of the resources will use them to make day to day use and planning decisions.