



EROS
EARTH
RESOURCES
OBSERVATION
SYSTEMS PROGRAM

EARTH RESOURCES TECHNOLOGY SATELLITE INFORMATION

[Modified from National Aeronautics and Space Administration, "Earth Resources Technology Satellite Educational Package"]

I. What ERTS is, and what it does...

ERTS (Earth Resources Technology Satellite) is a butterfly shaped observatory (fig. 1) flying in a 570 mile (920km) circular orbit which is nearly polar. From this vantage point its imaging systems provide useful information concerning agriculture and forest resources, mineral and land resources, water resources, marine resources, land use and environmental quality, and ecology.

ERTS circles the Earth every 103 minutes or 14 times per day (fig. 2). The pass is from north to south at an angle of 80° retrograde to the equator. Each pass covers a region 115 miles (185km) wide, however, there is some overlap between the preceding and succeeding passes. After 18 days or about 252 passes the satellite returns to the same position. In other words ERTS covers the entire globe every 18 days.

The sun-synchronous nearly polar orbit was specifically selected for the sun angle. On each north to south pass the satellite crosses the equator at 9:42 a.m. local time.

The Return Beam Vidicon (RBV) cameras consist of three cameras each viewing the same 115 by 115 mile (185 by 185km) area. The three RBV cameras view the same area in three different spectral bands, the blue-green (475 to 575nm), the red (580-680nm) and the near infrared (690 to 830nm). These cameras do not contain film but rather their images are stored on photosensitive surfaces within each vidicon camera which in turn is scanned by an internal electron beam to produce a video picture. This process requires 11 seconds to read out and transmit all three pictures. The RBV cameras will repeat the cycle each 25 seconds producing overlapping pictures of the ground scene below with 10 percent overlap. The RBV camera lenses have a diagonal field of view angle of 15.9° .

The Multispectral Scanner Subsystem (MSS) covers the same area as the RBV system in four wavelength bands, the green (500 to 600nm) red (600 to 700nm), the near infrared in two bands (700 to 800nm and 800 to 1100nm). This scanner returns a strip image in these four bands.

The Data Collection System (DCS) collects information from some 150 remote, unattended instrumented ground platforms and relays it to NASA ground stations for delivery to the user.

Two Wide Band Video Tape Recorders are used to record image data from those areas outside the range of U.S. ground stations for later playback.

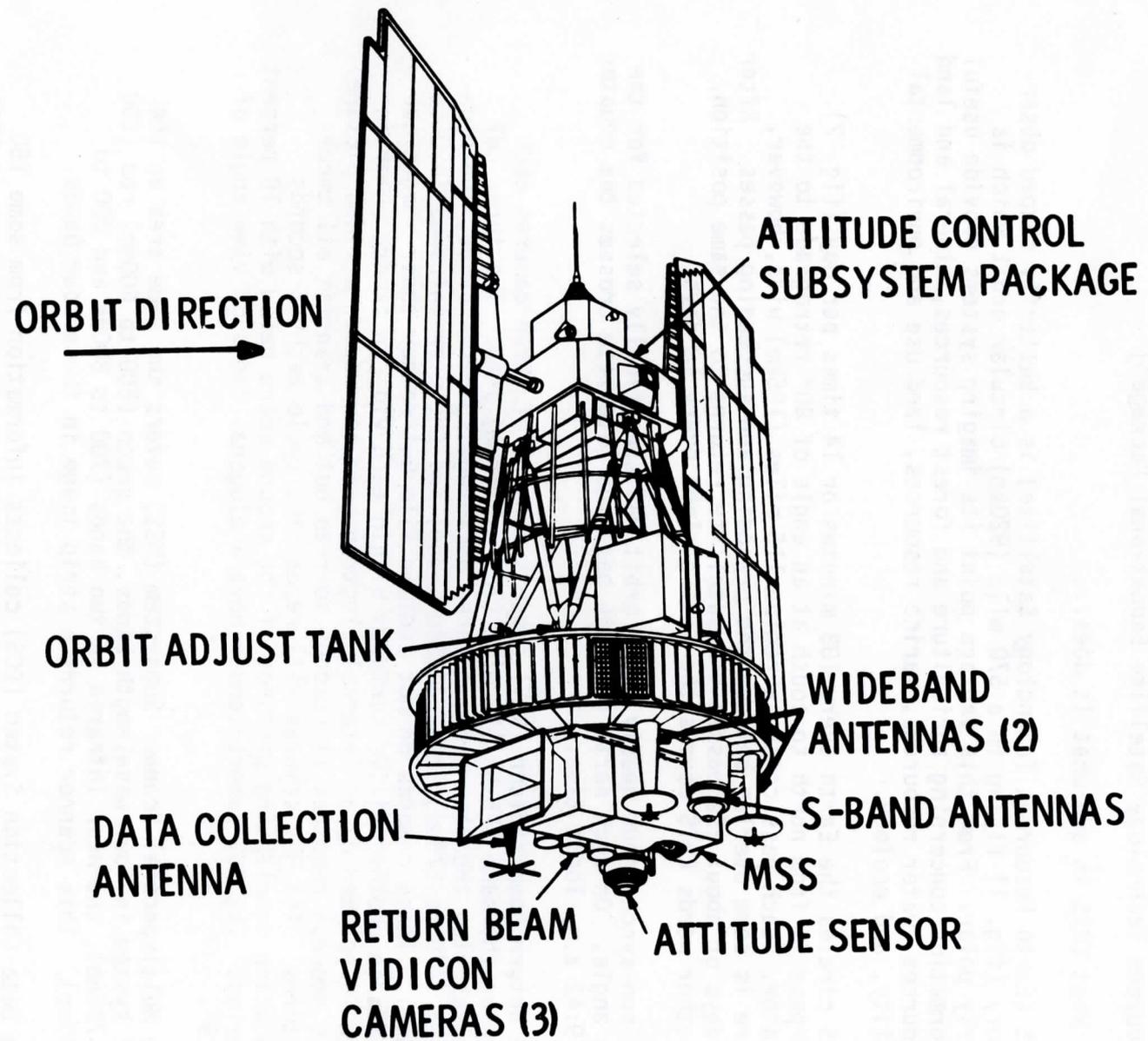


FIGURE 1. - ERTS OBSERVATORY CONFIGURATION

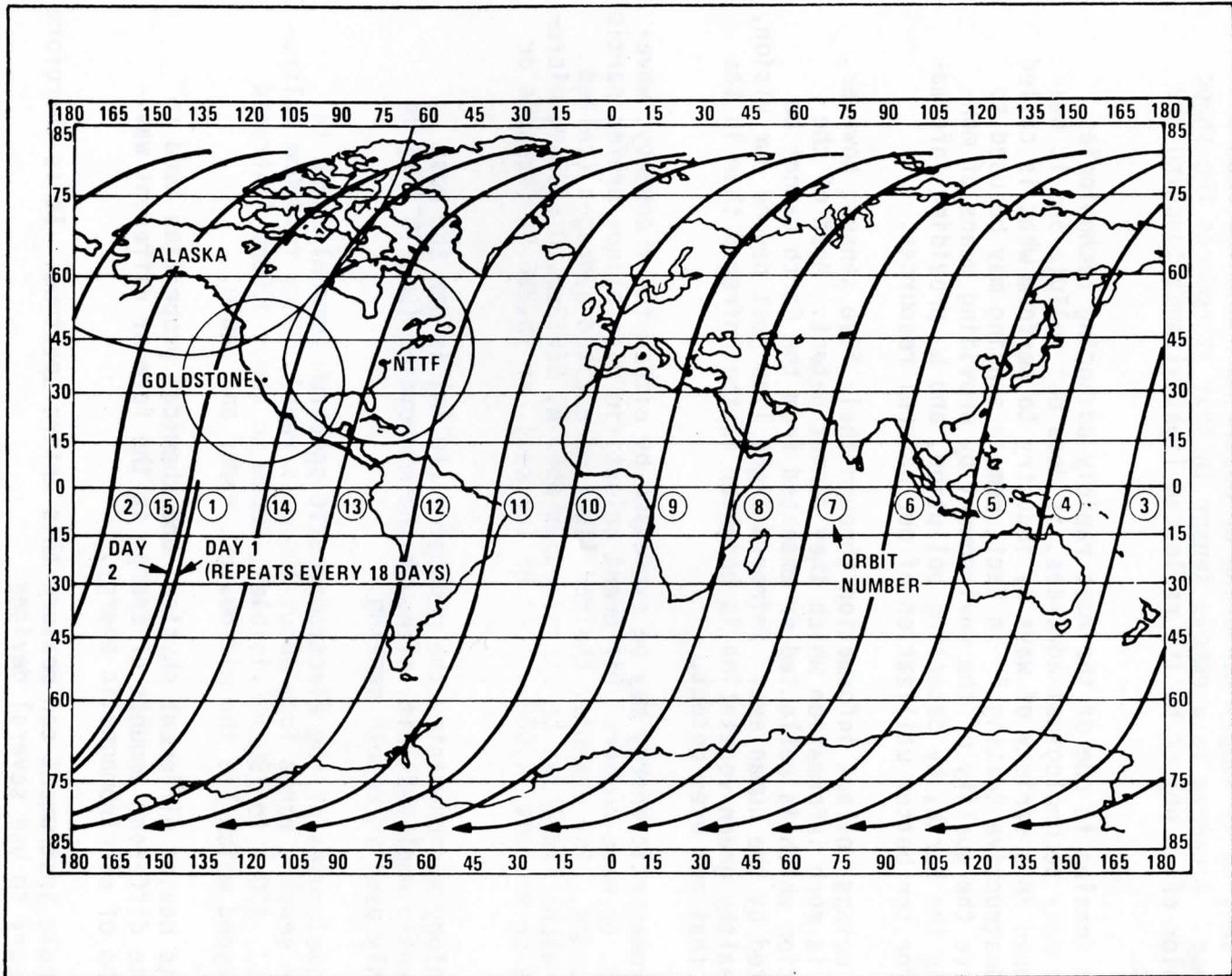


FIGURE 2. - ERTS ORBITS

II. Remote sensing and the type of imagery obtainable from ERTS

Remote sensing is simply measuring or observing something from a distance. A camera is a remote sensor in that it records the shape and color of an object by its reflected light without touching the object.

Remote sensing is one of the most rapidly advancing technologies. Unlike many technological advances, it does not pollute and it has been used in a variety of ways by industry to perform what is called "non-destructive testing." In fact, remote sensing may be used to preserve the quality of the environment by providing means of monitoring the Earth, by detecting pollution, and by providing information for the better utilization of our natural resources.

Human beings collect information through their five senses; however, there is much information which they cannot detect. Most of the radiation which is reflected or emanated from the Earth cannot be detected by the human eye. Infrared light lies just beyond our vision, and healthy green vegetation is brighter in the infrared than in the green that our eyes detect.

Electromagnetic energy may be expressed by either the frequency, wavelength, or wave-number. Different scientific disciplines prefer particular units. For example, the red light of excited hydrogen (called the H-alpha line) may be expressed as 6563 Å, 656.3nm, 0.6563µm, micrometers or microns, 4.568×10^{14} Hz (or cps), or 15,236.9K (Kaysers or cm^{-1}).

In biology and chemistry the nanometer (10^{-9}m) is now the most frequently employed unit, although the micrometer (μm , 10^{-12}m) is commonly used in remote sensing.

The wavelengths of the electromagnetic spectrum commonly used in remote sensing range from about 100nm (x rays), 100nm to 400nm (ultra-violet), 400nm to 700nm (visible), 700nm to about 3000nm (infrared and beyond which lie the microwaves, radar and radio.

Objects having different physical and chemical properties tend to radiate different amounts of energy in the form of different wavelengths of electromagnetic energy.

No single instrument can measure this entire spectrum. It is therefore necessary to use several devices.

The multispectral scanner and return beam vidicon cameras on ERTS I take pictures in desired wavelength bands. Green band 500 to 600nm. This band appears green to the naked eye. Water is quite transparent

in this band which tends to enhance features contained within water such as sediment. Light scattering in the atmosphere makes "seeing" in this band difficult at times. Red band (600 to 700nm). This band appears red to the eye. Unlike the green band, the red easily penetrates the atmosphere. This is good for land use mapping where regional population patterns need to be observed against the vegetation patterns. The red band shows good contrast between natural surface cover such as vegetation which absorbs most of this energy against man-made structures which strongly reflect this energy. Many man-made structures appear very bright against dark appearance of vegetation. Bare soil is often highly reflective in this band, so that deserts are best seen in this band. Infrared band (700 to 1100nm). This is invisible to the human eye. Water appears black in the infrared because water almost totally absorbs the radiant energy in these wavelengths. A significant characteristic about the 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 region.

The average green leaf reflects about 20 percent of green light and absorbs the other 80 percent. It absorbs approximately 95 percent of red light due to absorption by chlorophyll and is frequently called the chlorophyll absorption band. It reflects approximately 80 percent of infrared light and transmits the other 20 percent. The brightness of vegetation depends upon several things. First, the type of vegetation, i.e., big leaves will be brighter than small ones. Hardwood trees (deciduous) show up brighter than pine (evergreen). Because of leaf thickness, tobacco shows up brighter than wheat. Second, in the infrared, crop brightness depends upon plant health. Healthy crops, in the infrared will be much brighter than diseased vegetation.

III. How ERTS imagery may be obtained

ERTS imagery may be obtained at cost from several sources: EROS (Earth Resources Observation Systems), NOAA (National Oceanographic and Atmospheric Administration), and Dept. of Agriculture.

The RBV images cover 115 by 115 statute miles (185 by 185km) and are 7.3 inch square (18.5cm²) images on standard 9-1/2 inch (24cm) paper. The image scale is 1:1,000,000.

The MSS consists of successive scan lines cross-track and is put into a frame format which matches the RBV by the NASA Data Processing Facility (NDPF).

The annotations list the sensor, time of exposure, orbit number, sub-satellite 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.

The Department of the Interior's Earth Resources Observation Systems (EROS) Data Center is located at 10th and Dakota Avenue, Sioux Falls, South Dakota 57198.

The EROS Data Center staff will assist the user in locating imagery to suit individual needs. They respond to inquiries by telephone, letter, and personal visits.

The computerized imagery storage and retrieval system is based upon a geographical system, including the standard grid, supplemented by such information as date and scale. The staff will convert inquiries into searches of the computer based system. They will also assist in ordering reproductions. Visitors to the Center may consult the browse files to evaluate the frames of a particular interest before placing a purchase order.

The user may ask for pictures which include a particular map grid coordinate and indicate that only those available frames with less than a given amount of cloud cover are acceptable. In some cases clouds are an important phase of the study, whereas in others they may obliterate the desired ground features. One may also specify the desired bands (green, red, infrared, etc.), a color composite or a black and white of the color composite.

Browse file locations have been established by the Department of the Interior at:

EROS Data Center
U.S. Geological Survey
16 Miles NE of Sioux Falls
Sioux Falls, South Dakota 57198
Phone - 605/339-2270

Map Information Office
U.S. Geological Survey
Room B-310, GSA Building
18th and F Streets, NW
Washington, D.C. 20242
Phone - 202/343-2611

CARETS Information Center
U.S. Geological Survey
Room 837, 1717 H Street, NW
Washington, D.C. 20242
Phone - 202/343-5985

Water Resources Division
U.S. Geological Survey
Room 343, Post Office and Court
House Building
Albany, New York 12201
Phone - 518/472-3107

U.S. Geological Survey
5th Floor
80 Broad Street
Boston, Massachusetts 02110
Phone - 617/223-7202

EROS Program Assistance Office
Room B-210, Building 1100
U.S. Geological Survey
Mississippi Test Facility
Bay St. Louis, Mississippi 39520
Phone - 601/688-3541

Regional Topographic Engineer
U.S. Geological Survey
Room 2404, Building 25
Denver Federal Center
Denver, Colorado 80225
Phone - 303/234-4879

Water Resources Division
U.S. Geological Survey
Room 5107, Federal Building
230 North 1st Avenue
Phoenix, Arizona 85025
Phone - 602/261-3188

Public Inquiries Office
U.S. Geological Survey
Room 7638, Federal Building
300 N. Los Angeles Street
Los Angeles, California 90012
Phone - 213/688-2850

Public Inquiries Office
U.S. Geological Survey
Room 678, U.S. Court House Building
West 920 Riverside Avenue
Spokane, Washington 99201
Phone - 509/456-2524

Public Inquiries Office
U. S. Geological Survey
108 Skyline Building
508 2d Avenue
Anchorage, Alaska 99501
Phone - 907/277-0577

Regional Topographic Engineer
U. S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025
Phone - 415/323-8111

Inter American Geodetic Survey
Headquarters Building
Fort Clayton, Canal Zone
Phone - 117-1201 Panama Routine 833-227

Topographic Division
U. S. Geological Survey
961 Pine Street
Rolla, Missouri 65401
Phone - 314/364-3680

State Topographic Engineer
Florida Department of Transportation
State Topographic Office
Lafayette Building
Koger Office Center
Tallahassee, Florida 32304
Phone - 904/599-6212

Director
Portland Service Center
U. S. Bureau of Land Management
710 N.E. Holladay
Portland, Oregon 97208
Phone - 503/234-4100

EROS Program Library
U. S. Geological Survey
Room 827, 1717 H Street, NW
Washington, D. C. 20244
Phone - 202/343-7500

Chief, Maps and Surveys Branch
Tennessee Valley Authority
200 Haney Building
311 Broad Street
Chattanooga, Tennessee 37401
Phone - 615/755-2133

Dr. Everett A. Wingert
University of Hawaii
Department of Geography
Physical Science Bldg. Rm. 313-C
Honolulu, Hawaii 96822
Phone: 944-8463

EROS Coordinator
Office of the Governor
Pago Pago, American Samoa
Phone: 32203

EROS Coordinator
Trust Territory of the Pacific Islands
Office of the High Commissioner
Saipan, Mariana Islands 96950
Phone: 202-343-2141 or 2176

Dr. Frank J. Janza
Sacramento State University
Department of Electrical Engineering
6000 Jay Street
Sacramento, California 95819
Phone: AC-916-454-6545

Dr. Douglas Smith
University of Guam
EROS/P.I.E.R. Program
Section of the Pacific Room
P.O. Box EK
Agana, Guam 96910
Phone: 749-2921 ext. 363

The Department of Commerce, National Oceanographic and Atmospheric Administration (NOAA) has an Earth Resources Data Center at Suitland, Md. This Center will furnish data gathered by ERTS to users in the oceanographic, hydrologic, and atmospheric sciences as well as to the public.

To aid in selecting the data desired, NOAA has established public browse files at 22 locations around the nation. They are located in Hillcrest Heights, Md; Rockville, Md; Silver Spring, Md; Washington, D.C.; Miami, Fla; Norfolk, Va; Garden City, N.Y.; Woods Hole, Mass; Asheville, N.C.; Detroit, Mich; Kansas City, Mo; Fort Worth, Tex; Salt Lake City, Ut; Anchorage, Alaska; Honolulu, Hawaii; Norman, Okla; Boulder, Colo; La Jolla, Calif; Tiburon, Calif; Seattle, Wash; Madison, Wisc; and College Station, Texas. One may order from the National Climate Center, NOAA Environmental Data Service, Federal Building, Asheville, N.C. 28801. The costs are the same as from the EROS Data Center.

The Department of Agriculture also sells ERTS imagery dealing with agriculture. Photos may be obtained from the Western Aerial Photo Laboratory, Agricultural Stabilization and Conservation Service, USDA, 2505 Parley's Way, Salt Lake City, Utah 84109. The costs are the same as from the EROS Data Center.

All data entering the NASA Data Processing Facility will be categorized, logged and stored. Users will have access to this information through several files maintained by User Services at the Goddard Space Flight Center, Greenbelt, Maryland.

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

EROS Data Center Photographic Products Price List -- May 1, 1973

Contact prints, enlargements and transformed prints are unmounted and untrimmed. The reproduction will be printed on standard paper stock unless the order specifies other materials.

PRODUCT	PRICE		
	<u>1-25</u>	<u>Over 25</u>	<u>Full Rolls</u>
<u>Black and white</u>			
Contact prints:(paper only)			
70 mm	1.25	1.00	0.65*
5"x5"	1.50	1.00	0.75*
9"x9" or 10"x10" Neg. to Pos.	1.75	1.25	0.85*
10"x12" (PHOTOINDEX)	2.50	2.50	NA
20"x24" (PHOTOINDEX)	3.00	3.00	NA
Enlargements (paper only)			
9"x9" (from 70mm only)	1.75*	1.25*	1.00*
18"x18" THRU 20"x20"	3.50	3.00	NA
24"x24" THRU 30"x30"	4.50	3.50	NA
36"x36" THRU 40"x40"	9.00	8.00	NA
Film Transparencies & Inter-Negs			
16 mm (100ft. rolls)	NA	NA	10.00*
35 mm (100ft. rolls)	NA	NA	11.50*
70 mm	2.50	2.50	1.25*
5"x5"	2.75	2.75	1.35*
9"x9" or 10"x10"	3.00	3.00	1.50*
Film Transparencies-Enlargements			
9"x9" (from 70 mm only)	3.00*	3.00*	2.25*
20"x20"	NA	NA	NA
30"x30"	NA	NA	NA
40"x40"	NA	NA	NA
Kelsh Plates			
Contact Prints on Glass. Specify thickness (0.25 or 0.06 inch) and method of printing (emulsion to emulsion or through film base)	6.50	6.00	NA
ER-55 Plates			
Reductions on Glass (11x11cm)	5.00	4.50	NA
Transformed Prints			
From CONVERGENT or TRANSVERSE Low Oblique photographs	3.50	3.00	NA

	<u>1</u>	<u>2 or Over</u>	<u>Full Rolls</u>
Color			
Contact Prints (paper only)			
70 mm	4.00	2.50	1.25*
9"x9" or 10"x10" Neg. to Pos.	7.00	3.00	2.00*
Pos. to Pos.	7.00*	5.00*	2.50*
Enlargements (paper only)			
9"x9" (from 70 mm only)	7.00*	5.00*	3.75*
18"x18" THRU 20"x20"	15.00**	9.00**	NA
24"x24" THRU 30"x30"	20.00**	14.00**	NA
36"x36" THRU 40"x40"	25.00	20.00	NA
Film Transparencies & Inter-Negs			
16 mm (100 ft. rolls)	NA	NA	20.00*
35 mm (100 ft. rolls)	NA	NA	25.00*
70 mm	4.00	2.50*	1.25*
9"x9" or 10"x10"	10.00**	8.00**	4.00*
Film Transparencies-Enlargements			
9"x9" (from 70 mm only)	10.00*	8.00*	4.00*
20"x20"	20.00**	15.00**	NA
30"x30"	30.00**	25.00**	NA
40"x40"	60.00**	55.00**	NA

NOTES:

Prices listed are per frame except for 16 mm and 35 mm transparencies which are 100 ft. rolls. The "over 25" price applies only to those prints in excess of 25 of the same size. The full roll price applies to orders for all frames on the roll and for the product to be delivered in roll form.

For an intermediate-size enlargement, use the price listed for the next larger size.

*New photo product

**Revised price

INT: 6499-73