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DIGITAL DATA PROCESSING OF ERTS-1 IMAGERY OF DELAWARE BAY

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ABSTRACT

A user-oriented Earth Resources Data Center is in operation at Bendix Aerospace, which is capable of automatically producing classification imagery and thematic maps from ERTS Computer Compatible Tapes. The ERDC is now being used to process ERTS-1 data under a subcontract to Bendix from the University of Delaware.

ERTS coverage of Delaware Bay has been processed to produce classification imagery of water masses in the bay, and a map of all land-water boundaries along the shoreline including wetlands and inland lakes. The paper shows and describes the imagery and the user's video monitor color display, and describes the data processing facility and methodology.

1. INTRODUCTION

Bendix Aerospace is under sub-contract to The University of Delaware to provide data processing and other support for the University's ERTS-1 investigation of Delaware's coastal resources and environmental conditions. In the conduct of its work for the University, Bendix is using its Earth Resources Data Center (ERDC) to process ERTS-1 MSS data. The ERDC is a dedicated data processing facility designed to accept ERTS CCT's, MSDS and Skylab High Bit Density Tapes (HBDT's) and Bendix Modular Multiband Scanner HBDT's and to produce video and film outputs of original imagery and enhancements and thematic maps. The ERDC has been designed to be a user-oriented facility; i. e., it is intended to be used by Earth Resources investigators and not by data processing experts. Consequently, the procedures and the underlying methodology are of interest to all of the ERTS (and Skylab) investigators who are using CCT (or HBDT) data.

The balance of the paper will briefly describe the facility and the procedures for its use, and show preliminary decision imagery and a thematic map of the Delaware Bay region.

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Original photography may be purchased from
EROS Data Center
10th and Dakota Avenue
Sioux Falls, SD 57198

2. BENDIX EARTH RESOURCES DATA CENTER

The nucleus of the Bendix Earth Resources Data Center (ERDC) is a Digital Equipment Corporation PDP-11/15 computer with 32K words of core memory, two 1.5M word disc packs, two 9-5rack 800 BPI tape transports, a line printer, a card reader, and a teletype unit. Other units are: an Ampex FR 2000 14-track tape recorder; bit synchronizer and tape deskew drawers which can reproduce up to 13 tape channels of multispectral data from high density tape recordings; a high speed, hard wired, special-purpose computer for processing multispectral data; a 70-mm laser film recorder for recording imagery on film; and a color, moving window, computer-refreshed display. This facility is owned by Bendix: it is the result of an evolutionary program initiated in 1967 and is dedicated to the processing of remote sensing data. Access is also available to a computer controlled, precision plotting table (which is part of a Bendix Datagrid[®] Digitizer system) and the corporate IBM-370-155 facility, with which the ERDC is colocated. Access to these additional facilities is available through use of computer-compatible tape (CCT) for communication.

The ERDC can accept data on CCTs, high-density tapes (10,000 bits per inch per track, 13 tracks). The color display can be used for screening and editing data or as a processed output viewing device. Typical data inputs are ERTS CCTs, NASA 24-channel scanner high-density tapes or CCTs, EREP S192 reformatted high-density tapes or CCTs, and high-density tapes from Bendix scanners such as the Modular Multi-band Scanner (M²S). The facility is used for in-house applications research, current ERTS-1 experiments in addition to the Delaware investigation, commercial and government resource management contracts, and as a commercial service at hourly rates.

Processing of the ERTS MSS data can be broken down into a sequence of three steps. The first step is screening and editing, in which samples of data are extracted from the data tape for use in subsequent analysis steps.

Screening and editing are accomplished through use of a color display. The display is the moving window type with display refresh performed by the computer. The display is 128 elements by 128 elements. Full ERTS resolution is maintained by displaying only 128 cells from an 832-element scan record on the ERTS MSS data tape. The resolution element at which the display will start can be selected by the operator. In effect, the operator can move through the tape and see any selected 1/8 segment of the scan record displayed. When the area from which it is desired to select a data sample is displayed, the display can be stopped

and the computer can be instructed to dump the data displayed from the data tape onto the disc. A line printer printout is simultaneously generated showing the data dumped. The printout contains scan line count down the left-hand side, shows the beginning resolution cell number in the header, and has resolution cell counting aids every 10 cells at the top. Using these identifiers, training sets can be selected (one resolution cell at a time if desired) and transferred from the dump area of the disc to a disc area set aside for the particular target type selected. The display and dump sequence can be repeated as many times as desired.

The second step is off-line analysis. Multivariate analysis can be performed to separate or enhance targets. We have programs to perform regression analysis, factor analysis, principal component analysis, canonical analysis, cluster analysis, and discriminant analysis. Scatter diagrams and histograms can be generated to determine expected classification or enhancement algorithm performance. For level slicing or contouring, histograms are generated to permit selection of level slicing or contour intervals. Various tabular outputs, such as covariance matrices, are also available.

The third step is the actual processing. In this case the computer acts as a process control computer, and the processing is done in a special-purpose, hardwired computer. The special-purpose computer is used to allow high throughput rates (essentially the fastest rate at which the computer tape transport can read data). Processed output can be displayed on the display, or paper or film hard copy can be generated.

3. PROCESSED ERTS-1 IMAGERY OF DELAWARE BAY

Examples of processed ERTS-1 imagery are shown in the accompanying illustrations. All of the illustrations shown were produced from CCT's of the overpass of 10 October, 1972; Number 1079-15133. Three of the possible outputs are shown here; a strip of imagery from a CCT, decision imagery, and a thematic map.

Figure 1 is a portion of the overall ERTS-1 scene, that was produced in the Bendix ERDC. The segment shown, which is a print of MSS Channel 5, contains the section of data that was processed to provide the examples in the other illustrations. The banding that is exhibited on all of the illustrations except the thematic map is an ERTS-1 detector characteristic. The use of a radiometrically corrected CCT would have eliminated that artifact.

Figure 2 shows classifications of target categories achieved by the use of decision imagery. Five categories were selected by choosing training set areas through visual examination of bulk imagery, since ground truth data was not acquired from the University. The training sets are described in the image captions. The set marked "Coastal Inlet Sediments" may be suspect, since we were recently informed by the University that it is thought that they can see bottom in the lagoon from which the training set was drawn.

It should be emphasized that the decision imagery in Figures 2 and 3 is not density sliced, but represents separation by spectral signatures. Spectral signature recognition is more precise than photographic or electronic density slicing, in that spectral signatures are not as subject to modification by variations in atmospheric or illumination effects.

Figure 3 contains two illustrations. On the left is an illustration of the simultaneous displays of all classified categories. This is similar to what one would see on the video monitor display, except that only a portion of the scene is shown on the monitor as mentioned earlier, and the monitor is of course in color. The right hand illustration is a thematic map, which in this case shown the land-water boundaries. The map agrees with the 1:250,000 scale USGS maps of the region, except where the thematic map shows changes in the New Jersey shoreline since the 1966 edition of the USGS map. (This will be covered in detail in the University's reports.) The three small areas in the bay are probably ships. Vessels of 600' to 800' are known to pass here, though visual inspection of the bulk images did not disclose any vessels.

4. SUMMARY

The results shown here were produced by personnel who are data users, and not data processing specialists. We believe we have successfully developed and demonstrated a method by which virtually any ERTS investigator can achieve precise and quantifiable results directly from CCT data.



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Figure 1.

Portion of MSS Channel 5 Image, Produced on the
Bendix Aerospace ERDC.

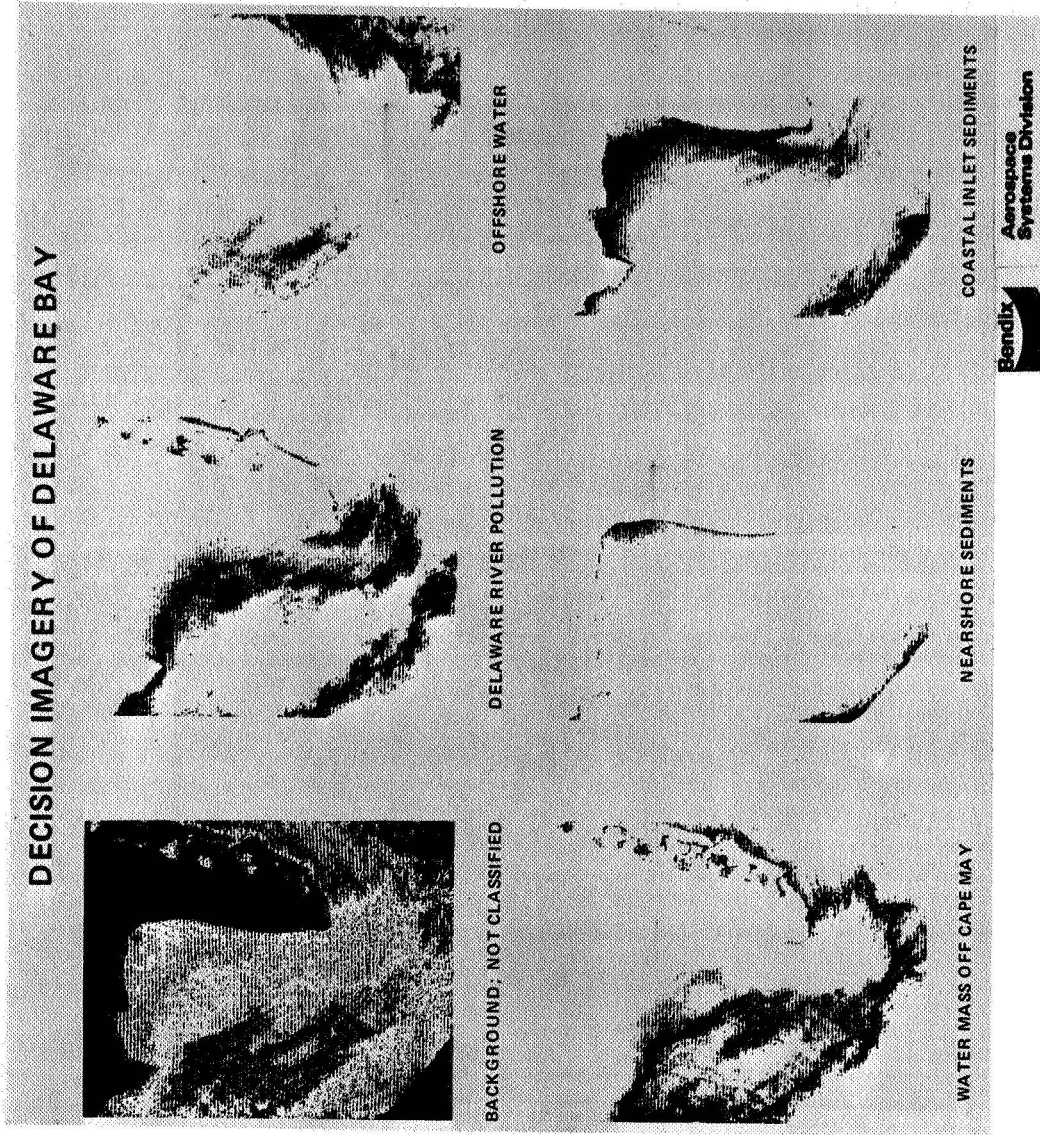
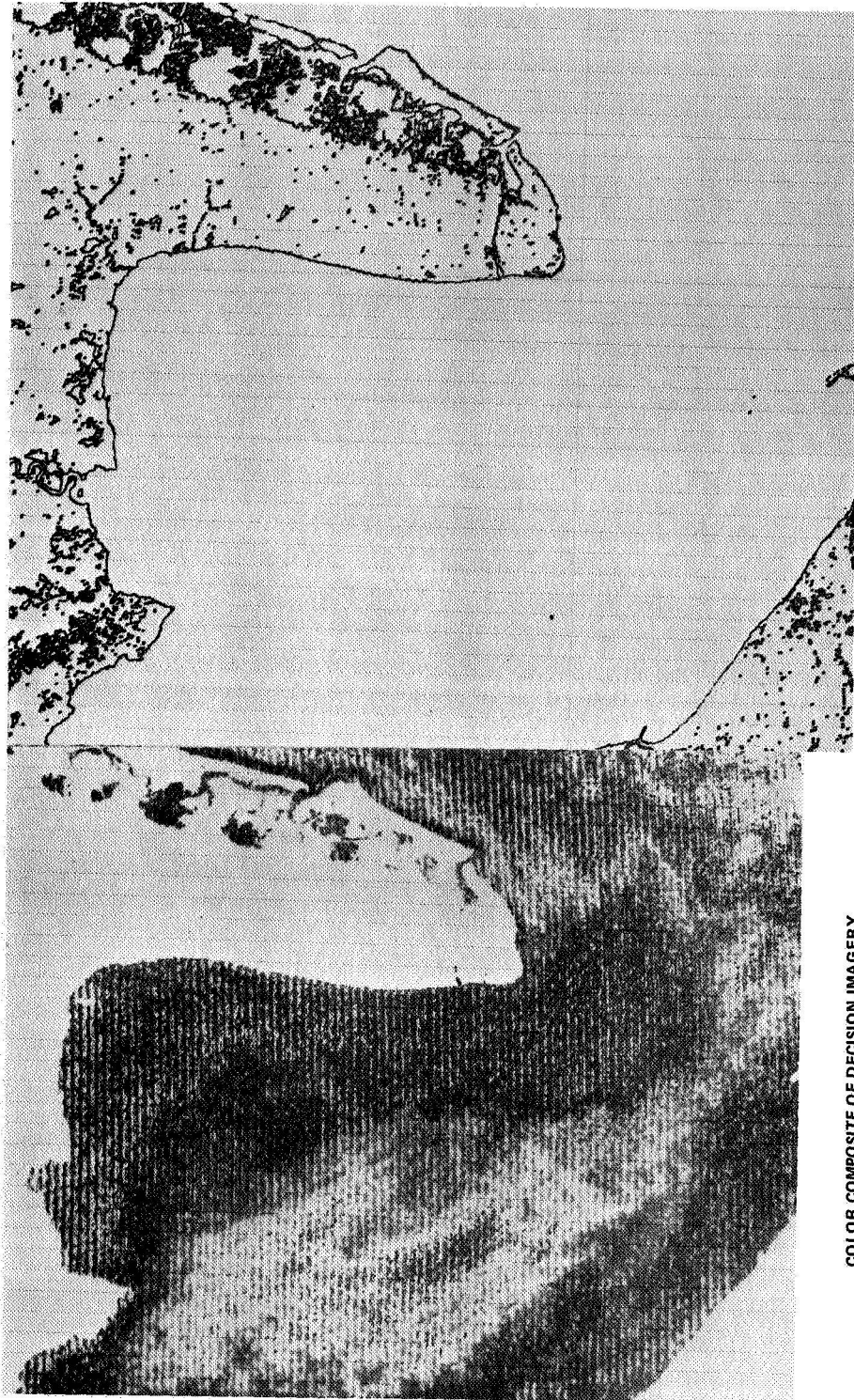


Figure 2.



COLOR COMPOSITE OF DECISION IMAGERY

CALCOMP PLOT OF LAND-WATER BOUNDARIES

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Figure 3 Processed ERTS MSS Data of Delaware Bay