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PROPOSED EXPERIMENTAL PROGRAMS FOR TESTING
REMOTE SENSOR APPLICATIONS IN THE
METROPOLITAN WASHINGTON AREA
TR-7

by

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ABSTRACT

TITLE: Proposed Experimental Programs for Testing Remote Sensing Applications in the Metropolitan Washington Area.

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SUBJECT: Discussions and specifications of suggested experiments with aircraft and ERTS-A satellite imagery of the metropolitan Washington D.C. area.

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ABSTRACT: The report describes a group of suggested experiments to be conducted with ERTS-A and high altitude aircraft imagery to be obtained during the 1972 period upon implementation of the ERTS Program. Methods of analysis and measurements of land use, urban change, transportation, and possible pollution using small scale, low resolution data are discussed.

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1. INTRODUCTION

This report is part of a series of studies undertaken by the Metropolitan Washington Council of Governments' (MWCOC) Remote Sensing Project. The Project has been conducted under a contract with the Geographic Applications Program of the U.S. Geological Survey, the basic objectives of which have been to investigate and assess the utility and value of remote sensing data as an information source in support of the MWCOC's urban and regional planning programs.

Studies in this series have been primarily concerned with reporting the results of investigations by the Project of specific areas of remote sensing application; the benefits to be achieved; and the possible cost advantages which may accrue from its use. These investigations have also attempted to relate certain information needs of the several departments of the Council of Governments to present and expected remote sensing system capabilities. Areas of study have included: Land use, urban growth and change detection, natural features, transportation, housing, water run off, thematic mapping and updating, sedimentation, pollution, photo research services, training, and other miscellaneous uses.

The project has, therefore, been entirely research oriented and most especially "user research" oriented, with prime emphasis on current or imminent applications to local and regional information problem areas. In this sense, therefore, the entire project has been experimental in character. Much that has been investigated and reported on, during this work has strong implications for consideration by regional and local officials in terms of providing data support for short and long range planning and decision making

processes. Possibly this work will have a bearing on influencing the planners' decisions concerning expanding remote sensor uses within the region. The authors are hopeful that this research will prove equally helpful to similar regional and local planning groups in other areas.

The referenced studies have utilized, assessed, or discussed remote sensor data acquired from several types of platforms: fixed-wing aircraft at high and low altitudes (with corresponding scale values); rotary-wing aircraft; and by projection, imagery from the expected ERTS-A Program. With respect to working with imagery derived from the first two platform types, there is an almost unlimited field of experience. With respect to the third, the TV and multi-channel scanner imagery to be provided by the Earth Resources Technological Satellite (ERTS-A) Program, there is no experience.

To insure, therefore, that optimum benefits will be derived from the forthcoming ERTS effort, major plans and studies for research and testing applications are currently being made by hundreds of investigators in conjunction with NASA at Federal, State, and regional levels, at Universities, and other research organizations. These investigations will include programs and projects involving the analyses and value assessment of the resultant imagery and covering many predetermined geographic multidisciplinary areas (geography, geology, hydrology, oceanography, agriculture, forestry, and others). It is expected that controlled and comparative assessments of both ERTS-A imagery and that of pre and post-ERTS imagery obtained from high altitude aircraft (flown under a coordinated

flight program) will be made. The entire ERTS Program is essentially experimental in nature. The investigative goals of the participating organizations are thus correspondingly oriented. Some participating organizations, government, industrial, and commercial, have more immediate and pragmatic needs for the information contained in this imagery. Their research efforts are therefore more user oriented. The present and future data needs of the Metropolitan Washington Council of Governments fall into this category.

This particular study, therefore, presents a series of suggested experimental data uses designed to assess the value to the Council of Governments' planning information requirements of ERTS-derived data.

2. EXPERIMENTAL DESIGN

The Earth Resources Technology Satellite (ERTS), Series A, is presently scheduled for launch in late May or early June 1972. In order to take fullest advantage of the expected data return from that program, the design of experiments should be appropriately matched to the unique sensors to be flown and operated and their specifications.

The spacecraft will be designed to orbit for a year's duration at an altitude of about 496 nautical miles in a sun-synchronous, nearly polar orbit. Its periodicity will be such as to recycle, moving westerly in its swaths, over the same area of the U.S. every 17-18 days with complete coverage of the entire United States being obtained during that period. Thus, the Washington, D.C.-Baltimore region would be scheduled for sequential observation and imaging on one of these 18 days.

The imaging systems aboard the spacecraft are essentially of two types. The first consists of three nadir-boresighted multispectral-TV (Return Beam Vidicon) cameras. All three cameras will be simultaneously viewing, exposing, and recording the same scene on the earth's surface, covering on each image frame, an area of 100 by 100 nautical miles. These TV cameras will be photographing all of the visible and some of the near infrared portions of the spectrum in their multispectral mode. By means of appropriate filters, each camera will photograph each of three preselected spectral bands. These are: 0.475 - 0.575 micrometers* (blue-green); 0.580 - 0.680 micrometers (yellow-red); and 0.690 - 0.830 micrometers (red to near infrared). The (RBV) imagery data will be transmitted by video.

* 1 micrometer = 1×10^{-6} meter

signal to one of several NASA data reception stations located in California, Alaska, Corpus Christi, ^{Texas,} and Greenbelt, Maryland for recording and processing. When the craft is not in optimal orbital position for transmission with respect to these ground stations, a recorder aboard the space craft will record the imagery data. Upon reaching more favorable locations, the system will be programmed for transmission of directly imaged data, as well as of pre-recorded imagery. At these data acquisition sites, the transmitted video signal will be converted and recorded on 2" magnetic tape for subsequent conversion to film. Average ground resolution depending upon image contrast ratios, has been estimated to be on the order of 150 to 300 feet.

The second of the data acquisition systems consists of the multi-spectral scanner system (MSS). This is a mechanical-optical system which will also be registering data from pre-selected spectral bands. The bands to be imaged are: Band 1, 0.5-0.6 micrometers; Band 2, 0.6-0.7 micrometers; Band 3, 0.7-0.8 micrometers; and Band 4, 0.8-1.1 micrometers. On subsequent Mission ERTS-B, scheduled for 1973 launch, there will be an additional band, 10.4 - 12.6 micrometers - well into the (near) infrared. Upon receipt by the U.S. data acquisition sites of the transmitted data from the spacecraft conversion to video tape of MSS imagery will also be accomplished.

Along with the imagery, additional technical and housekeeping data from the missions will also be transmitted and recorded. This information will provide data on spacecraft altitude, attitude, position, camera shutter intervals, time and other necessary

housekeeping information required for processing and use. It is estimated that for coverage, of the United States, 45 image data sets per day will be processed. One data set consists of three RBV and four MSS image frames (1 frame equals an image of a 100 nautical mile by 100 nautical mile area).

Upon receipt at the NASA Data Processing Facility (NDPF) at Goddard Spaceflight Center, all data will be uniformly processed, reproduced, stored, disseminated and handled as required by the programed investigations and other user groups. Included will be agencies of the Federal Government, such as the U.S. Geological Survey, which will provide the focal point for cataloging, review, distribution and purchase by other public and private users of imagery covering the United States. A new facility, the EROS Data Center, at Sioux Falls, South Dakota is being developed by the U.S.G.S. and being put into readiness to handle these functions.

Products from these acquisition systems will be available on a selective basis, initially to principal investigators, in the ERTS Program, other users and subsequently to the purchasers from the U.S.G.S. EROS Data Center. Data to be available at one or both of these centers will include negatives, positive transparencies and prints, color composites, catalogs of imagery and other data, digitized imagery and spacecraft performance data on magnetic tape.

During the pre-ERTS period, high altitude NASA aircraft will have been covering selected test sites within the United States for groups of investigators planning to use ERTS data after it arrives. This aircraft imagery, with good resolution and at scales of approxi-

mately 1:450,000 will be taken by four 70 mm film cameras, three of which are viewing these test sites in the same multispectral bands as the ERTS RBV TV camera systems will. The fourth camera is imaging with color infrared film. Several of these pre-ERTS flights have been made by NASA to date over the Washington, D.C. area within the framework of the U.S.G.S. CARETS (Central Atlantic Regional Ecological Test Site) Program. This coverage is being reviewed at present within elements of the U.S.G.S. and by other researchers.

The purpose, of course, of these pre-ERTS flights, is to give experience to user groups in the handling and analysis of the smaller scale imagery (about 1:3,000,000, before enlargement) which ERTS-A is expected to produce. Following the initial launch of ERTS-A, it is planned to continue the underflying aircraft program on a selective test-site basis.

Obviously, any consideration of experimentation with ERTS-generated imagery should provide for the parallel examination and evaluation for utilization and other purposes, of the imagery obtained by these pre and trans-ERTS aircraft flights. It is with that concept in mind that the several selected examples of possible experimental applications are proposed in the ensuing discussions.

In such an experimental series, one would want to identify for study and interpretation, those natural surface and cultural surface features of MNCOG regional interest which would be most likely to be visible and recorded on such imagery as has been described — scales and resolution permitting. The synoptic overview and the multispectral capabilities of the TV (RBV) and the multispectral scanner (MSS) imaging systems are such that it should

be possible to examine some of those activities within the region which have been previously discussed in this series of reports and in similar evaluations elsewhere. By matching data need and expected imagery return, it is possible then to select and suggest a likely group of subject areas for experimental investigation.

Such a matching process suggests the following: Land use, open spaces, vegetation (or lack of it), water areas, run off, sedimentation, pollutant sources, pin-pointing of air polluters, and corresponding air movement, general area growth and change (viz., new development areas), and general transportation studies. With respect to land use and urban change, particularly encouraging investigations suggest themselves.

Accordingly, in the following section, it is shown how the ERTS Program data — aircraft and satellite — would be acquired, analyzed, and assessed against the information requirements of the Metropolitan Washington Council of Governments.

3. EXPERIMENTAL PROGRAM

On the basis of the general design approach discussed in the foregoing section, a program of research analysis keyed to the data and imagery of the NASA ERTS-A system has been developed. Areas of MFCOG program planning information need and ERTS-A data system expectations which would be correspondingly related to those information need are shown in Table 1 in this section. The visible characteristics associated with the information need are identified, as are the potentially applicable sensor combinations; coverage frequency and specific program applicability.

It should be noted, of course, that the range of experimental remote sensing data development investigations which could be proposed in this context would be substantially larger than those which are being proposed. There are other necessary urban and regional data acquisition and analytical experimental opportunities for using aircraft - derived imagery awaiting investigation. Important examples of these would be: use of thermal infrared sensors to explore feasibility of delineating or identifying different housing and neighborhood condition surveys and for use in traffic analysis and other types of transportation surveys; use of black and white, color, and natural or reconstituted color infrared imagery for detailed studies of sedimentation behavior. These remote sensing experiments would be built around ground data acquisition efforts, and would require much lower flying altitudes, larger image scales, and higher ground data resolutions than that which will be available from ERTS. This group of suggested investigations and analyses is restricted to data products to be received from the ERTS-system.

The experimental work which would be undertaken in this program would be characterized essentially by two phases. The first would consist of an assessment and evaluation of the quality and interpretability of the high altitude pre-ERTS and the ERTS-A imagery to provide the levels of data required for the appropriate subject analysis. The second, based on the findings of the first, would be directed to the analysis of the imagery, data reduction, development of new, required analysis techniques, and testing for the integration of results into the MFCOG information programs.

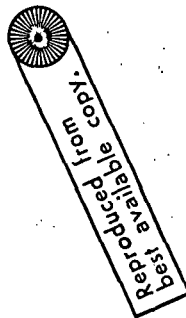


TABLE I
SUGGESTED EXPERIMENTAL PROGRAM

SUBJECT ACTIVITY	WHAT IS TO BE TESTED	PARAMETER TO BE MEASURED	SENSORS	WAVELENGTH microns	FREQUENCY OF COVERAGE	HOW TO BE USED IN MFCOG PROGRAM
<u>Land Use</u>	Use patterns, change, growth, and associated dynamics	Areas of activity; New development areas; (residential, and others); Open spaces; Livelihood areas; Water areas; Agricultural areas	Multispectral Black and White Color infra-red. ERTS-A and pre-ERTS data. (Enlargements and special viewing equipment)	0.4 - 1.0	Quarterly; semi-annually	Regional Planning Studies; Growth prediction studies and models; Impact studies; Land-use delineation maps; Possible parcel-file application. Use of small scale imagery for selective examination of larger scale imagery.
<u>Transportation</u>	Systems spread and layout	Rail routes; highway routes and status of change; Feeder routes; Possibly street patterns; Airports, certain facilities	Same	0.4 - 1.0	Same	Transportation route surveys; Use of small scale imagery for selective examination of larger scale imagery
<u>Pollution</u> Water and Air	Detection and location of area and point sources	Discoloration of river and stream courses; Direction and extent of flow, source. Stack gases, haze	Same	0.4 - 1.0	Regularly as feasible	Monitorship, event, detection, followup corrective action programs.

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SUGGESTED EXPERIMENTAL PROGRAM

SUBJECT ACTIVITY	WHAT IS TO BE TESTED	PARAMETER TO BE MEASURED	SENSORS	WAVELENGTH microns (μ)	FREQUENCY OF COVERAGE	HOW TO BE USED IN MNCOC PROGRAM
Sediment	Exposed soils and areas	Location and area exposed; change in status; period of time exposed.	Multispectral Black and White and color infra- red Enlargements and use of special viewing equipment	0.4 - 1.0	18 days	Monitor status; Measure immediate growth; Provide data for local use in follow-up corrective action programs.
	Sediment deposi- tion patterns	Deposition effect and patterns; location; area; extent, and source	Same	Same	Monthly	Improve knowledge of the Estuary; Study spread and flow of sedi- mentation.
Water Resources	River courses; reservoirs, etc. Service areas	Location of visible facilities; Drainage basins; Measurements and estimates of use Consumption	Same (es- pecially color infra- red composites)	0.4 - 1.0	Semi-annually	Areas of water supply, storage areas; Water resource planning studies, Use prediction models.
	Synoptic over- view of the region	All above activi- ties.	Multispectral Black and White and color infra- red 12	0.4 - 1.0	Annually	Overview displays; presenta- tions, briefing, large area planning graphics.

4. METHODOLOGY FOR DATA UTILIZATION

As the imagery and associated data from the pre-ERTS aircraft flights and ERTS, itself, become available, it will be necessary that systematic procedures and methods be instituted to insure efficient analysis of data and integration of results into the various MWCOG information programs. A scheme of such procedures are outlined and described in the following.

Internal procedure for receiving, handling, and storing the incoming imagery and having it available for analysis and research will be required. To expedite setting up any of these procedures, access to the appropriate mission data, which is to be acquired and utilized by NASA and the U.S.G.S. for similar housekeeping and control purposes, will be in order. Initially, however, it is felt that this need not be unduly burdensome for COG.

For effective data extraction and to explore fully the capabilities of the imaging systems, it will be necessary to make enlargements, magnify images through binocular microscopes, explore image enhancement techniques, and take advantage of special multi-spectral viewing equipment (some new prototype models of which are available locally). Should this work program be undertaken in conjunction with contractual or other arrangements with one or more Federal agencies, it would be expected that access to this specialized equipment would be afforded. Any detailed analysis will, of course, involve interpretive assessments and measurements of areas and other subject dimensions (such as census tracts, open areas, exposed areas, linear routes, etc.). Where possible, again to test the system, efforts will be made to undertake this work, where possible, utilizing standard

techniques and equipment. Expeditionous handling of work requiring numerous area measurements can be accomplished, as has been demonstrated during the course of this remote sensing project, by use of digital image density or similar automatic scanning devices.

Upon completion of basic interpretations, analyses, and associated data reduction of the assigned work tasks, the next step would involve data manipulation, comparisons with other data and presentations of results for use by COG data bases and other information needs. In some applications, this would require the preparation of subject maps or other graphics at some convenient scale. In other applications, the data would either be statistical or evaluative in nature, and in these forms, would be made available to COG user departments.

Several opportunities suggest themselves for exploring the use of computer techniques in this work. One involves use of computer recording capabilities for identifying and indexing of ERTS imagery of the region. Print-outs of coverage giving image quality data, area coverage data, and so forth, would be useful in researching a retrieval of the accumulating ERTS imagery. Alternately, it should be possible to negotiate with NASA for loan copies of their taped mission data as would be appropriate for this region. Another possible learning and production opportunity would be in the development of computerized mapping products with combined input data from remote sensing and other sources. Maps depicting land use and land use change suggest themselves as examples for development and test. Still another; since the imagery is transmitted from the spacecraft to the U.S.

data reception centers in electronic form and is converted there to video and digital tapes, it would be worth investigating, by using samples of this imagery in magnetic tape form, to explore the possibilities of developing additional techniques of data analysis, utilization, and presentation.

The technology -- human and mechanical -- for accomplishing many of these tasks is available. What is expected to ensue will be further development of skills and procedures in house and elsewhere, based upon experiences gained from working with the new data forms.

As a final note, because of the expected yet unaccustomed small scales and relatively lower resolutions (when compared with aircraft data) to be experienced in the initial ERTS data, there will probably be disappointments registered with the levels and quality of the data received. It must be observed, in this connection, that the ERTS Program, itself, is entirely experimental in scope, and represents but a start in the development of national data acquisition and analysis system. The full benefits of such a system are only beginning to be appreciated. In the follow-on train of ERTS development are the Earth Resources Experimental Package (EREP) of the manned Skylab program and the ERTS-B, tentatively scheduled for launch in 1973.

ERTS-A will provide the learning ground for these systems which will follow. It is believed that all of them will provide increasingly valuable data for those priority MWWOG planning and information programs which have been identified in this series of studies.

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