CHAPTER 117

COASTAL APPLICATIONS OF THE ERTS-A SATELLITE

by
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ABSTRACT

This paper describes the Earth Resources Technology Satellite (ERTS) placed in orbit in July 1972 and the ERTS simulation high altitude aircraft flights which have been flown for approximately one year. The ERTS satellite and simulation programs conducted by the National Aeronautics and Space Administration (NASA) have been developed to demonstrate the techniques for efficient management of the earth's resources. To achieve this objective the ERTS-A satellite provides for the repetitive acquisition of high resolution multispectral data of the earth's surface on a global basis. Two sensor systems have been selected for this purpose: a four-channel multispectral scanner (MSS) subsystem for ERTS-A and a three-camera return beam vidicon (RBV) system. Systematic repeating earth coverage under nearly constant observation conditions is provided for maximum utility of the multispectral images collected by the ERTS satellite, which operates in a circular sun synchronous nearly polar orbit at an altitude of 494 nautical miles. It circles the earth every 103 minutes completing 14 orbits per day and views the entire earth in 18 days. The orbit has been selected so that the satellite ground trace repeats its earth coverage at the same local time every 18-day period within 20 nautical miles. A number of data output products are available from this satellite which include 70 mm products for precise location of topographic features, 9.5 inch positive or paper prints and also computer compatible tapes or punched cards.

Also described are the results of the ERTS-A simulation flights flown at an altitude of 65,000 feet as related to coastal studies. Simulations of both the RBV and MSS in coastal areas are presented.

OBSERVATORY

The ERTS Observatory (Figure 1) satellite weighs approximately 2,100 pounds (953 kg) with a height of about 10 feet (3 meters), a diameter of 5 feet (1.5 meters) and with solar paddle assemblies extending out to about 13 feet (4 meters). A detailed description of this satellite is available in Data Users Handbook, NASA Earth Resources Technology

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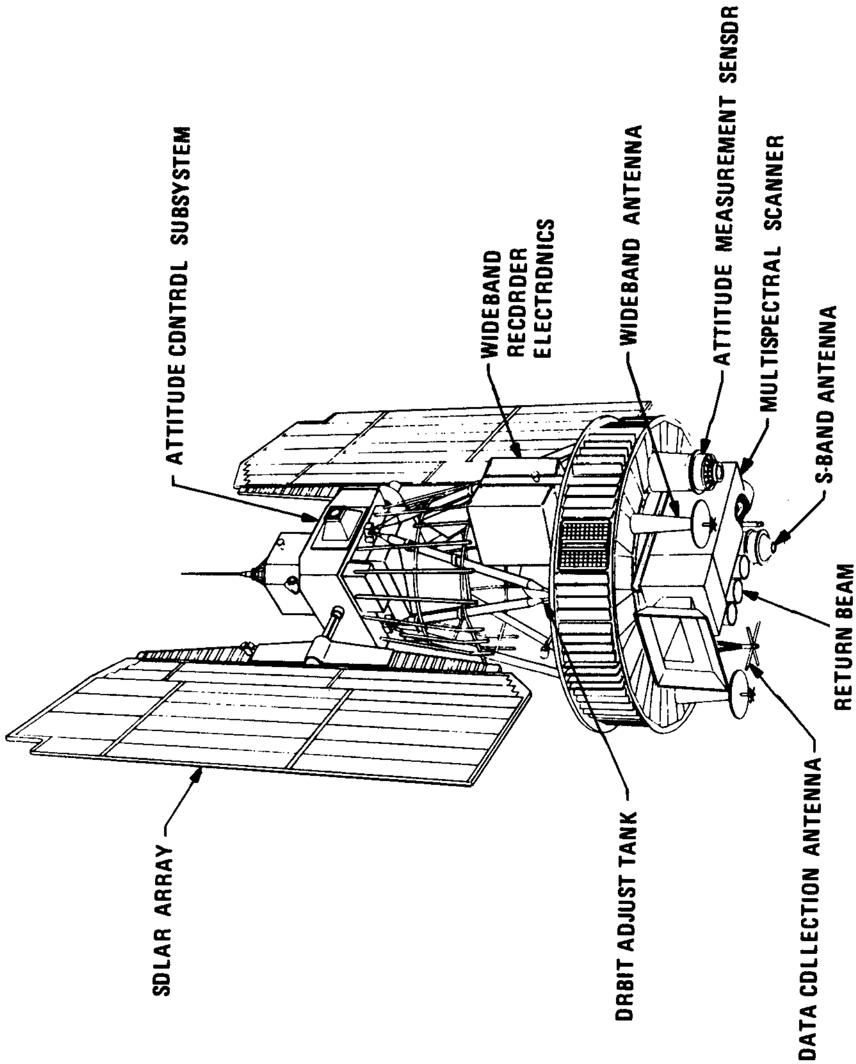
ATTITUDE CONTROL SUBSYSTEM
WIDEBAND RECORDER ELECTRONICS
WIDEBAND ANTENNA
ATTITUDE MEASUREMENT SENSOR
MULTISPECTRAL SCANNER
S-BAND ANTENNA
RETURN BEAM VIDICON CAMERAS (3)
DATA COLLECTION ANTENNA
ORBIT ADJUST TANK
SOLAR ARRAY

Figure 1

Satellite, Goddard Space Flight Center, Greenbelt, Maryland 20771, U.S.A., Attention: Mr. Thomas M. Ragland, Code 430. The basic remote sensing subsystems of interest to the coastal engineer are the Return Beam Vidicon Camera and Multispectral Scanner to be described below. This was also described by Magoon, et al[(1)]1971.

The Return Beam Vidicon (RBV) consists of three independent cameras sensing the following bands: RBV No. 1 0.48 - 0.575 (blue-green); RBV No. 2 0.58 - 0.68 (yellow-orange); RBV No. 3 0.69 - 0.83 (red) microns. As these bands are in the visible spectrum, this subsystem is operated only during daylight hours. The viewed ground scene which is roughly 100 (185 km) by 100 (185 km) nautical miles produces overlapping images every 25 seconds. The RBV camera orientation is shown on Figure 2.

The Multispectral Scanner (MSS) continuously scans a ground swath perpendicular to the spacecraft velocity as shown on Figure 3. Optical energy is sensed from four spectral bands as follows:

Band 1	0.5 to 0.6 micrometers
Band 2	0.6 to 0.7 micrometers
Band 3	0.7 to 0.8 micrometers
Band 4	0.8 to 1.1 micrometers

The ERTS provides repeating earth coverage under nearly constant observation conditions. The satellite's ground trace repeats its ground coverage every 18-day period within 20 nautical miles. A typical ERTS daily ground trace (daytime passages only) is shown in Figure 4.

SIMULATION FLIGHTS

In order to provide the ERTS user community with examples of imagery, NASA is operating two high altitude aircraft as a part of the airborne research program Earth Resources Aircraft Project (ERAP). These planes, Lockheed U-2's, are providing repetitive flights at 65,000 feet (20,014 meters) over 5 test sites. The time interval between flights, timed to simulate satellite coverage is approximately 18 days. The data collection system carried in the aircraft used for direct ERTS simulation consists of three cameras coupled to make three simultaneous images over 196 square nautical miles in the test site. The cameras have a focal length of 45 mm and use 70 mm roll film. A system of filters permits only selected portion of the spectrum which correspond to ERTS measurement to be recorded on the film. The spectral regions viewed by the cameras are in the 475-575 nanometer band width (green) the 580-680 nm band width (red), and the 690-760 nm band width (near IR or very red). The fourth camera identical to and coupled with the

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[(1)]Magoon, et al, <u>Use of Satellites in Coastal Engineering</u>, Port and Ocean Engineering Under Arctic Conditions, Trondheim, Norway, 1971.

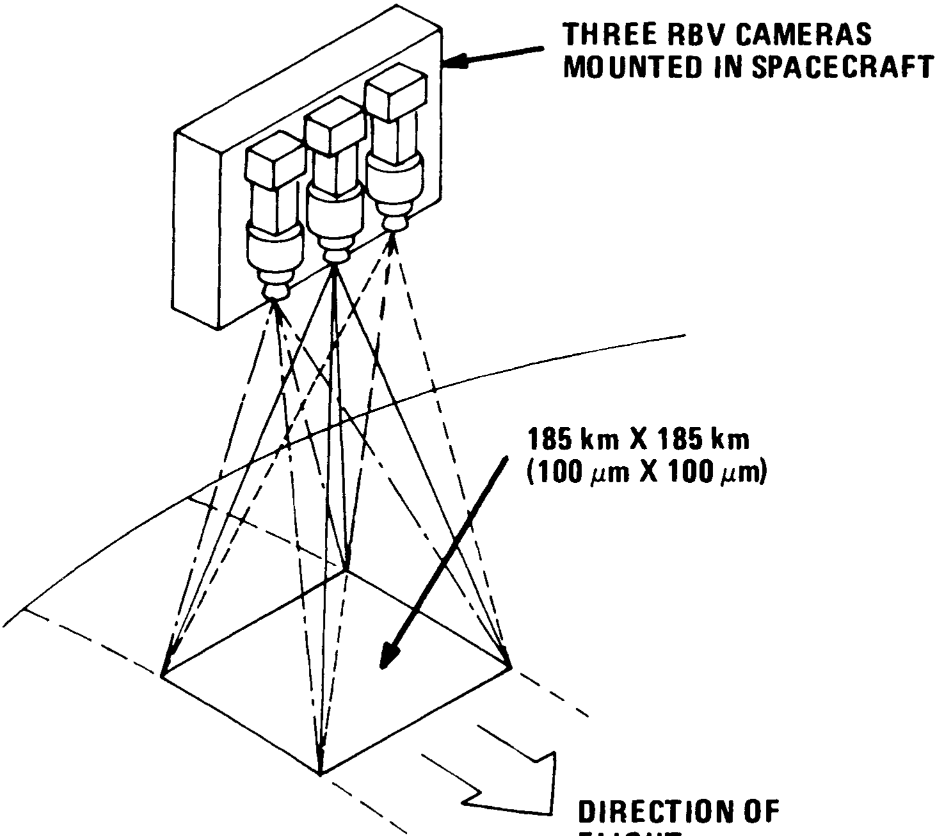
THREE RBV CAMERAS
MOUNTED IN SPACECRAFT
185 km X 185 km
(100 μm X 100 μm)
DIRECTION OF
FLIGHT

Figure 2

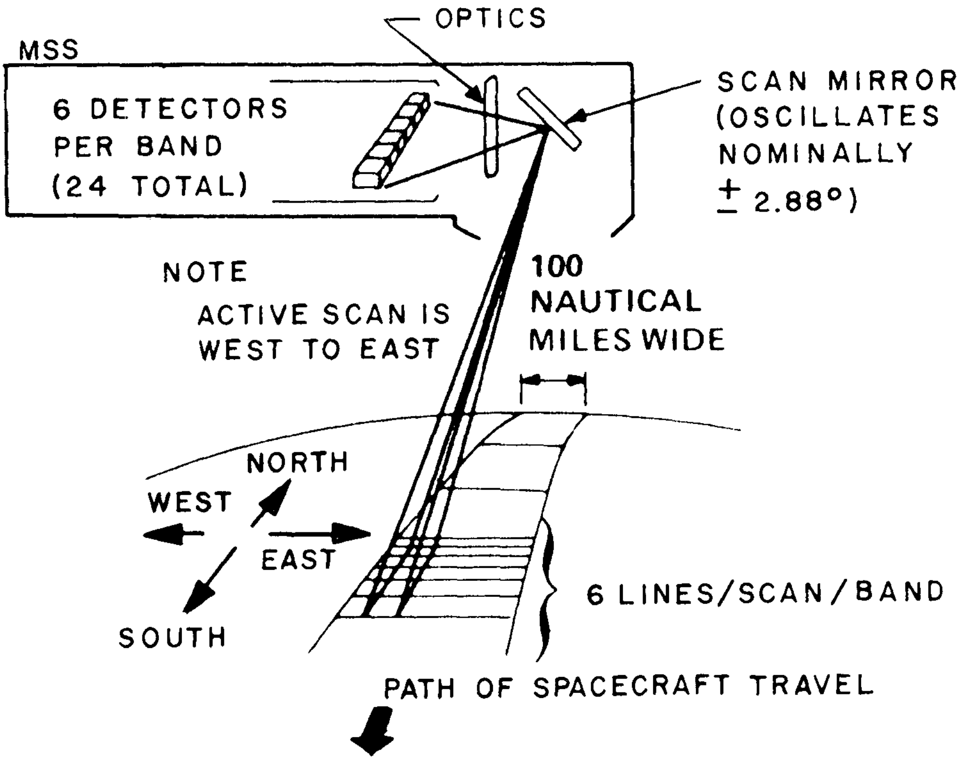
OPTICS
MSS
SCAN MIRROR
(OSCILLATES
NOMINALLY
± 2.88°)
6 DETECTORS
PER BAND
(24 TOTAL)
NOTE
ACTIVE SCAN IS
WEST TO EAST
100
NAUTICAL
MILES WIDE
NORTH
WEST
EAST
SOUTH
6 LINES/SCAN/BAND
PATH OF SPACECRAFT TRAVEL

Figure 3

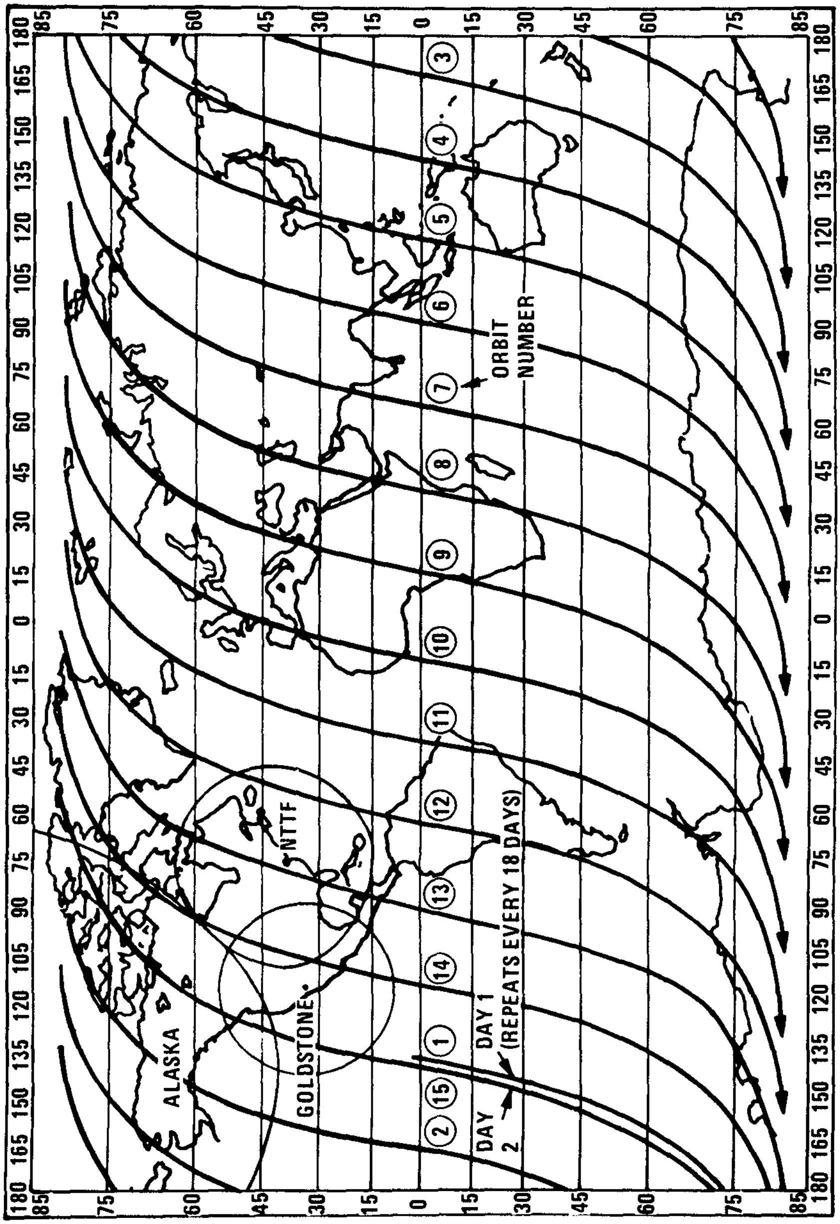
ALASKA
GOLDSTONE
NTTF
ORBIT NUMBER
DAY 1 (REPEATS EVERY 18 DAYS)
DAY 2

Figure 4

three primary cameras uses color infrared film to produce general purpose earth resources information in the 590-850 nm band width. The cameras automatically record images every 105 seconds over the test site. The number of frames exposed over the sites varies from 79 for the California Feather River and Lake Tahoe to 163 for the Chesapeake Bay. Data flights over all of the test sites are originated from NASA/Ames with exception of the Chesapeake Bay site which is staged from NASA's Wallops Island Station in Virginia.

Upon examination of the imagery supplied in conjunction with the NASA U-2 flights a number of coastal applications for this imagery and presumably the ERTS satellite imagery were noted for the purposes of this discussion, three general areas of interest are noted as follows:

a. Studies of the nearshore and coastal water movement by observing photographed sediment plumes or patterns,

b. Observing changes in inlet configurations and barrier beach or spit configurations, and

c. Studies relating to determination of wave direction

These general areas are discussed separately below.

NEARSHORE SEDIMENT MOVEMENT

A coastal area-inlet problem of considerable interest has been the area in the vicinity of the entrance to San Francisco Bay (Golden Gate). In this general area particular interest in the technical literature has been paid to Bolinas Bay and the entrance to Bolinas Lagoon. Recent literature describing Bolinas Bay are given by Johnson(2) and Wilde and Yancey(3). Of particular interest are the hypothesized circulation in Bolinas Bay taken from Wilde and Yancey. Additional study of this site is currently underway by Ritter(4). Wilde and Yancey and Ritter give somewhat conflicting views of sedimentation movement and inferred water circulation. Of particular interest in the Bolinas site is that the coast from the entrance to Bolinas Lagoon to Ducksbury Reef contains an eroding bluff which contains a sufficiently large amount

(2) Johnson, J. W., "Seasonal Bottom Changes - Bolinas Bay, California", 1970 12th International Coastal Engineering Conference, pp. 138-139.

(3) Wilde, P. and Yancey, T., "Sediment Distribution and Its Relation to Circulation Patterns in Bolinas Bay, California", 1970 12th International Conference on Coastal Engineering, pp. 1397-1415.

(4) Ritter, J., "Sedimentation and Hydrology of Bolinas Lagoon, Marin County, California, open file report", U. S. Dept. of Interior, Geol. Survey, Water Res. Div., Menlo Park, Calif.

of fine material to produce a natural pollution source which is readily visible to the unaided eye.

Inasmuch as the ERTS simulation photography of the San Francisco Bay test site overflies the Bolinas Bay/Bolinas Lagoon area ERTS simulation imagery was examined with an attempt to infer the water circulation at the time the photography was taken.

Repeated views taken by the ERTS simulation flights of the sediment plume from this source were seen extending out away from the bluff. False color enhancements of this imagery were made by use of the NASA/Houston Multiple Camera Film Viewer (MCFV) described in "Remote Sensing in the Study of Coastal Processes" by Magoon and Pirie printed elsewhere in these Proceedings. This device takes the three images and assigns colors to grey scales and then recombines the three separate color images to a single image.

Based on this imagery, it is concluded that the ERTS RBV will produce a viable product for coastal sediment studies.

In the analysis of the U-2 imagery major coastal sediment plumes were noted along many sections of the California coast. A particularly noticeable plume was seen off of Point Reys, California.

INLET CONFIGURATIONS

A second coastal inlet problem of major interest is the understanding and quantification of changes to inlets in barrier beaches and coastal bars and spits. These highly variable geomorphological features are extremely difficult and costly to study by conventional means, such as surveying, due to the extremely high cost associated with conventional ground surveys. Additionally, conventional low level photography, i.e., 10,000-foot range, normally results in the generation of large amounts of film and imagery and by and large results in greater detail than is necessary for general conformal studies. Of particular interest were ERTS simulation flights of the Delmarva Peninsula in Accomac County, Virginia, where major changes in coastal areas are readily detected from the ERAP images. In a sequence of views of these islands taken from the CARETS test site imagery, gross changes in inlet configuration can be readily detected. It is also important to note that the imagery for the entire 32,600 square mile area of the Chesapeake site can be contained in a very small space, i.e., a roll of film 70 mm wide and one inch in diameter. The Vinten cameras resolve scenes down to about 50 feet while the 24-inch cameras will resolve scenes down to about 3 feet.

WAVE DIRECTION

It is technically accepted that ocean waves produce one of the major forces that are associated with the configuration and establishment of coastal inlets. The technical literature contains vast numbers of references relating to correlation between coastal movements and ocean wave conditions. One of the important parameters that investigators have looked for is a viable system for measurement of wave direction. Unfortunately the theoretical analyses of the available wave direction models are subject to question due to the fact that there is little factual data on the configuration of deep water waves. This is in part due to the lack of a suitable platform to observe the major wave phenomena. Based on the work of Dr. D. Lee Harris at the Coastal Engineering Research Center it appears that the U-2 aircraft operating at an altitude of approximately 65,000 feet provides a unique platform for obtaining imagery related to wave direction.

CONCLUSIONS

Based on the imagery supplied by the NASA ERTS simulation efforts, it is concluded that ERTS imagery will be of use to coastal investigators in two principal areas: study of coastal sediment and related water mass movement through the repeated monitoring of coastal sediment plumes, and for the study of changes in highly variable sections of coasts such as offshore barrier islands and erodible shoals. Use of ERTS imagery in studies relating to deep water wave direction is problematical depending on the resolution of water surface waves in the final data products received from NASA.

ACKNOWLEDGMENTS

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