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National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt Road
Greenbelt, Maryland 20771

Attention: Mr. E. F. Szajna, Code 430

Contract: NAS5-21783

Subject: Fifth Bimonthly (Type I) Report for Period covering 1 March 1973 - 30 April 1973

Dear Sir:

The enclosed material comprises the fifth Type I bimonthly technical report for contract NAS5-21783, which describes the progress for the ten tasks of the Environmental Research Institute of Michigan program for the subject period. The required financial reports 533M and 533Q are submitted separately from ERIM's accounting department. The work on this contract is performed in the Radar and Optics Division (Task IV only) under the direction of Dr. L. J. Porcello and in the Infrared and Optics Division (for the other nine tasks) directed by Mr. R. R. Legault.

Principal investigators for each task are listed in each subsection of this report for the ten tasks. A summary listing of the tasks with names of the principal investigators and short titles is provided as an attachment to this letter.

The status, principal activities and accomplishments of the various tasks for this reporting period are noted here in summary form.

(1) Early in this reporting period the symposium, "Significant Results from ERTS-1", 5-9 March 1973, Goddard Space Flight Center, Maryland, involved most of the tasks and seven papers were presented from the ERIM tasks. An additional paper has been presented at the 2nd Annual Remote Sensing of Earth Resources Conference, UTSI, Tullahoma, Tennessee, 26-28 March 1973. Authors and titles are listed in an attachment to this letter.

(2) Data Analysis Plans have been submitted for all tasks that have received data permitting development of such plans. Tasks II, IV, and IX still have not received data from which the plans could be developed.

18 pp.

(3) A high gain data collection pass for Task VIII using MSS channels 4 and 5 to cover the New York Bight area, was requested and scheduled for 25 April 1973. Field work on the water also was conducted on that date.

(4) Revised water depth maps, using every 6th scan line and every 6th point within scan lines have been prepared for the Little Bahama Bank from the ERTS-1 data and the results show good agreement with the published depth charts for this area.

(5) An ERIM aircraft mission in support of the New York Bight studies was conducted on 7 April 1973. Dr. Wezernak (P.I., Task VIII), made coincident measurements on the water.

(6) A map has been prepared by Task X which displays the ratio of data from two different overflights of the Wind River, Wyoming (Atlantic City District) test site.

Reports prepared by the individual investigators follow in order by task number.

Respectfully submitted,

Frederick J. Thomson
Research Engineer

Approved by: Richard R. Legault
Director, Infrared and Optics Division

FJT/RRL/dlc

Attachments:
List of tasks
Titles of papers from the tasks
Type I reports for ten tasks

ERTS PROGRAM SUMMARY

Under Contract NAS5-21783

TASK	PRINCIPAL INVESTIGATOR	MMC #	UN	SHORT TITLE
I	Polcyn	063	200	Water Depth Measurement
II	Thomson	077	621	Yellowstone Park Data
III	Thomson	137	636	Atmospheric Effects (Colorado)
IV	Bryan	072	201	Lake Ice Surveillance
V	Sattinger	086	225	Recreational Land Use
VI	Polcyn	114	635	IFYGL (Lake Ontario)
VII	Malila Nalepka	136	612 178	Image Enhancement
VIII	Wezernak	081	625	Water Quality Monitoring
IX	Horvath	079	606	Oil Pollution Detection
X	Vincent	075	422	Mapping Iron Compounds

LIST OF PAPERS FROM THE TASKS FOR REPORTING PERIOD

1 March - 30 April 1973

TASK	TITLE
I	Calculating of Water Depth From ERTS-MSS Data Fabian C. Polcyn and David R. Lyzenga
II	Terrain Classification Maps of Yellowstone National Park Frederick J. Thomson
IV	Application of Dielectric Constant Measurement to Radar Imagery Interpretation M. Leonard Bryan
V	Digital Land Use Mapping in Oakland County, Michigan Irvin J. Sattinger and Robert D. Dillman
VI	Progress of an ERTS-1 Program for Lake Ontario and its Basin Thomas W. Wagner and Fabian C. Polcyn
VII	Atmospheric Effects in ERTS-1 Data, and Advanced Information Extration Techniques William A. Malila and Richard F. Nalepka
VIII	Monitoring Ocean Dumping with ERTS-1 Data Chester T. Wezernak and Norman E. G. Roller
	Monitoring of Ocean Dumping by Means of Satellite Remote Sensing Chester T. Wezernak
X	Ratio Maps of Iron Ore Deposits Atlantic City District, Wyoming Robert K. Vincent

Fifth Type I Progress Report - 1 March 1973 - 30 April 1973
Task I - Water Depth Measurement - 1388
F. C. Polcyn - UN 200, MMC 063

Because of noise level differences between the six detectors in each spectral band a new depth map for the Little Bahama Bank was generated using the best signal level in one of the detectors for each spectral range. This produced a depth map using every sixth scan line and every sixth resolution element along the line to maintain proper geometric aspect. The depth range was calculated and displayed in color format printed from the digital computer using two meter intervals. Comparison with HO chart 5990 shows excellent correlations with the ERTS map showing the additional information of new shoal areas some distance away from the Grand Bahama Island.

New ERTS frames for both test sites near Puerto Rico and Upper Lake Michigan have been received but these images still contain a large number of patchy clouds. Selected shoreline segments are clear and could be used for analysis and will be used if later cycles of ERTS passes fail to produce any better information.

Fifth Type I Progress Report - 1 March 1973 - 30 April 1973
Task II - Yellowstone National Park Data - 1398
F. J. Thomson, UN 621, MMC 077

Joint discussions were held early this period, during which Dr. Smedes and Ralph Root familiarized ERIM personnel with the techniques they were using to assess recognition accuracy of the 5 category color digital map. Fruitful results of these talks included the decision to generate additional recognition accuracy estimates for each category and determination of associated confidence intervals.

These data are being summarized in an interim progress report detailing the background and preparation of this first map. ERIM personnel have the specific responsibility of writing the "Data Processing Techniques" section. Anticipated release date for this publication is early summer.

Concurrently, work has begun on the second mapping effort, focusing primarily on making finer cuts of the initial five terrain feature categories. In preparation for this attempt, Mr. Root spent the week of 2-6 April at ERIM. During this time he and Norman Roller, a Graduate Research Assistant utilized high altitude aerial photography to refine and expand upon original training site selection, and define and identify several additional important ecological terrain features.

Training site selection was greatly facilitated through use of a high magnification, rapid scanning film viewing device known as the VARISCAN. The result of Mr. Root's visit is increased confidence in knowledge of training site parameters and signature extraction accuracy.

Signatures of these newly proposed categories and sites were computed and the spectral statistics analyzed to determine separability. Eighteen categories were ultimately considered significant and sufficiently separable to warrant a test recognition.

As before, two steps were performed preparatory to actual mapping. First, all within class training sites were merged to form "composite" signatures for each category. Then, optimum channels for discrimination were determined. MSS 5 is the single best channel for separating the following categories: Two densities of lodgepole pine, spruce-fir forest, 2 lesser densities of conifer forest on rock and grass substrates, light and dark rock exposures, brush, grasslands, a grass-brush mixture, alpine meadows, lowland shrubs, thermal deposits, shadow and water.

Recognition maps of restricted test areas containing a maximum amount of environmental variability were generated in the latter part of April. These were immediately shipped to Mr. Root for on-site recognition accuracy assessment. Based on his conclusions and Dr. Smedes recommendations we will either reiterate training site refinement until acceptable recognition is obtained or proceed to produce a final 12-15 category map of the entire park.

Inputs to this final map from the National Park Service are actively being solicited through co-investigator Don DeSpain. Several unique graphic display modes for the final product are also being investigated, including a computer controlled ink squirting device.

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Fifth Type I Progress Report - 1 March 1973 - 30 April 1973
Task III - Atmospheric Effects in ERTS-1 Data - 1410
F. J. Thomson, UN 636, MMC 137

This period, little progress was made actually analysing data because data ordered from User Data Services on about 20 March and 1 April have not yet arrived. Further, reports of Roland Hulstrom's 16 February 1973 field measurements have not yet been received.

Per previous and continuing discussions with Harry Smedes, the current plan is to process some of frame 1009-17075, 1 August, data which partially covers the test site, and write a data analysis plan. This processing will commence as soon as requested imagery and digital tape data are received from Goddard. Since these data were ordered in late March with a quoted 2-3 week delivery time, their arrival seems imminent.

Data processing to complete the land use mapping and atmospheric effects phases of the contract must await receipt of suitable ERTS and ground measurements data from 1973. A first potentially useful set of data for atmospheric effects assessment were obtained on 16 February. Roland Hulstrom made measurements, as previously reported, and imagery ERTS frame 1128-17075 has been ordered. However, neither of these data sets has been received.

In the next bimonthly period, it is expected that the 1 August 1972 data will be received, partially processed in collaboration with Dr. Smedes and assistants, and a data analysis plan written. Theoretical work on the effects of observed radiance on system noise will begin in preparation for interpreting the 16 February data and subsequent data to be received on the standing order, which was reactivated on 1 April.

Fifth Type I Progress Report - 1 March 1973 - 30 April 1973
Task IV, Lake Ice Surveillance - 1406
M. Leonard Bryan, UN 201, MMC 072

As indicated in the previous report, conditions, both concerning the weather and hardware for the radar flights, have caused considerable problems in the progress and scientific conduct of this aspect of the total ERIM (ERTS-1) program. Consequently, realizing the possibilities, and after consultation with both the scientific and technical monitors of this task, it was decided to cease incurring additional expenditures on this task and to re-evaluate the present and projected status of the task. Thus, this task is presently experiencing a cessation of activities pending a decision by all parties concerned. This decision is expected to be made by mid-May 1973.

Fifth Type I Progress Report - 1 March 1973 - 30 April 1973
Task V, Recreational Land Use - 1387
I. Sattinger, UN 225, MMC 086

Additional processing of a section of the available ERTS-1 coverage of Oakland County was performed. Past efforts at using likelihood ratio processing produced maps in which only about 65% of the scene elements were recognized. It is believed that the relatively low recognition fractions are caused by the great amount of detail and the high degree of variability of the scene. Many single scene elements contain a mixture of various types of surface. This is particularly true of the urban areas, where individual scene elements may contain a varying mixture of asphalt, concrete, roofs, grass, and trees. As a result, the probability that individual scene elements fall within preselected spectral signatures is low.

To counteract this problem, an additional processing was performed to increase the fraction of the scene recognized. This was done by modifying the computer program parameters to accept a larger exponent value of the probability density function. When this was done in conjunction with the use of 16 signatures, 99% of the scene elements were recognized. A general check of the result indicated that good recognition accuracy was maintained. Further study will be devoted to this problem during future data processing work.

In accordance with contract requirements, a Data Analysis Plan was submitted describing future plans for technical work throughout the remainder of the contract.

As indicated in the Data Analysis Plan, satisfactory cloud-free ERTS-1 coverage of Oakland County has not yet been obtained. Useful processing results have been obtained from a partially cloud-covered frame, but we believe that further data processing effort should be concentrated on improved ERTS coverage. We will give preference to an area within Oakland County, but such coverage will not be available before June, 1973 at the earliest. Since the availability of Oakland County coverage will not be determined for several months, project activity will be greatly reduced until this availability is determined.

Fifth Type I Progress Report - 1 March 1973 - 30 April 1973
Task VI - IFYGL (Lake Ontario) 1384
F. C. Polcyn - UN 635, MMC 114

Discussions with ground truth teams in Ontario were held and annotations of computer maps for the Oakville Representative Basin were initiated. This annotation coupled with stream runoff records will provide the calibration needed between various land use factors to be measured by ERTS data and the water budget parameters needed in the hydrologic analysis of the Lake Ontario Basin.

A program was written for improving the conversion of ERTS digital data to analog format which is needed for analysis with the ERIM-SPARC system. This will permit a large volume capability for taking ratio of channels and handling the eight ERTS frames under analysis. Analog ratio maps have now been generated which account for changes in illumination levels encountered in our study which uses data from three consecutive days.

Supporting aircraft data also have been obtained during this period with particular coverage of a time study of three major outfalls into Lake Ontario that will be correlated with the simultaneous passage of the ERTS.

Fifth Type I Progress Report - 1 March 1973 - 30 April 1973
Task VII - Image Enhancement and Advanced Information Extraction Techniques - 1385
W. A. Malila (UN612) and R. F. Nalepka (UN178), MMC 136

General

The general objectives of this investigation are to adapt ERIM multispectral information extraction techniques for their application to ERTS-1 data, to assess the applicability of these techniques on selected ERTS-1 data, and to identify any additional problems that might be associated with such processing of satellite multispectral scanner data. Data analysis to date has concentrated on portions of a frame over south central Michigan, collected Aug. 25, 1972.

Progress During Period, 1 March - 30 April 1973

The paper, "Atmospheric Effects in ERTS-1 Data and Advanced Information Extraction Techniques", included in the preceding bimonthly report, was presented at the Symposium on Significant Results Obtained From ERTS-1.

A data analysis plan was submitted for the remainder of the contract period.

Our analysis of the use of proportion estimation techniques for estimating surface areas of lakes was continued. In addition to the standard recognition processing algorithm and the proportion estimation algorithm, a simple level slicing algorithm was tested. Analysis and comparison of the results are not yet complete.

One serious problem that has been found in analyzing ERTS-1 data is the assignment of pixels to individual fields and test plots in the scene. This problem is especially severe for the evaluation of proportion estimation results. We have developed* a procedure for carrying out this task. A transformation, based on control points from photographs and/or topographic maps, is used to convert field vertices to ERTS line and point numbers. Initial tests of the new procedure are very promising.

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*Development costs are being shared by this contract and an ERIM subcontract from the Michigan State University ERTS contract, NAS5-21834.

One multispectral processing technique that has been developed at ERIM is the use of ratios of channels for enhanced contrast and/or removal of certain systematic effects in data. We have generated both analog and digital ratio maps of the intensive test area. An example analog ratio map of this test area, approximately 1/12 of an ERTS frame, is presented in Fig. 1. It was produced on the ERIM SPARC (Spectral Analysis and Recognition Computer) after digital-to-analog conversion. An analysis of the usefulness of ratioed data for interpretation and recognition is in progress.

All ratio images that included ERTS Band 6 were found to exhibit severe striping caused by the problem with every sixth line of data, discussed in previous reports. We have requested a re-digitization of this frame by NASA/GSFC in order to improve the quality of the data. The new tapes are expected early in May.

Plans for the Period, 1 May - 30 June 1973

The analysis of the surface-water data set for area estimation will be completed. We will fully test and begin using our new procedure for assigning ERTS pixels to individual fields. The ratio data over our site will be analyzed and evaluated.

Figure 1. Example Analog Ratio Image,
Portion of Frame 1033-15580
Lansing, Michigan, and Vicinity
Ratio: ERTS 7/ERTS 5 after Dark Object
Subtraction

Fifth Type I Progress Report - 1 March 1973 - 30 April 1973
Task VIII - Water Quality Monitoring - 1400
C. T. Wezernak - UN 625, MMC 081

The major effort during the reporting period has been directed towards processing and analysis of data from the Tampa and Lake Erie test sites. Additionally "ground truth" data were collected in the New York Bight on 7 April 1973 and 25 April 1973.

ERIM is currently working with NOAA in the New York Bight in one phase of NOAA's Marine Ecosystems Analysis (MESA) program. As part of the program the ERIM remote sensing aircraft was used to collect approximately 400 miles of data on 7 April 1973 and 48 miles of data on 6 April 1973. Portions of the data will be utilized in the analysis of ERTS data. Atmospheric conditions at the time of the ERTS pass on 7 April 1973 were very good (0% C.C. over the study area). Consequently, a good ERTS data set is expected.

A "high-gain" ERTS pass over the New York test site was scheduled for 25 April 1973. Accordingly, ground truth data were collected on this date. However, atmospheric conditions on this date were poor. Therefore, it is unlikely that a suitable ERTS data set was collected. It is recommended that a second "high-gain" orbit be programmed for the study area.

A report dealing with monitoring of ocean dumping was presented at the ERTS-1 symposium on 5 March 1973. A paper dealing with the same topic has been accepted for publication in AMBIO, an international environmental journal sponsored by the Swedish Royal Academy of Sciences.

A status report on the progress and results of the investigation to date, together with a data analysis plan, is in preparation and will be submitted to NASA in the very near future.

Fifth Type I Progress Report - 1 March 1973 - 30 April 1973
Task IX - Oil Pollution Detection - 1389
R. Horvath, UN 606, MMC 079

It has been confirmed that ERTS imagery of the Oakland, California oil spill of 19 January through 4 February was acquired with 10% cloud cover on 22 January and 60% cloud cover on 23 January. These frames have been ordered from NDPF.

The accompanying table updates previously reported information regarding the relationship between major oil spill incidents and ERTS overflights. Available spill reports from EPA represent incidents prior to 6 April 1973. As can be seen from the table, potential for useful data exists for the Houston spill of 12 March and the Puerto Rican spill of 12 March. As of 30 April, ERTS coverage information had not been entered into the NDPF computer for the appropriate passes over these sites.

COINCIDENCE OF MAJOR SPILLS AND ERTS OVERFLIGHTS

Location	Oil Type	Quantity	Report Date	Clean Date	ERTS Date	Comments
Salem, Mass.	#2 & #5 Fuel Oil	29,500 gal.	2 Oct 72	after 4 Oct	8 Oct 72	Good Data Too late
Barataria Bay, Louisiana	Crude	336,000 gal.	9 Oct 72	Dissipated before 17 Oct 72	18/19 Oct 72	Overcast
San Antonio, Tex.	Diesel Fuel	678,000 gal.	11 Oct 72	≈ 17-18 Oct 72	24 Oct 72	Too late
San Juan City, New Mexico	Crude	100,000 gal.	12 Oct 72	≈ 1 Nov. 72	16/17 Oct 72	Overcast
Lake Barre, Louisiana	Crude	700 bbl.	22 Nov 72	≈ 24 Nov 72	23/24 Nov 72	Overcast
Albemarle Snd, N. C.	Bunker C	1000 gal.	28 Nov 72	29 Nov 72	3 Dec 72	Good Data Too late
Gulf Coast Penzoil rig J, Storm II	Gas & oil (burning)	?	4 Dec 72	6 Dec 72	11 Dec 72	Overcast Too late
Timbalier Bay, La. (well blowout)	Gas, Light	(minor?)	6 Dec 72	?	12 Dec 72	Overcast
Jennings, La. (Bayou Nezpique)	Crude	3720 bbls.	14 Dec 72	?	12/13 Dec 72	Too early
Alameda, Ca. (Naval Air Station)	10% diesel 20% solvent 70% 20/40 lube	>1400 gal.	22 Dec 72	23 Dec 72	17 Dec 72	Too early
Fenwick, Conn. (L. I. Sound)	#6 Fuel Oil	12,000 gal.	26 Dec 72	30 Dec 72	7 Jan 73	Too late
Gulf Coast, La. (Pltfm A West Delta 79, Signal Oil Co.)	Crude	400,000 gal.	10 Jan 73	11 Jan 73 (Dissipated)	15/16 Jan 73	Too late

Location	Oil Type	Quantity	Report Date	Clean Date	ERTS Date	Comments
Oakland, Ca.	Waste Oil	≈ 120,000 gal.	19 Jan 73	Contained 24 Jan. Completed 4 Feb	22/23 Jan 73	Data Ordered (10%-60% cloud cover)
Vicksburg, Miss.	#2 Fuel Oil	4500 bbl.	31 Jan 73	3 Feb 73 (Dissipated)	4 Feb 73	Too late
Baton Rouge, Lo.	Crude	126,000 gal.	1 Mar 73	Before 13 Mar 73	12 Mar 73	Too late
Bellingham, Wash.	?	est. 1000 gal. (7 sq. mi. slick)	2 Mar 73	?	3 Mar 73	Overcast 3/3/73
Cold Bay, Alaska	Diesel and Gasoline	235,000 gal.	9 Mar 73 (start 8 Mar)	18 Mar 73	14/15 Mar 73	Overcast
Houston, Texas	Oil and Diesel	420,000 gal.	12 Mar 73 (start 9 Mar)	19 Mar 73	15 Mar 73	Investigate
LaParguera, Puerto Rico	Crude	38,000 bbl.	19 Mar 73	After 5 April 1973	29 Mar 73	Investigate
Baton Rouge, Lo.	Slop Oil	40,000 gal.	28 Mar 73	Dissipated 29 Mar 73	30 Mar 73	Too late

Fifth Type I Progress Report - 1 March 1973 - 30 April 1973
Task X - An ERTS Experiment for Mapping Iron Compounds - 1383
R. K. Vincent, UN 422, MMC 075

During this reporting period a Data Analysis Plan was submitted to NASA, a computer study of existing laboratory rock and mineral data was begun and 80% completed, and the first digital temporal ratio map was constructed. The computer study is designed to calculate the 6 non-redundant spectral ratios possible from ERTS MSS data (R_{76}, R_{75}, R_{74}, R_{65}, R_{64}, and R_{54}) for approximately 750 spectral curves in the NASA Earth Resources Spectral Information System and to compress this information into a six-digit number for each spectrum. The resulting six-digit numbers permit easy grouping of targets with similar spectral properties. This procedure will be written up for the next report. Of greatest interest to this task are the following questions:

1. What discrimination can be made among iron oxides?

2. What other natural materials will be confused with iron oxides in ERTS ratio images?

3. Can soils and rocks be discriminated from one another as two general groups?

4. What geologically important groups of rock types are discriminable from most or all other natural materials?

The compression of laboratory spectra into six-digit numbers should be useful for storing lab data in future real-time data processors, which produce truly automatic recognition maps.

A temporal ratio is made in the following manner. Spectral ratio maps (R75 for example) of two different ERTS passes are produced, with dark object subtraction and ratio normalization to correct for atmospheric effects. The two spectral ratio maps are merged such that they spatially coincide, and then one is divided by another to produce what will be called a temporal ratio. Only those objects on the ground which have changed should have a temporal ratio appreciably different from 1.0, if the empirical atmospheric corrections are accurate. The first temporal ratio map has just been produced over the Atlantic City District and is being studied. The two ERTS passes were in August and October 1972; during the latter pass, the test site was half-covered by cumulus clouds. The path radiance, as determined from dark object subtraction, is about the same for both passes, even though the August frame is cloud free. Most non-vegetative targets have a temporal ratio within 10% of 1.0 in this first attempt. The normalization area had to be chosen inside the iron mine (non-vegetative and not cloud covered); hence, the ground in the normalization area could have changed slightly in spectral properties in the two months between frames. For this reason, another area will be temporally ratioed before conclusive results are available.