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A selected bibliography of Corps of Engineers remote sensing reports

Theodore C. Vogel and E. James Books

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Cold Regions	Thematic Mapping
Multispectral Imagery	Trafficability

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The purpose of this bibliography is to present a selected list of remote sensing technology reports and papers published by the U.S. Army Corps of Engineer Divisions, Districts, and Research Laboratories. This bibliogrpahy documents the importance of remote sensing technology to the Corps of Engineers and the many and varied tasks to which it has been applied.

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PREFACE

This literature search, conducted in the Data Processing and Products Division of the Geographic Sciences Laboratory (GSL), was produced under the authority contained in project 4A762707A855, Task T3 entitled "Military Geographic Analysis Technology." The work resulted from a paper entitled "Corps of Engineers Applications for Remote Sensing of the Environment" prepared by COL M. K. Kurtz, Jr., Commander and Director, U.S. Army Engineer Topographic Laboratories, and Mr. J. W. Jarman, Office, Chief of Engineers, that was presented at the Eleventh International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan, on 29 April 1977.

The authors wish to express their sincere appreciation to Mr. J. S. Odell, Photographic Technologist, GSL, for suggestions concerning technical subject areas that should be included in this report and to Ms. N. Kothe, Chief, Scientific and Technical Information Center, for her aid and suggestions in locating reports and formulating the Bibliography.

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INTRODUCTION

The purpose of this Bibliography is to present a selected listing of the remote sensing technology research, technical, and contract reports, including professional papers, published by the U.S. Army Corps of Engineer Divisions, Districts, and Laboratories.

In addition to compiling the literature published by the Corps of Engineers, this Bibliography also documents the many and varied tasks to which remote sensing technology has been applied within the Corps of Engineers.

Within the body of the Bibliography, the reports are divided into subject categories and then listed alphabetically by author. Those reports, papers, etc. that were applicable to more than one category are listed at the end of each section by section number. Identification of the author's affiliation is presented as it was at the time the report was published. This information is presented in parenthesis preceding the author abstract.

The authors recognize that in all probability a number of important reports and papers have not been listed. In all of these cases, however, no oversight was intended, and the authors would be grateful for receipt of any additions or corrections.

Some of the reports listed are limited in distribution to U.S. Government agencies and their contractors because of either military or commercial reasons. These reports, identified by the "L" following the AD Number, can not be released without permission from the originating agency.

Those persons desiring copies of any reports or papers referenced in the Bibliography should purchase them by AD Number from:

National Technical Information Service (NTIS)
ATTN: Operations Division
5285 Port Royal Road
Springfield, VA 22151

However, the originating organizations should be contacted directly when copies of the reports are required for study of original illustrations.*

*A mailing address for each Corps of Engineers Division, District, and Laboratory referenced has been provided in the appendix.

1. AUTOMATED IMAGE DATA PROCESSING

ACKERMAN, D. L., M. A. Crombie and M. L. Powers, Image Correlation on a Parallel Processor, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-0061, July 1976, NTIS AD-A030 636.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Digital photogrammetry requires that conjugate imagery be located by image correlation. Image correlation involves many computations and can be the most time consuming part of the digital photogrammetry process. This report, in line and area correlations, investigates the feasibility of performing the image correlation calculations on a parallel processor. Line correlation involves searching along epipolar lines using a one-dimensional window of gray shades. Area correlation pertains to using a two-dimensional window of gray shades to search for a match point either over an area or along a specific epipolar line. Functions include the linear correlation coefficient, the covariance, and the sums of absolute differences. The computer programs in this report were written for the GAC*STARAN at ETL. The parallel processor may not reach the speeds of a special-purpose, hard-wired correlator, but it has the advantage of being readily reprogrammed. The parallel processor will be used in the interactive digital image processing facility at ETL.

BONRUD, L. O., K. W. Enstrom, D. J. Panton, and M. O. Schroeder, Analysis and Development of Digital Mapping Systems Software, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Final Report ETL-CR-74-5, May 1974, NTIS AD 781 613.
(Digital Image Systems Division, Control Data Corp., Minneapolis, MN)

Author Abstract - This report describes the work done in the area of digital stereo mapping under contract with the U. S. Army Engineer Topographic Laboratories.

The philosophy and techniques developed by the Digital Image Systems Division of Control Data Corporation in the area of digital image correlation and matching in the past have been applied to the design and implementation of a software system to be used in the development of algorithms that relate to the problem of digital stereo matching.

The system is designed as a research tool with the basic characteristics of flexibility and simplicity incorporated into a block processing environment. The major tasks of data handling and stereo image matching are logically separate from one another and are further subdivided into versatile functional components that are easily interchangeable as new algorithms are developed.

*Goodyear Aerospace Corporation

Preliminary results of experiments relating to the matching system performance indicate that the use of fast simplistic algorithms in the software structure produce reasonably accurate matching results, but they are not sophisticated enough to attain the desired cartographic accuracy for all types of terrain.

BOWEN, R. V., Orthophoto Viewer and Transfer Device, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., June 1965, NTIS AD 722 788.

Author Abstract - This is a final report of a study to determine the feasibility of employing automatic change detection techniques in the map and orthophoto revision process. Tests were conducted to determine the technical design requirements and operational capabilities of a change detection unit. Five design concepts are described. It was concluded that automatic correlation and electronic change detection are suitable to aerial photos and orthophotos but not to intercorrelation with maps.

BROOKE, R. K., Jr., Parallel Optical Processing to Convert Elevation Data to Slope Maps: Phase I, Theoretical Analysis, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-RN-74-9, October 1974, NTIS AD A011 179. (USAETL, Fort Belvoir, Va.)

Author Abstract - Given a photographic transparency with an amplitude transmittance function, $t(x_o,y_o)$, that is equivalent to a functional representation of elevation information, $h(x_o,y_o)$, for a particular geographic area, the slope information can be rapidly displayed using a coherent optical system and a one-dimensional differentiating filter. Implementation of this technique could provide an electro-optical system for the high speed conversion of elevation data to a slope map. It is concluded that slope map displays can be obtained from elevation function transparencies, though negative and positive slopes of the same magnitude are displayed identically. This is not expected to affect the utility of the output.

Change Detector Studies, Modification No. 2, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., October 1961.
(Goodyear Aircraft Corporation, Akron, Ohio)

Author Abstract - No abstract.

CROMBIE, M. A. and D. L. Ackerman, Line-of-Sight Determination from Digitized Imagery, presented at the American Society of Photogrammetry Meeting, Phoenix, AZ, October 26-31, 1975.
(USAETL, Fort Belvoir, Va.)

Author Abstract - The basic notion of regarding the photograph as the primary data base is used to develop three single model techniques for determining whether line-of-sight exists between any two points within a stereo model. Two of the techniques use digital imagery. Only one of the methods is analyzed numerically. Matching processes using correlation methods are applied to a pair of digital images to determine the line-of-sight of two points 1,200 meters apart. A microdensitometer with comparator capabilities created the digital gray shade data. The third technique, a visual one, requires that the model be set up in a stereoscopic device.

CROMBIE, M. A., P. G. Lem and T. A. Hay, Single Photo Analysis of Sampled Aerial Imagery, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-RN-74-10, August 1974, NTIS AD A012 176.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Three single photo analyses of aerial photography utilizing digital techniques are presented. A statistical description of thirty scenes taken from two stereo models is presented with a preliminary matching analysis using correlation procedures and a preliminary compaction analysis using Fourier techniques.

Preliminary results indicate that image compaction using Fourier techniques is feasible and promising. Several useful properties of image matching were revealed in the analysis.

Development of an Evaluation Model Change Detector, November 1965, GER - 12368.
(Avionics and Electronics, Research and Development Division. Goodyear Aerospace Corporation, Akron, Ohio)

Author Abstract - This is the final technical report on a study of Automatic Stereo Perception of Aerial Photography by Optical Correlation. It includes a discussion of the principles of optical correlation and the application to stereo measurements, a description of some potential stereo correlator instrumentations, a study of the behavior of the autocorrelation function as the sample size is reduced, a comparison of stereo measurements under three different conditions, and an investigation of improved configurations.

The principal result is that optical correlation is suitable for stereo measurements. It is felt that optical correlators will ultimately prove superior to electronic versions because the bulk of the computation is performed in the compact optical front end.

Digital Image Manipulation and Enhancement System (DIMES) User's Handbook, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-73-7, June 1973, NTIS AD 764 280
(Computer Sciences Corp., Falls Church, Va.)

Author Abstract - The DIMES User's Handbook gives full details of how to use DIMES programs to carry out a series of processing steps on a digitized image which has been stored in a raster format on magnetic tape or disk. DIMES operates on image data by means of a modular library of image manipulation and enhancement programs. The user selects which programs are to operate on the data through a flexible command language. This language also allocates tape and/or disk image files and transfers user-supplied parameters to each processing routine.

This handbook contains an introduction which summarizes the general capabilities of the DIMES system. Next, information is supplied as to how to set up an image processing run deck for execution on the Control Data Corporation (CDC) 6600 computer. CDC control cards are described and the DIMES command language is fully explained. The first section contains descriptions of each task program, including a brief summary, description of inputs and outputs, parameters, restrictions, examples, and timing estimates. Remaining sections describe printer output, special DIMES utility program capabilities, examples of some typical DIMES applications, and a list of DIMES error messages.

DINSTEIN, I., R. M. Haralick, S. K. Shanmugam, and D. Goel, Texture Tone Study Classification Experiments, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-72-16, December 1972, NTIS AD 759 505.
(University of Kansas, Lawrence, Kansas)

Author Abstract - From aerial photography, image data sets were classified on the basis of a large class of quickly computable textural features. When the most appropriate features and decision rule were selected, identification accuracy on the order of 75 percent was obtained for 9 to 11 terrain categories. Conclusions drawn from these experiments suggest: (1) that the most powerful features are the entropy and inverse difference features measured at distance 1 and at distance 1/10th the length of the image side; (2) that the class of quickly computable textural features needs to be supplemented by tonal and context features in order for better identification to be obtained. This second conclusion is not to be unexpected since a photointerpreter who tries to make interpretations on the basis of a 1/8" x 1/8" square specially processed for high contrast on a 9" x 9" 1:20,000 aerial photograph does not do any better than 75 percent correct identification as previously reported.

DINSTEIN, I. and R. M. Haralick, Texture Tone Study - Category Maps, Gradient and Homogeneity Images, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-73-10, May 1973, NTIS AD 765 526.
(University of Kansas, Lawrence, Kansas)

Author Abstract - Two scenes were selected from 1:20,000 aerial photographs provided by ETL in order to demonstrate generation of category maps and gradient and homogeneity images. The category maps generation used a MINMAX decision rule to identify three categories in each one of the scenes. Gradient and homogeneity images were generated utilizing the JDATA programs (3). All the results were displayed on the IDECS colored monitor. Photographs of the results are provided in this report.

DINSTEIN, I., Texture Tone Study - (Quantizing on the IDECS/PDP), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-72-3, March 1972, NTIS AD 743 526. (University of Kansas, Lawrence, Kansas)

Author Abstract - The hardware design and an algorithm for equal probability quantizing on the IDECS/PDP are reported. The PDP 15/20 computer is interfaced to the IDECS (Image Discrimination Enhancement and Combination System) which is an analog-digital near real time image processing system. A brief description of the IDECS is provided. The addition of the designed hardware will make it possible to input film images to the IDECS/PDP and perform both quantizing and processing.

ESTES, J. E. and L. W. Senger, Multi-Image Correlation Systems Study - Quantitative Evaluation of Electronic Multi-Image Processor, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., September 1969, NTIS AD 870 453L. (The University of Kansas, Lawrence, Kansas)

Author Abstract - This report is supplementary to a report entitled "Multi-Image Correlation Systems Study for MGI," by G. W. Dalke and J. E. Estes (1968) and documents the findings of A Quantitative Evaluation of Electronic Multi-Image Processors. It presents a methodology for performing such an evaluation and follows with a systematic description of the procedures used and the results achieved. The procedures used in administering quantitative evaluation tests to image analysts were a function of the experimental design and the statistical model (a one-way classification with n=3 replications) employed, both of which are described in detail (see Section 2). The results of these tests are presented in the form of raw data, Appendix V, and image rankings, Section 3, derived from statistical analysis. The results are then analyzed and conclusions drawn about the capabilities of the multi-image processor (IDECS) under direct investigation. Similar conclusions could be made relative to the potential of any of the systems reported on here by an analysis of the raw data by the reader. The conclusions are based strictly on a comparative analysis approach, since one of the best ways to evaluate a new system is by comparing its performance with that of other systems that are currently in use. The findings clearly show that IDECS is a very useful system for interpretation of earth features.

FABIAN, E. S., Type II Interim Technical Report, Image Tube Validation Study, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-70-5, August 1970, NTIS AD 881 011L.
(North American Rockwell Information Systems Company, Anaheim, CA)

Author Abstract - The Image Tube Validation Study will determine the utility of integrating image storage tubes as parallel image processing devices by construction and evaluation of a breadboard device. This Interim Technical Report describes the operation of the breadboard device being fabricated, the method of control, certain problems that might arise and avenues for their solution. Additionally, it contains a detailed report of past work by Mr. J. L. Riedl in experimental characterization of image tubes.

GREENZANG, F., S. Paluszkiewicz, J. Schulman, A. Kelemen, and M. Molin, Automation of Airborne Profile Recorder Data Reduction, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Final Technical Report, July 1967, NTIS AD 825 545.
(Kollsman Instrument Corporation, Systems Management Division, Syosset, New York)

Author Abstract - This report describes the work performed to improve the techniques for accumulating and reducing data for determining terrain elevation. The work entailed the development of (1) a set of computer programs interfacing the USAE-28 aerial terrain determination data directly with the Army Multiple Station Analytical Triangulation (MUSAT) Program, and (2) a breadboard of an altitude deviation sensor supplying an accurate and independent digital output of deviation from any pre-set isobar. The development of the computer programs was composed of the conversion of six major SDS-910 programs, i.e., PRED, PAMR, METR, EAMS, EAMR, and EAMT, and the creation of two new programs, i.e., CAMORI and CAMDIS, for operation on the IBM-7094 machine. End-to-end tests comprised the major portion of the validation of the developed programs. By running actual flight test data with both the original SDS-910 and new IBM-7094 programs, the programs were checked under operational conditions. The checking of results yielded excellent agreement. The newly developed system of programs provides the unique capability of reducing any USQ-28 airborne flight data on a single computer - the IBM 7094 - within a relatively short time. The tests performed on the developed altitude deviation sensor breadboard demonstrated that the unit satisfied all accuracy and resolution requirements for the overall terrain determination system. Recommendations are made to (1) convert remaining SDS-910 Ground Data Reduction Programs to complete the interface between USQ-28 and MUSAT, (2) have USAETL recommend to the Air Force utilization of the newly developed altitude deviation sensor, and (3) perform necessary hardware and software modifications for incorporation of APR frame number and replacement of relative profile by hypsometer deviation on the raw airborne magnetic tape.

GUNNELS, G., KANDIDATS, Kansas Digital Image Data System, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-71-3, January 1971, NTIS AD 721 306. (Center for Research, Inc., University of Kansas, Lawrence, Kansas)

Author Abstract - KANDIDATS is a software package of multi-image processing programs designed to run on the GE-635 computers. The primary purpose for the writing of this system was to consolidate many digital image analysis programs into a single package and to make them easily useable along or in combination on large data sets. Some objectives followed in the writing of the system were to make user interface fairly simple to make the machine processing efficient, to use a standard data format for compatibility between analysis programs, to make expansion to include new analysis programs easy, to maintain machine compatibility wherever possible, and to be able to handle all likely data sets.

The heart of KANDIDATS is a program monitor. This is an executive program which supervises execution of analysis programs, handles user interface with KANDIDATS, and handles interface with the operating supervisor, GECOS. The monitor contains all coding for the reading and writing of data in KANDIDATS standard format.

KANDIDATS executes as a single-activity batch program. It determines which analysis programs to execute, which data sets to use, and what program options to exercise from user control cards. It then executes the analysis programs in the order specified by the user. The KANDIDATS monitor performs mounting, dismounting and positioning of data tapes as needed and performs the reading and writing of data in the standard data format.

HARALICK, R. M. and D. E. Anderson, Texture-Tone Study with Application to Digitized Imagery, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-71-14, November 1971, NTIS AD 737 722. (Center for Research, Inc., University of Kansas, Lawrence, Kansas)

Author Abstract - An image data set of 54 scenes was obtained from 1/8" by 1/8" areas on a set of 1:20,000 scale photography. The scenes, which consisted of 6 samples from each of the nine categories - scrub, orchard, heavily wooded, urban, suburban, lake, swamp, marsh, and railroad yard, were analyzed manually and automatically.

For the automic analysis, a set of features measuring the spatial dependence of the grey tones of neighboring resolution cells was defined. On the basis of these features and a simple decision rule, which assumed that the features were independent and uniformly distributed, an identification accuracy of 70% was achieved by training on 53 samples and assigning an identification to the 54th sample and repeating the experiment 54 times. This identification accuracy must be compared with the average 81% correct identification which five photointerpreters achieved with the same scenes, although the 81% correct identification is the accuracy achieved when they used the 9" x 9" photograph to interpret from. Note that the photograph is data of considerably higher resolution having much more context information on it than the small digitized 1/8" x 1/8" area the automatic analysis had available.

HARALICK, R. M., Texture-Tone Study with Application to Digitized Imagery, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-74-17, August 1974, NTIS AD A008 030.
(University of Kansas, Lawrence, Kansas)

Author Abstract - Texture is one of the important characteristics used in identifying objects or regions of interest in an image, whether the image be a photomicrograph, an aerial photograph, or a satellite image. This paper describes some easily computable textural features based on grey tone spatial dependencies and illustrates their application in category identification tasks of three different kinds of image data; photomicrographs of 5 kinds of sandstones. 1:20,000 panchromatic aerial photographs of 8 land use categories and ERTS (Earth Resources Technology Satellite) multispectral imagery containing 7 land use categories. We use two kinds of decision rules; one for which the decision regions are convex polyhedra (a piecewise linear decision rule) and one for which the decision regions are rectangular parellel pipeds (a min-max decision rule). In each experiment, the data set was divided into two parts, a training set and a test set. Test set identification accuracy is 89% for the photomicrographs, 82% for the aerial photographic imagery and 83% for the satellite imagery. These results indicate that the easily computable textural features probably have a general applicability for a wide variety of image classification applications.

HARALICK, R., The Bayesian Approach to Identification of a Remotely Sensed Environment, Advanced Research Projects Agency, Washington, DC, July 1969, NTIS AD 860 060.
(University of Kansas, Lawrence, Kansas)

Author Abstract - The first part of this paper provides a brief tutorial introduction of the Bayesian Approach to identification of a remotely sensed environment. The second part describes the input data deck setup for the Fortran IV program which has been written to implement this approach. The third part describes file usage and subroutine organization. The fourth part provides a listing of the program with a simple sample data set,

HARALICK, R. M. and J. Bissell, Texture Tone Study with Application to Digitized Imagery, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-70-9, December 1970, NTIS AD 724 117.
(Center for Research, Inc., University of Kansas, Lawrence, Kansas)

Author Abstract - This report describes initial research efforts undertaken to determine if texture - a significant but ill-defined property of virtually all substances can be utilized in a practicable automated image interpretation technique. We attempt to establish a basis for measures which define the important qualities of texture by first considering discrete tonal features in an image as constituents of areas of homogeneity or lack of homogeneity ('unhomogeneity'). The concept of homogeneity is intended here to signify the existence of groups of similar neighboring resolution cells, which have been judged similar by some prespecified criterion. Homogeneity displays or plots are constructed by linking or connecting the similar neighboring resolution cells and ignoring all others. Unhomogeneity infers a lack of similarity of neighboring resolution cells; and an unhomogeneity plot then, is a display of linked, dissimilar neighboring resolution cells.

Digital computer algorithms were written to determine the extent of homogeneity for each resolution cell in a picture, and a group of ten (5 homogeneity and 5 unhomogeneity) on-line plots were made for each of the 36 images. The intra-plot variation was dependent on a threshold which controlled the number of resolution cells that could be linked. The threshold values ranged from 5% to a maximum of 25%. That is, for a threshold setting of 5%, the homogeneity plot would display that group of linked resolution cells which were more similar than the remaining 95% of the resolution cells in the image, while the corresponding unhomogeneity plot would link that 5% of the resolution cells which were the least similar.

IRVIN, M. M., Survey of Digital Image Scanning Systems, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Contract Report ETL-0087, June 1976, NTIS AD-A036 337. (Aerospace Corporation, Los Angeles, CA)

Author Abstract - This report investigates currently available devices which digitize data from film to use as input to a digital computer. The report describes the general specifications for a scanning/digitizing system and describes the various available devices which meet the requirements. The report found that vidicon camera systems were the lowest cost scanners and the flying spot scanners were the most expensive. The most precise instrument, and the most expensive, is the flat bed microdensitometer. In conclusion, the application scenario must be known and the requirements carefully evaluated before any of the digitizing systems described in the report are selected.

LUKES, G. E., Integration of Optical Power Spectrum Analysis and Projective Sampling for Land Use Change Assessment, presented at the American Society of Photogrammetry 43rd Annual Meeting, Washington, DC, February 27 - March 5, 1977. (USAETL, Fort Belvoir, Va.)

Author Abstract - Analytical procedures that provide an automated technique for locating specified terrain locations in an aerial photograph have been used to assess significant changes in land use imaged by sequential aerial photography. Land use patterns imaged in aerial photography display distinctive optical power spectra which can be electronically sampled to automatically classify the pattern. Projective sampling algorithms were incorporated into the digital control system of the Recording Optical Spectrum Analyzer. Three sets of photography taken of an expanding urban area over a 30-year period were sampled rigorously accounting for camera scale, position and orientation, and then analyzed for significant change in land use patterns. Examples of optical power spectra for various land use patterns and the results of the change assessment experiment will be presented. Advantages and limitations of optical power spectrum analysis for this application will be cited.

MARDAM-BEY, O., Analog to Digital Converter to Digital Magnetic Recorder Interface, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-71-4, February 1971, NTIS AD 729 383.
(Center for Research, Inc., University of Kansas, Lawrence, Kansas)

Author Abstract - This report is a complete description of the Interface between the Analog to Digital Computer AF01 (referred to as A/D) and the Digital Magnetic Recorder P1-1207 (referred to as TAPE). The report is basically a documentation of the interface, but will discuss the A/D or the TAPE whenever this is required to clarify the documentation.

The A/D-Interface-TAPE System is a part of an image digitizing system used in conjunction with the IDECS and is capable of high resolution. The image under analysis will be scanned by a Scanning Densitometer, the analog output of which is fed to the A/D Converter where it is digitized and scored on the TAPE. Later the digital data can be computer processed and/or displayed on the IDECS.

The system can also be used for digitizing and recording any analog signal and in that respect can stand out as a complete system independent of the image scanning system.

MUNSEY, C. J., Electro-Optical Image Processing with an Image Storage Tube, U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., May 1968, NTIS AD 836 685.
(Philco-Ford Corporation, Aeronutronic Division, Newport Beach, CA)

Author Abstract - This report describes the principle, construction, and test results of an image processing apparatus capable of spatial filtering and other image processing operations on outdoor scenes without the intervention of photographs. Experimental demonstration of image processing with this apparatus was the principle task. Spatial filtering is implemented by direct performance of the superposition integral in an image storage tube. Superposition takes place between the scene being filtered and a stored two-dimensional function. The experimental tests with o.d. clad actors and o.d. painted vehicles were performed outdoors in a vegetated setting. The existence of a real-time technique for spatial filtering, moving target indication, and correlation tracking has been demonstrated.

MURPHY, L. P., Evaluation of the Prototype Natural Image Computer, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report 48-TR, November 1969, NTIS AD 868 296L. (USAETL, Fort Belvoir, Va.)

Author Abstract - This report covers the tests and procedures for evaluating the prototype Natural Image Computer (NIC) and systems' software. The prototype system was designed as an exploratory laboratory device for pattern recognition studies and limited feature delineation capability using nominally vertical aerial photography as an input. The structure of the recognition algorithms is based upon recognition and correlation to basic feature shapes and statistical characteristics of the gray-scale distribution of Military Geographic Intelligence. The NIC is a versatile laboratory device capable of accepting cut-film photographs ranging up to 9x9 inches and producing grey-scale digitization of the imagery at 16, 32, and 64 grey-scale levels.

MURPHY, L. P., Early Results from the Experimental Automated Image Data Extraction System, presented at the American Society of Photogrammetry Fall Convention, 10-13 September 1974. (USAETL, Fort Belvoir, Va.)

Author Abstract - The USAETL experimental Automated Image Data Extraction Sytem (AIDES-1) was fabricated to enable experimentation leading to the development of a man/machine interactive, multiple-image processing system to facilitate the extraction of terrain information (e.g. vegetation, soils, etc.) from a variety of imagery such as conventional aerial photographs, multiband images, and radar images. Examples of early data extraction experiments are shown and described which used multiband input images to spectrally separate features at analog processing rates.

MURPHY, L. P., Digital Image Processing for Terrain Pattern Recognition, presented at the ACSM-ASP Technical Conference at Denver, Colorado, 7-10 October 1970. (USAETL, Fort Belvoir, Va.)

Author Abstract - The U. S. Army Engineer Topographic Laboratories have evaluated and tested a prototype digital image processing system for performing pattern recognition experiments. Tests and procedures are described for evaluating the Natural Image Computer (NIC) with its systems software, in addition to the conclusions reached from the analysis. The prototype system was designed as an exploratory laboratory device for pattern recognition studies and limitd feature delineation capability using vertical aerial photography as an input. The structure of the recognition algorithms is based upon recognition and correlation to basic feature shapes and statistical characteristics of the grey scale distribution of Military Geographic Intelligence. The NIC is a versatile laboratory device capable of accepting cut film photographs and producing grey scale digitization of the imagery at 16, 32, and 64 grey scale levels.

MURPHY, L. P. and E. G. Trelinskie, Jr., Preliminary Image Data Extraction Experiments with the Phase I, Automated Image Data Extraction System-I, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-RN-74-7, December 1974, NTIS AD A010 644.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This research note describes an experimental device, referred to as the Automated Image Data Extraction System, and the results of a limited number of terrain data extraction experiments using multiband input images.

MURPHY, L. P. and W. W. Abbe, An Automated Technique for Measuring Built-Up Urban Areas from Map Graphics Through Analog Image Processing, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-0012, May 1975, NTIS AD A011 446.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This research report describes a production application using experimental analog (video) image processing equipment for measuring areas (Km^2) depicted on graphic map input as built-up urban areas. The note concludes that state-of-the-art analog image processing components can be configured and used to measure built-up areas in one-twelfth of the time required by conventional manual means.

MURPHY, L. P. and E. G. Trelinskie, Jr., Analog Graphic Processing for 3-D Terrain Displays, Profiles, and Elevation Layer Tints, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-0026, October 1973, NTIS AD 017 493.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This report briefly describes a computerized technique for transforming digital elevation data into gray-level-encoded film. This film is then used for near-real-time analog graphic (nondigital) processing for the display of terrain perspectives, profiles, and elevation layer tints. This report concludes that this approach offers considerable potential, at base and/or field levels, for producing special map graphics, displays, and analyzing terrain conditions for line-of-sight problems or nap-of-the-earth flight plans.

NISENSON, P., J. Feinleib, R. A Sprague, and S. Iwasa, Characterization and Optimization of an Electro-Optic Imaging Device for Real-Time Map Profiling, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-74-18, October 1974, NTIS AD A005 561.
(Itek Corporation, Lexington, Massachusetts)

Author Abstract - The operation of an electro-optic image modulator and storage device for use in real-time optical processing systems is described. Major emphasis was placed in optimizing the device performance by proper selection of design and operating parameters. The Pockels Read-Out Optical Modulator (PROM) is used to provide temporary storage of an image that can be read into the PROM either sequentially from a laser or CRT scanner or in parallel from a transparency. The stored image can then be read out by incoherent light or by a laser for coherent optical processing. The stored image may undergo certain operations such as level slicing, edge enhancement, or contrast inversion by utilizing the electronic characteristics of the device. This feature is useful for incoherent image processing and also allows zero order suppression in coherent processing application.

The work was divided into three areas: device characterization, complex spatial frequency filtering, and device fabrication. The effects of crystal thickness, applied voltage, and wavelength of read-in light were important parameters in determining device sensitivity and the modulation transfer function. Optimum parameters provided a resolution of 500 cycles per millimeter. Real-time optical cross-correlation and matched filtering for pattern recognition were successfully demonstrated using the PROM. Device fabrication work included increasing useful crystal area to 2 inches and flatness to 1/10 wavelength.

OLSSON, G., Spatial Sampling: A Technique for Acquisition of Geographic Data from Aerial Photographs and Maps, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-71-11, May 1971, NTIS AD 725 612.
(Regional Research Associates, Ann Arbor, Michigan)

Author Abstract - Modern remote sensing techniques have produced such large numbers of images that conventional analytic and evaluative procedures are no longer sufficient. Existing spatial sampling techniques were investigated to see if information could be retrieved in a less costly and time-consuming manner. More specifically, the purpose of the project was to determine whether available techniques could be used for identifying and measuring geographic features as they are depicted on maps and aerial photographs. This final report includes 6 appendices: Spatial Sampling, an Annotated Bibliography; Problems in Spatial Sampling; Error Components in Scientific Model Building; Statistical Properties of Spatial Distributions; Large Scale Variations in Spatial Data; and Empirical Experiments in Sampling of Spatial Phenomena.

RASTATTER, J. A., Map Revision Using Digital Techniques, presented at the American Society of Photogrammetry 41st Annual Meeting, Washington, DC, March 9-14, 1975.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This paper presents the initial work accomplished toward the development of an approach to map revision utilizing digital techniques. A photograph was reduced to approximate the scale of the map, and both the map and photograph were digitized on the DICOMED image processing system. The Digital Image Manipulation and Enhancement System (DIMES) software was used to geometrically warp the aerial photograph so that it would register with that portion of the map which it covered. The map and the warped photo were combined on the DICOMED equipment to form a composite picture illustrating the changes that have occurred since the map was published.

SCHROCK, B. L., Image Analysis: Interactive Digital Image Processing, presented at the USAETL-ASP Workshop for Environmental Applications of Multispectral Imagery, Fort Belvoir, Va., November 11-13, 1975.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Digital image processing appears to offer great promise for the extraction of topographic and intelligence information from multisensor imagery. However, the extraction process is, in general, a pattern recognition problem of such complexity that the computer alone is often unable to completely solve the problem. Therefore, it appears reasonable to combine the superb pattern recognition abilities of the human interpreter with the computational power of the digital computer to form an interactive system. However, in order to be successful, an interactive system must cope with those fundamental problems of digital image processing which result in excessive response times. Such a system is being developed at USAETL and will be applied to a broad range of problems in interactive image analysis.

SECTION	REPORT TITLE
8	Lucas, J. A., A High Speed Disc Memory and a Color Image Display for a Small Computer.
8	Patterson, C. C., Survey of Digital Image Display Systems (Soft Copy).
14	Leighty, R. D., A Logical Approach Toward Automated Terrain Pattern Recognition for Engineering Purposes.
14	Leighty, R. D., Optical Power Spectrum Analysis (OPSA).
18	Kennedy, J. G., and A. N. Williamson, A Technique for Achieving Geometric Accordance of LANDSAT Digital Data.

2. CARTOGRAPHY

CODD, J. F., Transformation of Coordinates of Cartographic Digital Data, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-TR-74-8, October 1974, NTIS AD A006 491.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Map and chart features are now digitized during the semi-automated processes of compilation and cartography so that they may be transformed by computer processing for use in a different format. The resulting magnetic tapes of digital data then are stored in a library or data bank against their possible future use. Topographic maps, charts, and associated graphics are 2-dimensional projections of the 3-dimensional features of the earth's surface. Digitizing-table coordinates and projection, Earth-meter coordinates are plane rectangular systems; geographic, geocentric, and local-secant coordinates are 3-dimensional systems. It is relatively easy to transform coordinates between plane rectangular systems, but it requires rigorous mathematical formulation to transform coordinates between 3-dimensional systems and plane rectangular systems, and this process is expensive in computer time. The problems of indexing and of retrieval of data from the data bank should not confuse the choice of the most cost-effective format in which to store the digital data. It is desirable that the data be held in any plane rectangular coordinate system in order to minimize the expense of transformation by computer processing. Data stored in rectangular coordinates expressed in inches on the map sheet can be indexed, retrieved, and later transformed to any desired coordinate system if adequate header information is included.

LIVINGSTON, R. G., The Cartographic Equipment Handbook, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va.
(USAETL Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

SECTION	REPORT TITLE
18	Vogel, T. C., An Analysis of LANDSAT Systems for Cartographic and Terrain Information.

3. COASTAL ENGINEERING

BARWIS, J. H., Catalog of Tidal Inlet Aerial Photography, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-GITI-75-2, June 1975, NTIS AD-A012 798. (USAEWES, Vicksburg, MS)

Author Abstract - Data on approximately 6400 aerial photographic coverages of tidal inlets are presented in tabular form, along with information on how any given photography may be obtained. The compilation covers inlets along the Atlantic, Gulf, and Pacific Coasts of the contiguous U. S. coastline from 1938 to 1974, and includes the following information: (1) inlet name; (2) geographic coordinates; (3) National Ocean Survey Navigation Chart covering inlet; (4) Georef Grid Square; (5) month and year of photography; (6) Federal, state or commercial agency holding film; (7) project number; (8) pertinent exposure numbers; (9) scale; and (10) film type. Information is also given on sources of additional photography, and on obtaining photography of beach areas between any two inlets. An index, by Corps of Engineer District, is given.

McCLENAN, C. M. and D. L. Harris, The Use of Aerial Photography in the Study of Wave Characteristics in the Coastal Zone, Coastal Engineering Research Center, Fort Belvoir, Va., Report TM-48, January 1975, NTIS AD A008 011. (CERC, Fort Belvoir, Va.)

Author Abstract - Aerial photos can provide information about the geometry of the ocean surface not readily obtainable in any other manner. Photos reveal information about the number of wave trains present, the bending of wave crests due to refraction effects by both bottom topography and currents, and the existence of many nonlinear processes with regard to waves, some of which are rarely discussed in textbooks or oceanographic literature.

Good aerial photos of waves shows that multiple wave trains are common in the coastal zone. The relative importance of the various wave trains is changed by refraction and shoaling. The breakers, most prominent in the shore zone, often result from long, low swell, which is hardly discernable against the background of shorter waves a few hundred meters from shore. The generation of solitions and the regeneration of breakers which have crossed bars may lead to a breaker which is shorter than the period of the swell responsible for the breakers. Cylindrical waves radiating outward from rocks or shoals which penetrate the surface are formed from long-crested waves coming from the open sea. A wave pattern which appears random and chaotic when viewed on photos taken at a low elevation may appear to be highly organized when viewed at an elevation over 5,000 feet.

This report discusses conditions which favor good aerial photos of waves and presents examples of many phenomena in wave behavior which are best seen from the perspective afforded by a high elevation.

LIND, A. O., Photo-Geomorphology of Coastal Landforms, Cat Island, Bahamas (Vol. II), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-SR-74-5, January 1974, NTIS AD A008 954.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This report provides the aerial imagery used in the analysis of the coastal landforms of Cat Island in the east-central Bahama Islands. Interpretive maps and a brief description of the significant aspects of the coastal terrain are presented. The photo interpretation project was undertaken while the author served as a Research Geographer with the Photographic Interpretation Division, U. S. Army Cold Regions Research and Engineering Laboratory (now under the U. S. Army Engineer Topographic Laboratories) under the direction of Mr. R. E. Frost, Division Chief.

MAGOON, O. T., CERC, Fort Belvoir, Va., and D. M. Pirie, U. S. Army Engineer District, San Francisco, CA; Remote Sensing in the Study of Coastal Processes, Proceedings of the 13th Coastal Engineering Conference, Vancouver, B.C., Canada, by the American Society of Civil Engineers for the U. S. Army Coastal Engineering Center, July 10-14, 1972, NTIS AD 770 194.

Author Abstract - The quantifiable determination of important coastal parameters remotely rather than by in situ measurements combined with automatic data reduction and analysis will result in a greatly increased understanding of the parameters being studied. This paper gives a progress report on joint Corps of Engineers-National Aeronautics and Space Administration (NASA) efforts to apply remote sensing in coastal studies. The devices used were multiband photography, the infrared scanner, the Side Looking Airborne Radar and various image enhancement and processing devices.

MAGOON, O. T., U. S. Army Engineer Division, South Pacific, San Francisco, CA; J. W. Jarman, Office, Chief of Engineers, Wash, DC; and D. W. Berg, CERC, Wash, DC, Use of Satellites in Coastal Engineering, Proceedings of the First International Conference on Port and Ocean Engineering under Arctic Conditions, Volume II, Technical University of Norway, NTIS AD 754 890.

Author Abstract - No abstract.

PIRIE, D. M. and M. J. Murphy, California Coastal Processes Study - Aircraft, SRT Project X-098, National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Texas, December 1975.
(U. S. Army Engineer District, San Francisco, San Francisco, CA)

Author Abstract*- The purpose of this report is to investigate the applicable uses of aircraft remote sensing for assisting coastal planners and engineers in coastal phenomena studies. The NASA-Houston aircraft remote sensing flights began in October 1971 and ended in January 1974 and were conducted over the California coast.

The United States Army Corps of Engineers is responsible for developing methods of coastal protection, improving coastal engineering knowledge, and quantifying those nearshore coastal processes which most closely affect the works of man. To accomplish these responsibilities in an effective manner, the development of remote sensing techniques for studying coastal parameters has been promoted to analyze the effectiveness of aircraft and satellite imagery.

This report describes problems encountered on the California coastline and relates to sites or geographical areas that best demonstrate the application of remote sensing methodology to the Corps of Engineers mission.

*(Abstract provided by bibliography authors.)

PIRIE, D. M. and M. J. Murphy, Photographic Remote Sensing of Bolinas Lagoon, California, presented at the ASCE National Water Resources and Ocean Engineering Convention, San Diego, CA, April 5-8, 1976.
(U. S. Army Corps of Engineers, San Francisco District, San Francisco, CA)

Author Abstract*- This report explores the use of aerial remote sensing techniques to identify the various coastal and estuarine processes that impact the environment of the study area. The study area is the Bolinas Lagoon, located on the California coast about 12 miles (19 km) northwest of the Golden Gate.

The aerial remote sensing has been useful to define sedimentary processes, as well as wetland morphological processes. The report also discusses photographic techniques used to define coastal processes. However, the use of thermal scanning, multispectral scanning, and side-looking airborne radar (SLAR) has also been discussed.

Beneficial uses must be evaluated to determine whether modifications are desirable or necessary to preserve and enhance the quality of the lagoon ecosystems. Remote sensing provides a means for monitoring the continuous physical, biological, and ecological processes within coastal lagoons and wetlands.
(*Abstract provided by ETL author.)

SELLMAN, P. V., K. L. Carey, C. Keeler, and A. D. Hartwell, Terrain and Coastal Conditions on the Arctic Alaskan Coastal Plain, Arctic Environmental Data Package Supplement 1, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH, SR 165, March 1972, NTIS AD-741 354.

Author Abstract - This group of four reports describes the characteristics and seasonal variation of prominent relief features on and along the margin of the arctic coastal plain. These relief features include polygonal ground patterns, lake scarps and coastal features. The range of polygonal ground patterns commonly found is illustrated by a number of transects. The influence of the seasonal snow cover or relief is indicated by profiles taken during the summer and the winter. The winter profiles were taken during the period of maximum snow accumulation. The subduing influence of the seasonal snowpack is much more apparent in areas of high relief. Irregularities in the snow surface may approach those found in the more featureless areas of summer relief. A discussion of properties of the snow cover is also included from observations in the Barrow study areas. Constant reworking by the wind of small amounts of snow results in a snow surface with high bearing capacity and low (0.2 m) surface relief. The aerial photo study

area provided statistics concerning the occurrence and amount of relief associated with polygonal ground terrain. Approximately 64% of the area was covered with prominent polygonal ground relief. Polygonal ground patterns with relief > 0.5 m and seldom exceeding 1.0 m with 1.5 m being the practical upper limit cover 10.7% of the area. The remainder of the study area can be grouped into two general categories: 1) 53% with polygonal ground relief less than 0.5 m, and 2) 36% containing all other relief categories, including water surfaces. The study of coastal processes and relief features along the northern Alaskan coast was in part based on maps and aerial photos. Mean coastal relief or sea-cliff height was approximately 3.9 m, with about 75% of the coast having 5 m or less relief. Profiles from the Barrow area reveal that the surface geometry of the coast is dramatically altered by the seasonal windblown snow cover which tends to ramp the sea cliffs. The frequency of gullies, streams, embayed rivers and drowned thaw lakes along the coast was examined since they provide "windows" through the scarp and access to inland areas. There are approximately 800 windows along this coast or about 0.4 per km, with a mean width of about 200 m and mean inland extent of 0.4 km.

STAFFORD, D. B., An Aerial Photographic Technique for Beach Erosion Surveys in North Carolina, U. S. Army Coastal Engineering Research Center, Fort Belvoir, Va., Technical Memorandum No. 36, October 1971, NTIS AD A022 336.
(CERC, Fort Belvoir, Va.)

Author Abstract - This study presents a procedure developed to use existing aerial photographs to survey beach erosion. The use of the procedure is illustrated by data from Onslow and Carteret Counties in North Carolina. A preliminary evaluation of the results obtained in these two counties is given. The procedure is applicable to a variety of conditions and has important advantages over other methods of collecting beach erosion data.

The procedure consists of selecting stable reference points on aerial photographs taken in different years and measuring between the stable reference points and points on the transient beach. The measurements are converted to ground distances, and the difference in ground distance is computed. The difference in ground distance represents the change in location of the beach between the dates of the aerial photographs and is converted to an annual rate of change by dividing by the time interval. The change in two locations on the beach, the dune line and the high water line, is determined.

A special effort was made to reduce the effects of the errors inherent in aerial photographs. An extensive review of the literature concerning the applications of aerial photographs to investigations of coastal phenomena is included.

STAFFORD, D. B., R. O. Bruno and H. M. Goldstein, An Annotated Bibliography of Aerial Remote Sensing in Coastal Engineering, Coastal Engineering Research Center, Fort Belvoir, Va., Miscellaneous Paper No. 2-73, May 1973, NTIS AD 766 720. (CERC, Fort Belvoir, Va.)

Author Abstract - This bibliography covers representative literature on the applications of aerial remote sensing techniques in coastal engineering. About 200 references published since 1934 are presented. Annotations accompany each bibliographic entry and are a concise and informative summary of the references describing the characteristics of each remote sensor in coastal engineering investigations. Computer indexes of authors, titles, and keywords are included.

TELEKI, F., R. Musialowski and D. A. Prins, Data Acquisition Methods for Coastal Currents, Proceedings of the Specialty Conference on "Civil Engineering in the Oceans/III," held at the University of Delaware, Newark, Delaware, 9-12 June 1975, NTIS AD 029 739. (CERC, Fort Belvoir, Va.)

Author Abstract - Design criteria for the type and location of coastal engineering structures depends heavily on the understanding of nearshore processes and the evaluation of the ranges of significant parameters such as waves, currents and sediment transport. Gauging of these parameters, in and around the zone of breaking waves has been difficult for the lack of rugged implements and instruments, mobility and adequate experimental designs.

In answer to some of the previous shortcomings, a Towed Oceanographic Data Acquisition System (TODAS) has been developed for collection of nearshore current and wave data. The sensors are located on a mobile platform (the sea sled) and data acquired by them are telemetered to shore and digitally recorded. TODAS was designed for the real time evaluation of the characteristics of flow between shore and a depth of 30 ft., and because it is mobile and battery-operated it can be used to survey reasonably large areas at even remote locations. Two experimental designs were developed for TODAS; a mobile mode for the monitoring of waves and longshore currents in shore normal profiles, and an in-situ mode in which Eulerian and Lagrangian techniques of flow measurements are combined. In the latter, fixed point metering is supported by aerial photography and concentration measurements of dispersing dye plumes.

TELEKI, P. G. and D. A. Prins, Photogrammetric Experiments on Nearshore Mixing and Diffusion, Second International Conference on Port and Ocean Engineering Under Arctic Conditions, University of Iceland, NTIS AD 014 216. (CERC, Fort Belvoir, Va.)

Author Abstract - Aerial multispectral photography and fixed point metering were used in the study of coastal currents at two sites in California. The system combining current meters, low-altitude photography and photodensitometric analysis of the suspended matter or tracer dyes is well suited to the study of both advective and diffusive processes in the ocean. Experiments are carried out in the vicinity of marine structures for the purpose of understanding their influence on coastal circulation.

SECTION	REPORT TITLE
18	Magoon, O. T., and D. M. Pirie, and J. W. Jarman, Coastal Applications of ERT-A Satellite.
18	Pirie, D. M., and D. D. Steller, California Coastal Processes Study - LANDSAT II.
18	Pirie, D. M., and D. D. Steller, California Coastal Processes Study - SKYLAB.

4. COHERENT OPTICS

BENNETT, V., J. Iwasa, J. Frattarola, T. Sparks, P. Nisenson, and R. Turpin, Characterization of the PROM for Coherent Optical Processing Applications, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0053, August 1976, NTIS AD-A030 137. (Itek Corporation, Lexington, Massachusetts)

Author Abstract - The effort was divided into two primary tasks as follows:

Task 1 - Image Plane Processing and Cross Correlation

Using a pair of stereo transparencies of a laboratory slope model, photographs of constant elevation fringes were obtained using 5 mw of HeNe laser for PROM readout. The technique was shown to be feasible and it was determined that significantly more readout illumination, such as 50 mw or more from the Krypton 647 nm line, would be required for a usable image reconstruction which displays the contours.

Task 2 - Fourier Plane Filtering

a. PROM Filtering. Complex Vander Lugt filters were exposed on the PROM and film and reconstructed. A comparison of the PROM and film filters was discussed.

b. Pattern Generator/PROM. Various programmable filter patterns were written on the PROM and the characteristics of the Laser Raster Generator (LRG) were analyzed. A tradeoff study of LRG spot size versus scan overlap was performed.

c. Minicomputer PROM Filters. Versatile software for filter computation on the HP 2116C minicomputer was written, checked out, and demonstrated with the LRG and PROM. Software for fast disk readout to the LRG was also demonstrated.

d. Two-PROM System. The feasibility of real-time optical processing was demonstrared using two PROM devices. The first PROM was used in the input image plane as an incoherent-to-coherent converter and the second PROM was used as a laser addressed, programmable Fourier plane filter. Low-pass filtering, orientation selection, and spatial differentiation were demonstrated.

HECHT, A. S., Parallel Optical Processing to Convert Elevation Data to Slope Maps: Phase II: Practical Considerations, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-RN-74-12, February 1975, NTIS AD A012 790. (USAETL, Fort Belvoir, Va.)

Author Abstract - The considerations in designing and calibrating a coherent optical data processing system for quantitative slope computation from a transparency with amplitude transmittances as a function of surface terrain elevations are described in this report. Methods of designing the spatial filter and criteria for selecting the optical system components to minimize the errors in determining slopes are described. Procedures for calibrating the input transparency and the optical system are specified.

KURTZ, M. K., Jr., Coherent Optics in Mapping - A Suggested Three-Hour Course, presented at the American Society of Photogrammetry 41st Annual Meeting, Washington, DC, March 9-14, 1975. (Defense Mapping School, Fort Belvoir, Va.)

Author Abstract - The availability of a number of recent papers related to application of coherent optics in mapping suggests the need for an interdisciplinary course of instruction as a foundation for further study and investigation. The background review identifies optical data processing alternatives to current limitations of digital imagery processing. Course prerequisites include advanced photogrammetry and modern optics. The content of a one semester course, including laboratory work, is outlined. Text material is based on that assembled jointly by the American Society of Photogrammetry and the Society of Photo-Optical Instrumentation Engineers for a tutorial seminar in Rochester, New York, March 27-29, 1974. The scope of the course parallels current research and development effort.

LEIGHTY, R. D., A Short Tutorial on Coherent Optics, presented at the American Society of Photogrammetry 41st Annual Meeting, Washington, DC, March 9-14, 1975.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Coherent optical techniques will undoubtedly play a number of key roles in mapping systems of the future. Today, however, the mapping community asks, "What is coherent optics?" This short tutorial will present a simplified discussion of five basic concepts of coherent optics: (1) a definition of coherent optics, (2) interference, (3) diffraction, (4) a generalized coherent optical image processing system, and (5) holography. These simplified mental images will then be applied to a discussion of potential mapping applications: near real-time image processing, automated extraction of cartographic data, automated photogrammetric data reduction, and mass optical memories.

MARGERUM, E. A., Transformations for Dimension Reduction and Expansion of the Discrete Fourier Transform under Scanning, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-RN-74-3, January 1974, NTIS AD 787 269.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Direct relationships are developed between the discrete Fourier transform of a two-dimensional (rectangular) array and the discrete Fourier transform of the one-dimensional array formed by scanning the two-dimensional one. The forward and inverse relations both take the form of sums involving certain coefficients which are defined as a sum of complex exponential functions. It is shown that these coefficients can be expressed by a relatively simple formula. The method can be readily generalized for the reduction of dimension of transforms of arrays of higher dimensionality.

5. COLD REGIONS

ACKLEY, S. F. and W. D. Hibler, Measurements of Arctic Ocean Ice Deformation and Fracture Patterns from Satellite Imagery, SCOR/SCAR Polar Oceans Conference, McGill University, Canada, MP 652.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Imagery of sea ice was analyzed to: (1) remotely measure the deformation of the ice cover, (2) estimate correlation of the deformation with atmospheric driving forces so that the primary winter contribution to the atmosphere-ocean exchange can be calculated.

The distribution of ice openings from the March, 1973, VHRR infrared images obtained by the NOAA-2 satellite over the Beaufort Sea were compared with the changes in the atmospheric pressure field during this period. Divergence rates an order of magnitude high ($1\%\ h^{-1}$) than previously seen in this area were measured. The general divergence of the pack correlated with the presence of a prolonged high pressure system in the region. It is concluded that the passage of several systems of this type could significantly change the ice mass balance for a large region for a given year by increasing the amount of thin ice available that is subsequently piled up in pressure ridges.

ANDREEV, V. N., Use of Aerial Methods for the Study of Tundra Landscapes and for their Agricultural Utilization, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 6, 1969, NTIS AD-691 972.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Aerial methods make possible the study of individual types of the microrelief of the tundra landscapes and the establishment of correlations of the soil-vegetation groupings. The results are of practical importance for agriculture.

BILELLO, M., Surface Measurements of Snow and Ice for Correlation with Data Collected by Remote Systems, Advanced Concepts and Techniques in the Study of Snow and Ice Resources, MP 667, December 2-6, 1973.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Reconnaissance by aircraft or satellite is one way to determine the areal extent of the earth's snow and ice cover. However, determining the depth and physical properties of the snow cover and the thickness of ice on lakes and rivers and along coastlines by this remote method is in an early stage of development. Data collected from such remote systems could be correlated with actual surface conditions by using an existing network of over 100 snow and ice observing stations located in North America above 45°N latitude. This network, established by the U. S. Army Cold Regions Research and Engineering Laboratory in cooperation with other U. S. and Canadian Government agencies, provides weekly snow and ice measurements during the winter. This paper identifies the stations in the network, reviews the types of measurements made and equipment used, and summarizes the results of studies derived from the collected data. The 10 to 20 years of record, as well as the data currently being received, provide an extensive and reliable source of information for comparing or verifying observations obtained by other methods.

BILELLO, M. A., Surface Measurements of Snow and Ice for Correlation with Aircraft and Satellite Observations, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 127, May 1969, NTIS AD-689 449.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The seasonal extent of the earth's snow and ice cover can easily be determined by aircraft and satellite reconnaissance. However, determination of the depth and physical properties of the snow cover and the thickness of ice on lakes, rivers and along coastlines by these remote sensors is in an early stage of development. Correlation of the remote sensing data with actual surface conditions could be accomplished through use of an existing network of snow and ice stations located throughout North America. This network, comprising over 100 stations, is maintained by U. S. Army Terrestrial Sciences Center (USATSC) in cooperation with other government agencies and accumulates the most extensive and reliable data for such correlation studies.

BROWN, J., P. L. Johnson, U. S. Army CRREL Topographic Map, Barrow, Alaska (1:25,000), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 101, May 1966, NTIS AD-644 602.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The map covers the land area north of 71 deg. 15 min. N in the vicinity of Barrow, Alaska. Infrared aerial photography was flown at scale of 1:9500 with an infragon, 3-in. focal length lens and a Wratten 89B filter in July 1964. Twenty-six map sheets at a scale of 1:5000 were prepared photogrammetrically with a contour interval of .5 m. These sheets were then compiled on a photographic base for the present map.

Cold Regions Research and Development Symposium, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 80, March 1964, NTIS AD-634 471.

Author Abstract - Included are the papers presented at the symposium and the discussions which accompanied them. Among the topics were cold regions research programs, military problems in Alaska and Greenland, visibility, sea and lake ice structure, glacier water supply and sewage disposal, pile foundations in permafrost and trafficability of snow and muskeg.

DUNKLE, R. V. and J. T. Gier, Spectral Characteristics of Wet and Dry Snow Between 0 and -60C, University of California Institute of Engineering Research, TR 16, August 1955, NTIS AD-088 575.

Author Abstract - No abstract.

FROST, R. E., Aerial Photography in Arctic and Subarctic Engineering, American Society of Civil Engineers, Air Transport Division. Journal, May 1960 86 (AT1) MP 126.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The use of aerial photographs as a means of getting information about surface materials and their condition, which will assist in solving scientific, engineering, or military problems in arctic, subarctic, and polar areas is discussed. The discussion is limited to a short review of problems related to permafrost and severe frost activities; the airphoto method of obtaining information; the determination and evaluation of the regional environmental aspects responsible for permafrost and severe frost action; the identity and significance of minute photo pattern features, and direct permafrost and frost activity indicators. An example of a typical analysis of aerial photographs is included.

FROST, R. E., J. H. McLerran, R. D. Leighty, Photointerpretation in the Arctic and Sub-Arctic, National Research Council Publication, No. 1287, International Conference on Permafrost, Nov. 11-15, 1963, Lafayette, Indiana, MP 127, 1966.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Successful use by engineers of remote and often inaccessible areas is contingent on knowing the identity, physical properties, and distribution of soils and rocks and their behavior when disturbed. Regions can be studied through small-scale areal photos, assembled either in mosaic or in photo-index forms. Stereoscopic pairs of contact photos typical for each major pattern are studied to determine physical characteristics of the minute features. Data are correlated and areas of agreement or disagreement are determined. In arctic and subarctic regions photoanalysis is significant not only because of regional remoteness and inaccessibility but also because of the problems of use, alteration, and disturbance of the frost and permafrost in the area, as well as giving the identify and distribution of the various soils and rocks.

HIBLER, W. D., Characterization of Cold-Regions Terrain Using Airborne Laser Profilometry, Journal of Glaciology 1975, 15(73), MP 831.
(USACRREL, Hanover, New Hampshire)

Author Abstract - This paper provides a review of the characteristics of airborne laser profilometry and its application to quantitative characterization of cold-regions terrain. The limitations of profilometry due to the profiler instrumental characteristics and instability of the aircraft platform (resulting from variations in aircraft altitude and attitude) are discussed. For typical aircraft speeds of the order of 100 m/s these limitations restrict the accurately measured roughness content to the approximate wavelength range 2 m to 300 m. Digital filtering and hardware techniques for removing the aircraft motion, and hence extending the long wavelength validity of the profile, are discussed.

Regarding terrain characterization, particular attention is given to Arctic sea ice. Ridge height and spacing distribution models for sea ice in conjunction with digitally processed laser profiles allow efficient characterization of sea-ice ridging using only a few parameters. In particular, a single ridging intensity parameter has been found to allow reasonable estimation of the number of ridges encountered at any height level along a straight-line path. Examination of spectral characteristics of first-year and multi-year ice suggest that laser profiles may be used to identify the ice type of floes and ridges. Comparisons of laser data and submarine sonar data are made which suggest the ratios of c. 6.5: I can be used to estimate ridge keel depths from laser data. Use of laser profilometry to characterize tundra and indirectly to measure variation in snow depth is briefly discussed.

HIBLER, W. D., Removal of Aircraft Altitude Variation from Laser Profiles of the Arctic Ice Peak, Journal of Geophysical Research, Dec. 20, 1972 77(36), MP 572.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Standard high-pass-filtering procedures are not in general adequate for removal of aircraft altitude variation from laser profiles of the arctic pack ice because of the spectral overlap between the surface roughness spectrum and the aircraft height variation spectrum. Owing to this overlap, a high-pass filter tends to depress high ridges and thus makes the resulting profile unsuitable for ridge height analysis. To bypass this difficulty, a straight-forward three-step process is presented. The technique is first to carry out a conventional high-pass-filtering operation and then to estimate minimum point, which can then be used to estimate an ice roughness base line. The estimated ice roughness base line is then low-pass-filtered. This process can be used routinely for processing various profiles, since the filter cutoffs are not critical. The filtering operations are

performed by small-error low-pass filters with guaranteed maximum errors of $<0.9\%$ outside of transition band.

JOHNSON, P. L., Remote Sensing as an Ecological Tool, Ecology of the Subarctic Region, Vol. 1 of Ecology and Conservation, Paris, UNESCO, MP 205, 1970.
(USACRREL, Hanover, New Hampshire)

Author Abstract - In interior Alaska an extreme continental climate prevails in the latitudinal tension zone of tree growth. The present vegetation mosaic is a mixture of forest, shrub and herbaceous stands in various stages of plant succession. Their stability appears proportional to: (a) the stability of the permafrost and the resulting drainage condition; (b) the elapsed time since the last fire or flood disturbance and the intensity of the burn or duration of the flood; (c) the age of the organic or mineral substrate which is usually a function of topographic position. Examples of Alaskan subarctic vegetation were selected from a recent study of structure and standing crop in the Yukon Flats region to reveal the utility of aerial photography, radar and thermal imagery. The potential of synoptic ecological information from Earth-orbiting platforms is suggested as a realistic means of extrapolating local studies to management size units in resource planning.

JOHNSON, P. L. and F. B. Kistner, Breakup of Ice, Meade River, Alaska, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 118, October 1967, NTIS AD-667 946.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The climatic conditions and chronology of ice breakup on the Meade River, Alaska, in 1966 are reported and documented photographically. These observations and the interpretation of aerial photography suggest that ice damming, flooding, and dam release are the typical patterns of breakup that progress repetitiously downstream. The implications of ice breakup on plant succession on river bars and on channel erosion are discussed.

KASTEN, P., Albedo and Sky Radiance Measurements in Greenland, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 180, April 1966, NTIS AD-635 376. (USACRREL, Hanover, New Hampshire)

Author Abstract - This paper presents the results of measurements made in June 1961 on the ice sheet of Northern Greenland. The following quantities were measured: total and visual albedo of the snow surface under overcast and blue skies as well as the corresponding albedos in several spectral ranges; vertical distributions of the luminance and of the radiance of densely overcast sky and snow surface in several spectral ranges; and aximuthal distributions of luminance and near-infrared radiance of overcast skies of different densities. The interdependence of these quantities and their relationship to whiteout are discussed on the basis of the measurements. It is concluded that in order to fully or partly overcome whiteout, the luminance distribution must be made more or less nonuniform. This may be accomplished by cloud seeding, dark objects on the ground, or the use of light of other than visible wavelength.

KOVACS, A., H. L. McKim and C. J. Merry, Islands of Grounded Ice, Journal of the Arctic Institute of North America, MP 852, September 1975.

Author Abstract - No abstract.

KUMAI, M. and J. D. Russell, Attenuation and Backscattering of Infrared Radiation by Ice Fog and Water Fog, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 264, April 1969, NTIS AD-689 447. (USACRREL, Hanover, New Hampshire)

Author Abstract - Ice fog crystals consisting of many spherical particles, and some hexagonal plates and columns, were observed at ambient temperatures of about -40C in the Fairbanks, Alaska, area during mid-winter. The concentrations and the size distributions of the ice-fog crystals were measured. The attenuation and backscattering of infrared radiation by ice-fog crystals were computed for optical wavelengths of 2.2 mu, 2.7 mu, 4.5 mu, 5.75 mu, 9.7 mu and 10.9 mu using the Mie theory. The minimum attenuation coefficients and backscattering functions of ice fog were found to be at 9.7 mu wavelength in the observed wavelengths. Optical attenuation coefficients and volume backscattering functions of water fogs were also computed using the Mie theory. The minimum attenuation coefficients and back-scattering functions of water fog were found to be at 10.9 mu wavelength in the region of 2.2 mu, 2.7 mu, 4.5 mu, 5.75 mu, 9.7 mu and 10.9 mu. Both the attenuation coefficients and backscattering functions of ice fog are within the same order of magnitude as water fog for equivalent fog concentration and wavelengths.

McLERRAN, J. H., Airborne Crevasse Detection, Proceedings of 3rd Symposium on Remote Sensing of Environment, University of Michigan, Ann Arbor, Michigan, October 14-16, 1964, MP 287. (USACRREL, Hanover, New Hampshire)

Author Abstract - Experimental and theoretical work on the feasibility of aerial detection of crevasses by infrared sensing.

McLERRAN, J. H., Remote Sensing and Interpretation of Sea-Ice Features, Proceedings of Symposium on Oceans from Space, 1969, MP 290.
(USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

MEYER, M. A., Remote Sensing of Ice and Snow Thickness, Proceedings of 4th Symposium on Remote Sensing of Environment, University of Michigan, Ann Arbor, Michigan, April 12-14, 1966.

Author Abstract - A high resolution monocycle v.h.f. radar has been developed and tested over lake ice. Tests were conducted with the U. S. Army Cold Regions Research and Engineering Laboratory using a boon as the antenna support in 1965, and using a moving helicopter as a support in 1966. Ice thickness and snow thickness were readily measured by visual data reduction. Thickness measurement accuracies of the order of 1 cm. are possible utilizing this technique.

Results of measurements and the data taken are discussed as well as the expected results for such a measurement. The application of these measurements to the determination of dielectric constant is discussed.

Proceedings of the Workshop on Snow and Ice Hydrology at Colorado State University, MP 293, August 18-22, 1969.

Author Abstract - Contains the presentations and discussions in which progress in knowledge and problems remaining to be solved regarding snow and ice are identified, and research activities of various groups, committees and institutions are described, with emphasis on interdisciplinary aspects of snow and ice research and the need for cooperatior among various disciplines.

POULIN, A. O., V. H. Anderson, J. M. McAnerney, Aerial Reconnaissance of Sea Ice and Snow Covered Terrain, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 65, July 1963, NTIS AD-352 349.
(USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

POULIN, A. O., T. A. Harwood, Infrared Imagery in the Arctic Under Daylight Conditions, Proceedings of 4th Symposium on Remote Sensing of Environment, 12-14 April 1966, MP 368.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Infrared thermal imagery and concurrent aerial photography were obtained from various altitudes over a broad geographical area in Arctic North America and the Polar Basin prior to the start of the melt season. Solar altitudes during the periods of data collection varied from 2 to 27 degrees, and clear weather prevailed most of the time. It was found that some terrain features and conditions depicted in the infrared imagery were not apparent or were only weakly suggested in the conventional aerial photography and that solar irradiation produced both good and bad effects in the thermal imagery. Examples of a few of these findings are presented.

RINKER, J. N., R. E. Frost, Application of Remote Sensing to Arctic Environmental Studies, Alaska Remote Sensing Symposium, Anchorage, 1969 (Juneau) Alaska Department of Economic Development, MP 194, 1969.
(USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

SMALL, F. A., Project Blue Ice: Greenland Crevasse Reconnaissance, Summer 1954, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 21, April 1955, NTIS AD-716 665.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The Corps of Engineers program in northwestern Greenland during the summer of 1954 included a reconnaissance group whose purpose was to investigate a crevassed area on the Ice Cap, to provide information for initiating a research program in 1955. This report on the project, called 'Blue Ice' in the field, is intended, first, as an information source for outlining a research program and, second, as a record of observations in a crevassed area.

WEEKS, W. F. and W. J. Campbell, CRREL-USGS Program at Camp 200; A Post-Operations Summary, Arctic Ice Dynamics Joint Experiment, AIDJEX Bulletin, No. 8, MP 629, May 1971. (USACRREL, Hanover, New Hampshire)

Author Abstract - The most intensive airborne remote sensing and ground truth investigations ever made of sea ice took place during the 1971 AIDJEX pilot expedition to the Beaufort Sea. Multiple missions over and around the AIDJEX site at 74 deg. N., 131 deg. W. were performed by three remote-sensing aircraft: the NASA Convair 990, the U. S. Coast Guard Hercules, and the Navy "Birdseye" Constellation. The ground truth team succeeded in establishing a tellurometer deformation triangle and occupying it during all but two of the aircraft overflights. For the first time, the following kinds of data were obtained. (1) sequential synoptic imagery of a given area of sea ice; (2) mesoscale deformation of sea ice; (3) microwave emissivities of sea ice. In short, we believe that this remote sensing and ground truth experiment was a success.

SECTION	REPORT TITLE
17	Anderson, V. H., Radar Imagery of Arctic Pack Ice, Kane Basin to North Pole.
17	Hoekstra, P., P. V. Sellman, and A. J. Delancy, Airborn Resistivity Mapping of Permapost Near Fairbanks, Alaska.
17	Kovaks, A., and G. Abele, Crevasse Detection Using an Impulse Radar System.
17	Leighty, R. D., Terrain Information from High Altitude Side-Looking Radar Imagery of an Arctic Area.
18	Anderson, D. M. et al, An ERTS View of Alaska.
18	Anderson, D. M., et al, The Use of ERTS-1 Imagery in Regional Interpretation of Geology, Vegetation Permafrost Distribution, and Estuarine Processes in Alaska.
18	Gatto, L. W., Cook Inlet, Alaska, Bay Processes.
18	Haugen, R., L. W. Gatto, et al, ERTS-1 Imagery Arctic and Subarctic Environmental Analysis.
18	Hibler, W. D., et al, Analysis of Shear Zone Ice Deformation in the BEAUFORT Sea Using Satellite Imagery.
19f	Johnson, P. L., and T. C. Vogel, Vegetation of the Yukon Flats Region, Alaska.
5	Currin, T. R., and J. W. Ingram, Terrain Data of Mount Hayes D-4 Quadrangle, Fort Greely, Alaska.
19a	Anderson, V. H., Sea Ice Pressure Ridge Study.
19a	Andreev, V. N., Interpretation of Different Type of Tundra from Aerial Photographs and Their Aerovisual Description on the Basis of Frost Jointing.
19a	Leighty, R. D., Use of Aerial Photographs and Field Reconnaissance for Ice Cap Route Location at Narssarssuaq, Greenland.
20	Diamond, M., and R. W. Gerdel, Radiation Measurements on the Greenland Ice Cap.
20	Dunkle, R. V., T. Gier, Radiation in a Diffusing Medium with Applications to Snow.

6. ENVIRONMENTAL ANALYSIS

CRESS, D. H. and L. E. Link, Jr., The Use of Remote Sensing Devices for Acquiring Data for Environmental Management Purposes. Report 2. Application of Photographic Remote Sensors to an Environmental Management Problem, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, WES-TR-74-8-2, May 1976, NTIS AD-A025 616.
(USAEWES, Vicksburg, MS)

Author Abstract - This report demonstrates the application of a procedure developed for the systematic application of photographic remote sensor systems to specific environmental data acquisition problems. Of particular importance to this procedure is a quantitative approach to predicting a proper mission profile (i.e. film-filter combinations, scale, etc.) as a function of properties of the features of interest and the surrounding environment. The application of the procedure to an environmental management problem at a military facility within CONUS, Fort Carson, Colorado, is discussed. The primary emphasis of the work is on the acquisition of data relevant to measurement of the effects of maneuvering vehicles on the environment in two training areas (80 KM2) on the post. The parameter selected for measurement is the length of vehicle paths per unit area, referred to as vehicular usage. An obvious application of the map is to support scheduling of training in areas of lowest vehicular usage and to identify areas subject to severe environmental damage.

GARDNER, J. G., A Study of Environmental Monitoring and Information Systems, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-72-1, January 1972, NTIS AD 739 553.
(University of Iowa, Iowa City, Iowa)

Author Abstract - Environmental information has a variety of uses. The report emphasizes one such use: the monitoring and periodic description of environmental quality. Operational and planned schemes for environmental monitoring are briefly reviewed. The status of remote sensing or data collection is discussed in relation to pertinent environmental elements and variables. The attributes or variables by which the physical environment may be described are outlined along with a measure of human activities, land use. On the basis of the review, the organizational structure of an environmental information system is outlined and discussed.

It is very apparent that the amount of environmental information is enormous and promises to increase in volume at an increasing rate. This and the numerous efforts to monitor various aspects of the environment suggest priorities in the development of an environmental monitoring and information system. Top priority is given to the development of a Coordination and Resource Data System which would monitor data gathering and research activities related to environmental matters. The emphasis is placed on avoiding duplication, an essential prerequisite in a field as diverse and complex as environmental science.

KURTZ, M. K., Jr., and J. W. Jarman, Corps of Engineers Applications for Remote Sensing of the Environment, presented at the Eleventh International Symposium on Remote Sensing of Environment, conducted by ERIM, Ann Arbor, Michigan, 25-29 April 1977.
(USAETL, Fort Belvoir, Va., and Office of the Chief of Engineers, Wash, DC)

Author Abstract - An objective overview is presented of the application of remote sensing technology in the Corps of Engineers. Examples are given of attempts to use the current state-of-the-art to achieve particular disciplinary or mission-oriented goals. The Corps, presently engaged in both research and development and technology transfer, has encountered some interesting situations. Practical operational utilization depends not only on technology, but also on economic benefit/cost factors and some unprecedented legal, political and social issues. Yet, at a time when increased agency commitment to operational usage is being sought, an assessment of the state-of-the-art reveals that sensor technology, data processing and analysis, and models still require further development. There is a challenge in synchronizing technology push with the demand pull of dimly perceived user needs. They should complement each other rather than oppose. The goal is to use the combined push-pull effect to lead to increased productivity and responsiveness by the Corps.

LINK, L. E., Jr., The Use of Remote Sensing Techniques for Detection and Identification of Pollutant Discharges, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-Misc Paper-M-73-11, August 1973, NTIS AD-A017 727.
(USAEWES, Vicksburg, MS)

Author Abstract - The purpose of this study was to evaluate by quantitative simulation techniques the capabilities of current photographic remote sensing techniques for detecting and identifying pollutant discharges. The first portion of the report consists of a detailed discussion on the basic principles of remote sensing. The basic theory of electromagnetic radiation, the use of electromagnetic radiation for remote sensing, and the techniques and equipment used to obtain remote imagery are presented. The second portion of the report is a presentation of a mathematical model developed during the conduct of this study. The model provided a general analysis capability that has not existed prior to its development. The final portion of the report concerns the application of the computer model to assess the capabilities of remote sensing techniques for detecting and identifying pollutant discharges.

LINK, L. E., The Use of Remote Sensing Systems for Acquiring Data for Environmental Management Purposes. Report 1. A Procedure for Predicting Image Contrasts in Photographic Remote Sensing Systems, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-TR-M-74-8-1, November 1974, NTIS AD-A002 070.
(USAEWES, Vicksburg, MS)

Author Abstract - Airborne remote sensors provide a potentially expedient technique for obtaining environmental data for baseline descriptions of multi-purpose military installations or of impact of activities on the environment within a reasonable time and cost framework. Although the feasibility of using remote sensing techniques for these purposes has been demonstrated, the acquisition of imagery of sufficient quality to provide the necessary data for the many and diverse environmental features and phenomena of interest requires systematic and quantitative planning. This report presents an analytical procedure (referred to herein as the remote sensing simulation model) that provides a means for selecting a sensor system and mission profile objectively to enhance imagery for specific purposes. The model is computerized and calculates the amount of contrast that will occur between two features of interest on a photographic image as a function of reflectance properties on materials, atmospheric conditions, solar zenith angle, sensor altitude, and sensor characteristics. Illustrations of model application to two hypothetical problems are given. The remote sensing simulation model provides a general tool for acquisition of photographic remote sensing techniques and evaluation of the applicability of these techniques to specific or general problem areas.

LINK, L. E. and J. H. Shamburger, Application of Remote Sensors to Army Facility Management, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-TR-M-74-2, February 1974, NTIS AD-775-407.
(USAEWES, Vicksburg, MS)

Author Abstract - A study was conducted to determine the feasibility of applying remote sensing techniques to Army needs for data in environmental monitoring, resource management, and master planning at multipurpose military installations in the Continental United States. The environmental data requirements for these purposes were defined, and a general assessment was made of the applicability of current photographic, thermal infrared, and microwave imaging systems to obtain these data. Aerial photographic techniques were found to be the ones most generally applicable to acquisition of data relevant to basic environmental conditions. Prototype products, consisting of maps of basic environmental conditions, cultural features, and land use were produced from aerial photography of Fort Belvoir, Virginia, and surrounding area.

LINK, L. E. and J. R. Stabler, The Use of Remote Sensing Systems for Acquiring Data for Environmental Management Purposes, Report 3, A Nomogram for Computing Optical Density Contrast, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, WES-TR-M-74-8-3, May 1976, NTIS AD-A026 718. (USAEWES, Vicksburg, MS)

Author Abstract - Previous efforts as part of this program resulted in a new capability for predicting photographic-image optical density contrasts. The product of the effort was a computerized system model that provides a rigorous, quantitative means of objectively selecting a sensor system and mission profile to enhance the success of a remote sensing data acquisition program. The execution of the model requires computer facilities and specialized personnel. A graphic form of the model was developed to provide a simple planning tool that can be applied by users having a wide range of backgrounds and without computer facilities. This report presents a nomogram for predicting optical density contrasts on aerial photographs. The concept and formulation of the nomogram are discussed and an example of its application presented. The accuracy of the nomogram with respect to the computer program from which it was derived is also evaluated.

LINK, L. E. and D. H. Cress, Application of Remote Sensing to Environmental Management at Military Facilities, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 1976, NTIS AD-A026 063. (USAEWES, Vicksburg, MS)

Author Abstract - The systematic application of remote sensing techniques at Fort Carson has provided critical information for the environmental management of vehicle-maneuver training areas. The remote sensing simulation model provided a quantitative means for selecting the best film-filter combination for the job. Only one type of information was extracted from remotely sensed data for the purposes of this example; the techniques and systematic procedures followed herein could easily be applied to more complex studies requiring other types of information. It must be emphasized that the application of remote sensing to a specific problem must be closely allied with the specific data requirements necessary for the solution of the problem. Accuracy, scale, and threshold values considered critical for detection must be identified prior to the conduct of the remote sensing mission to allow adequate planning of the data acquisition program, both on the ground and with remote sensor systems.

LINK, L. E., and A. N. Williamson, Jr., Use of Automated Remote Sensing Techniques to Define the Movement of Tow-Generated Suspensed Material Plumes on the Illinois and Upper Mississippi Rivers, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, WES-TR-M-76-6, June 1976, NTIS AD A025 733.
(USAEWES, Vicksburg, MS)

Author Abstract - Sequential color-infrared aerial photos and corresponding surface water samples were obtained at selected sites on the Illinois and upper Mississippi Rivers to examine the movement of two-generated suspended material plumes. The aerial photos were digitized with a scanning microdensitometer, and optical density values were extracted for correlation with suspended material concentration data obtained by laboratory analysis of the water samples. Correlation of the optical density and concentration values for each site and for sample positions at each site did not produce a statistically significant relation between the variables. The poor correlation between optical density and concentration values prevented quantitative definition from the imagery of the distribution of suspended material concentrations at the sites as a function of time. Digital data handling procedures were used to enhance the visibility on the imagery of the two-generated plumes. The procedures applied were successful in delineating the movement and dissipation of the two-generated plumes under favorable sun and water conditions.

MARLAR, T. L. and A. D. Randall, Data Base Development Using Photo Interpretive Mapping - Report for Regulatory Branch, N.E.D., July 1977.

Author Abstract - No abstract.

MARLAR, T. L. and A. D. Randall, An Analysis of Surveillance Techniques Useful for Regulatory Data Base Up-Date - Report for Regulatory Branch, N.E.D., September 1977.

Author Abstract - No abstract.

RINKER, J. N., Environmental Analysis - A Challenge to the Remote Sensing Community, presented at the American Society of Photogrammetry Meeting, March 9-14, 1969. (U. S. Army Terrestrial Sciences Center, Hanover, New Hampshire)

Author Abstract - Severe environmental problems are beginning to develop throughout the world as a result of the population explosion and the highly developed technical abilities of man. Some of these problems - population, food, water, pollution, atmospheric contamination, etc., are discussed from the point of view of indicating where and how remote sensing and interpretation techniques can be of aid in remedying existing difficulties and avoiding future ones.

RINKER, J. N. and R. E. Frost, Environmental Analysis, Remote Sensing and Education, Proceedings of 4th Symposium on Remote Sensing of Environment, University of Michigan, Ann Arbor, Michigan, MP 393, April 12-14, 1966. (USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

SHAMBURGER, J. H. and H. K. Woods, Application of Remote Sensors to Army Facility Management; Appendix B: Validation of Environmental Maps Produced Through Air-Photo Interpretation, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-TR-M-74-2, NTIS AD-A005 556. (USAEWES, Vicksburg, MS)

Author Abstract - A study was performed to validate environmental baseline factor maps of the Fort Belvoir study area, which were prepared through air-photo interpretation without the aid of any supplemental data. A field data collection program was conducted to provide data to be compared with the information derived from the analysis of the aerial photos. It was found that the air-photo interpretation was quite accurate, but that increased accuracy would result if ground truth data were available to the interpreters during the interpretation process.

SMITH, M. H., Feasibility of Monitoring Flow Patterns and Sediment and Pollutant Dispersion of Water Bodies with 24-Channel Spectral Data, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, WES-MP-M-76-10, May 1976, NTIS AD-A025 333. (USAEWES, Vicksburg, MS)

Author Abstract - The primary objective of this research effort was to develop data-handling procedures to transform digital data collected by a Bendix 24-channel airborne sensor into radiance

values and to produce images free of skew and reflectance geometry distortion. Data collected over the Chesapeake Bay area on 26 October 1972 and 22 April 1973 at approximately 3200 M and later recorded on computer-compatible tapes (CCT) were studied. Special attention was focused on data from the Rappahannock River. The scanner system, including the mechanics, optics, and electronics, is described with an explanation of data formatting on the NASA-generated CCT and the formatting required by existing U. S. Army Engineer Waterways Experiment Station (WES) computer software and programs to handle remotely sensed data, specifically ERTS or LANDSAT CCT data.

WILLIAMSON, A. N., W. K. Dornbusch and W. E. Grabau, Remote-Sensing Practice and Potential, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, WES-MP-74-2, May 1974, NTIS AD-A035 977.
(USAEWES, Vicksburg, MS)

Author Abstract - Six essential processes that must be accomplished if use of a remote-sensing system is to result in useful information are defined as problem specification, ground control data acquisition, remote-sensor information acquisition, data manipulation, information extraction, and information presentation. Several fairly common and not so common sensor types are introduced, and some devices and information extraction and presentation techniques found to be useful in remote-sensing projects are described. An overview of the current state-of-the-art of remote sensing is presented.

SECTION	REPORT TITLE
5	Rinker, J. N., and R. E. Frost, Application of Remote Sensing to Arctic Environment Studies.
18	Haugen, R., et al, ERTS-1 Imagery Arctic and Subarctic Environmental Analysis.
20	Carney, J. R., T. C. Vogel, E. R. Love, and G. E. Howard, Interagency Energy and Environmental Survey.

7. HOLOGRAPHY

GEORGE, N., Full View Holograms, AF Office of Scientific Research (SREE), Arlington, VA, March 1970, NTIS AD 716 276.
(California Institute of Technology, Engineering and Applied Science Division, Pasadena, CA)

Author Abstract - A multiple exposure or sandwiched planar hologram is described on which is recorded the entire wavefront emanating from a localized object space. An observer walking around this illuminating hologram sees an image in space accurately rendering a 3-D object for a solid angle of 4π steradians, asymptotically. With large outdoor objects, the holographic stereogram is used as in intermediary in making the composite full-view hologram.

GLASER, G. H. and E. M. Mikhail, Study of Potential Application of Holographic Techniques to Mapping, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-70-8, December 1970.
(Purdue Research Foundation, Purdue University, Lafayette, Indiana)

Author Abstract - This report is primarily concerned with the precision and pointing at a holographically produced image. After consideration of several possibilities, measurements performed by placing a small self-illuminated dot within the space of the virtual image from the hologram proved to be most feasible. It is shown that images from holograms can be measured by use of a floating dot in a manner similar to that used in mensuration of photogrammetric stereomodels.

Simulation studies were performed and indicated that shifts in the reconstruction beam angle of up to 5 degrees could be tolerated. A shift of larger than 5 degrees caused large distortions in the image geometry which could not be removed by a linear transformation.

The investigation is in three parts: concise discussion of the properties of holography and photogrammetry; theoretical imaging characteristics; and mensuration.

KURTZ, M. K., Jr., N. Balasubramanian, E. M. Mikhail and W. H. Stevenson, Study of Potential Application of Holographic Techniques to Mapping, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-71-17, October 1971.
(USAETL, Fort Belvoir, Va., and Purdue Research Foundation, Layfayette, IN)

Author Abstract - The potential uses of optical holography in photogrammetric mapping are identified. Techniques are given for presenting information which has been quantitatively extracted by mapping holographic virtual images of realistic objects and terrain. During measurement, with a self-illuminated measuring mark, it was found that the position accuracy varies inversely with magnification and directly as the square of the viewing distance to the image. By modifying the Wild A7 Autograph so that the holographic virtual image could be absolutely oriented, it was possible to map the image both digitally and by plotting detailed outlines, planimetry, profiles and contours. It is believed that the first topographic maps ever made from holographic images were produced.

If the object is unsuitable for direct holography and mapping at 1:1 scale, then it can be photographed with incoherent illumination using a metric camera to provide imagery of the scale desired. The newly developed concept of the holographic stereomodel provides for holographic recording of the relatively oriented stereomodel constructed from imagery thus obtained. The first holographic stereomodels of a quality suitable for photogrammetric purposes were used to extract target coordinates and to prepare topographic maps.

In addition to providing useful images for mapping applications, holography offers potential for display purposes and in the construction of holographic corrective optical elements.

MacANALLY, R. B., Holography and Stereoscopy, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-72-2, January 1972, NTIS 893 272.
(California Institute of Technology, Pasadena, California)

Author Abstract - Theoretical and experimental investigations in modern optics, emphasizing problems in holography and stereoscopy were conducted. Among the subjects studied were Full-View Holograms, Full-View Holographic Stereograms and real image projection from holograms. The techniques of full-view holography

and holographic stereoscopy allow holographic recording, on a planar emulsion, of propagating wavefronts filling, asymptotically, a solid angle of 4π steradians about the hologram plate. This technique has applications in mapping, modeling and display. In particular, the wide viewing angle is a useful feature for real image projection.

McCRICKERD, J. T., Holographic Stereogram Display Techniques for the Viewing and Mensuration of Stereo Photogrammetric Imagery, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Final Report ETL-CR-74-2, November 1973, NTIS AD 778 790.
(Northrop Corporation, Hawthorne, CA)

Author Abstract - Holographic stereograms, holograms of stereo-pair aerial-photos, are measured to determine geographical coordinates of terrain features. The holograms are stereoscopically viewed and measured in three dimensions through a conventional binocular-eyepiece microscope. A pair of cross-hair reticles in the eyepieces give the illusion of a floating cursor which, to facilitate mensuration, can be moved throughout the breadth and depth of the 3-D terrain display. Microscope dial readings are interpreted by geometrical formulae to yield coordinates of terrain features. Measurements are made relative to reference points, which appear as a three dimensional array in the display. Aerial photo distortions are compensated by proper placement of the points.

8. IMAGE DISPLAY

BRAMLEY, Jenny, Display Technologies for Topographic Applications Assessment of State-of-the-Art and Forecast: U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0016, June 1975, NTIS AD B005 962L. (USAETL, Fort Belvoir, Va.)

Author Abstract - This report deals with display technologies for simultaneous presentation of map or other archival pictorial information and computer updates in the form of symbols and graphics. An assessment is made of the state of the art and of its limitations. A forecast is made with regard to more complex and potentially more satisfactory display implementations. Experiments are suggested for evaluating the more easily realized approaches and for determining their adequacy. Cathode ray tube technology is found to be the only one available in which the state of the art might satisfy expressed needs. The other technologies identified have not been adequately pursued in the past few years. As a result, they are either too costly or not sufficiently advanced, or both, or pose presently unacceptable display difficulties. The implications for topographic data formats implicit in each display method are noted.

LUCAS, J. A., A High Speed Disc Memory and a Color Image Display for a Small Computer, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., October 1970, NTIS AD 878 975L. (Center for Research, Inc., University of Kansas, Lawrence, Kansas)

Author Abstract - It is well known that the human eye can distinguish differences in color more readily than differences in grey levels. However, at the present time most computer displays are black and white. A color display can be extremely useful if image data is to be presented to a human interpreter. A flexible low cost interface system has been designed which is suitable for displaying information on black and white or color CRT monitors.

The display system presented in this thesis is capable of displaying black and white image data with 64 grey levels, color image data, or merely dot patterns for alpha-numeric output. Unlike most computer display systems which require a large amount of magnetic core memory, the display system described in this thesis utilizes a low cost fixed head digital disc memory which has a maximum readout of 24 binary digits per 1/3 microsecond. Similar discs are available with output capabilities of 72 binary digits per 1/3 microsecond. The cost per bit of the digital storage is only one-half of a cent as compared to seven to twelve cents per bit for magnetic core memory. A six bit seven megahertz digital to analog converter was designed and utilized in the interface from the digital disc to the monitors. Three of these converters are needed for a color system.

The digital disc memory has been interfaced to the computer such that it can also be utilized as a 2.4 million bit dynamic memory when it is not being used for image storage. Computer-disc data transfers can be accomplished at a maximum rate of 18,000,000 bits per second with a maximum latency of 1/30 second.

McCRICKERD, J. T. and G. H. Glaser, Stereoscopic Terrain Display for Measurement Applications, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Final Report ETL-0002, December 1974, NTIS AD A008 085.
(Northrop Corporation, Hawthorne, California)

Author Abstract - A stereoscopic terrain display is developed which looks realistic because visual parameters are closely matched to those encountered in natural environments. Wide-view rear projection is achieved without need for spectacles or eyepieces; the light beams from left- and right-viewpoint pictures are individually directed into the respective eyes of the user. Terrain can be continuously scanned across the display screen without interruption of stereoscopic effect. Pictures are loaded into the display unit as slides. Parallax normal to the eye-base direction (i.e., y-parallax) is zeroed at once across the entire display area without user effort, by rectifying the pictures in production. Good resolution is achieved by rectifying the pictures with perfectly focused lenses. Also treated are methods to make precise measurements of terrain features in the display. Errors anticipated in a well designed measurement system are anticipated. Most convenient measurement scheme may use holographic picture-slides. A display unit was demonstrated with a holographic picture-slide.

PATTERSON, C. L., Survey of Display Devices (Hard Copy), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0086, June 1976, NTIS AD-A036 339.
(Aerospace Corporation, Los Angeles, CA)

Author Abstract - This report determined the types of hard copy devices available, the relative advantages and disadvantages, and cost for the various systems. Manufacturers were identified that produced hard copy display systems. The objective of the report was to review as many types of instruments as could be located. Results of the survey found that there is little that is new in the field. The basic system types included flying spot scanning, a few laser devices, rotating drum with incoherent sources, and several flat bed systems based on microdensitometer techniques.

PATTERSON, C. L., Survey of Digital Image Display Systems (Soft Copy), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0085, June 1976, NTIS AD-A036 338. (Aerospace Corporation, Los Angeles, CA)

Author Abstract - The survey in this report is directed toward the CRT display systems in order to assess the current state of interactive display systems. This report goes further than previous surveys in that monitor systems were reviewed independent of the total systems. Another primary element in the digital image display system is the refresh technology used by any system. This report pays particular attention to the refresh technique. The results show that most new developments in the field were predicted, such as solid state memory for refresh of the monitor and the appearance of a new '1000' line monitor from two suppliers.

9. IMAGE QUALITY

BROOKE, R. K., Jr., Spectral/Spatial Resolution Targets for Aerial Imagery (Report No. 1 in the ETL Series on Remote Sensing), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-TR-74-3, March 1974, NTIS AD 784 090. (USAETL, Fort Belvoir, Va.)

Author Abstract - A set of aerial spectral/spatial resolution targets was designed and fabricated by the U. S. Army Engineer Topographic Laboratories (USAETL) for use in the USAETL Color and Multiband Test Program. Three-bar resolution targets consisting of color bars on a neutral background and a 10-step gray scale make up the test pattern. Special paints were formulated to achieve the desired spectral reflectance characteristics, and the targets were sectioned for transporting to various test sites.

HECHT, A. S. and J. S. Odell, Image Quality Analysis and Control of Color and Multiband Photography, presented at the ASP Meeting in St. Louis, MO, on 10-15 March 1974. (USAETL, Fort Belvoir, Va.)

Author Abstract - Major requirements for any aerial photographic imaging system are, first, for the precise control of the operations of image acquisition, original film processing, duplicating on film and printing on paper; and, second, for the evaluation of the image quality of each step and of the final products. In this instance, the task is increased by the need to intercompare the results from black and white and a variety of color and multiband photography. A review of the methods used and selected results obtained will be presented.

LEIGHTY, R. D. and G. E. Lukes, Cloud Screening from Aerial Photography, presented at the American Society of Photogrammetry Meeting at St. Louis, MO, on 10-15 March 1974. (USAETL, Fort Belvoir, Va.)

Author Abstract - This paper illustrates how signals detected by a segmented spatial frequency plane detector in a coherent optical system can be computer processed with pattern recognition software for automated cloud screening from aerial photography. A short introduction to the sampling hardware is presented with an analytical characterization of aspects of optical power spectrum sampling and considerations for proper use of the optical and electronic subsystems. Computer software, pertaining to feature selection and recognition algorithms, associated with cloud screening is then reviewed prior to discussion of cloud screening experiments. Finally, conclusions are given for cloud screening via optical power spectrum analysis.

ROBERTSON, K. D., Two Approaches to a Portable Color-Measuring System, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Research Note No. 15, January 1966, NTIS AD 629 704. (USAETL, Fort Belvoir, Va.)

Author Abstract - Two approaches to color measurements are presented, the spectrophotometer and the reflectometer. Descriptions are given of two portable instruments, one of each type.

The first instrument was built using a flashlight lamp as light source, a wedge interference filter as monochrometer, and a cadmium sulphide photoresistor as a detector.

The second instrument was built with three filters which provided the tristimulus curves of the CIE standard observer, a flashlight lamp, and three barrier layer cells as detectors.

THOMPSON, L. G., The Use of Edges of Photographic Images as Specifiers of Image Quality, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Final Report ETL-CR-72-15, November 1972, NTIS AD 753 947. (The Ohio State University Research Foundation, Columbus, Ohio)

Author Abstract - The primary objective of this study was to search for some measurable quantity which would specify the quality of an image with reference to a photogrammetrist's ability to measure to an edge. The image quality criterion was the closeness together of the edge determinations of four experienced observers who were asked to set a measuring mark tangent to a series of edges generated by rapidly rotating various patterns. An edge of high measuring quality was defined as any edge which rendered a high degree of agreement in edge determination and was measured by computing the standard deviation in edge location of the four observers. The second objective of studying where an observer determines the edge to be located was easily studied as a result of the many edge determinations required in ranking the edges as to the image quality. A new term called decutance was derived which correlates very highly with the measured image quality. Additionally acutance and the slope of the density edge trace also displayed a high correlation with image quality. Other possible specifiers were examined and found to be of lesser value. It was found that an observer subjectively locates an edge slightly into the less dense region as measured from the inflection point of the density edge trace. Based on this study and assuming that one micrometer on the photograph subtends an angle of 10 seconds of arc at the observer's eye, the ambiguity in subjective edge location can cause an error as great as $\pm 3\mu m$ in edge location at the photo scale. It would seem that the subjective error connected with edge location could be greater than the otherwise obtainable accuracy using present day photogrammetric techniques.

10. IMAGE SENSING ARRAYS

McVEY, E. S., E. A. Parrish, Jr. and G. Cook, The Application of Image Sensing Arrays to Metrology, Detection and Mapping, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-74-9, June 1974. (The University of Virginia, Charlottesville, Va.)

Author Abstract - *This report covers the fourth year of* a research effort devoted to the study of the application of image sensing arrays and related problems. Recent progress is reported in the areas of signal perturbation for edge detection and picture printing via LED's, optical data acquisition, use of Kalman filtering and smoothing for data resolution enhancement, and reseaux detection using spatial filtering techniques. It is intended that results of this effort will ultimately be applied to map processing and to other related areas.

SECTION	REPORT TITLE
15	O'Connor, D., and P-F Chen, A New System of Measurement Using Sensor Arrays.

11. INLAND WATERWAYS

DINGMAN, S. L., H. R. Samide, D. L. Saboe, M. J. Lynch, and C. W. Slaughter, Hydrologic Reconnaissance of the Delta River and its Drainage Basin, Alaska, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 262, February 1971, NTIS AD-722 217. (USACRREL, Hanover, New Hampshire)

Author Abstract - A one-year reconnaissance study was made of a large braided glacial river and its drainage basin for which a minimum of hydrometric and meteorologic data existed. The report includes estimates of the water balance, flow-duration curves, and sediment characteristics, and descriptions of stream response to glacial melt and rain, channel geometry and channel processes. Surveys and ground and aerial photography are used to describe channel changes.

KOKOLOV, N. N., Landscape Investigations of Reservoirs Using Aerial Methods (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 151, August 1969, NTIS AD-692 375.

Author Abstract - Reservoirs are man-made features which are in a state of constant change, both seasonally and over a relatively short number of years. Being important economic units, of great concern to a number of branches in the national economy, they must be kept under constant surveillance in order to determine any significant changes. The most effective means for conducting such observations is the use of aerial photographs. The article is devoted to the importance of aerial photographs for this purpose giving some examples of the type of information which can be read from aerial photographs, and some proposals for the more effective use of aerial photographs in studying the dynamic picture of changes in reservoirs.

LINK, L. E., Jr., Air-Photo Analysis of Armor Stones on Cleveland Dikes, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, WES-MP-76-8, April 1976, NTIS AD-A024 066. (USAEWES, Vicksburg, MS)

Author Abstract - The air-photo procedure described herein is a rapid and accurate means of acquiring armor-stone-size data. The data acquired by this procedure show that the armor-stone-size data for the 50-ft-wide control sections are representative of the armor-stone conditions over the extent of dikes 1, 2 and 12. Estimates of the actual percentage by number of armor stones weighing less than 1.5 tons were determined for each 100-ft-wide section over the entire extent of the dikes. The average value of these data was 51.8 percent. Analysis of ground-measured armor stone dimensions and actual weights indicates that the 2.73-ft template circle diameter used in this study was a conservative procedure and was biased toward classifying stones as having weights equal to or greater than 1.5 tons when they may in fact weigh less than 1.5 tons.

McKIM, H. L., L. W. Gatto and C. J. Merry, Inundation Damage to Vegetation at Selected New England Flood Control Reservoirs, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 240, March 1975, NTIS AD-A018 558.

Author Abstract - The effect on vegetation of inundation caused by the regulation and impoundment of water at six New England flood control reservoirs during the June-July 1973 flood was assessed from color infrared photography and corroborative ground surveys. A large amount of reservoir storage was utilized during the two-week inundation period resulting in extensive damage to vegetation. Four degrees of apparent vegetative damage were differentiated from color infrared photography based on color differences ranging from bright red or magenta for healthy foliage to cyan for unhealthy, damaged or dying vegetation. Correlative ground truth data showed that the deciduous trees, particularly silver maple and red oak, were least affected and that coniferous trees, especially white pine, were most affected by siltation and inundation. Much of the understory vegetation, i.e., popular, basswood and hornbeam lost all leaves after inundation but new buds and shoots reappeared by late September 1973. Generally, trees inundated for less than 90 hours were not extensively damaged.

McKIM, H. L., L. W. Gatto, C. J. Merry, D. M. Anderson, and T. L. Marlar, Land Use/Vegetation Mapping in Reservoir Management, Merrimack River Basin, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 233, July 1975, NTIS AD-A013 490.

Author Abstract - No abstract.

SECTION	REPORT TITLE
17	Davis, B. R., J. R. Lundien, A. N. Williamson, Jr., Feasibility Study of the Use of Radar Imagery to Detect Surface and Ground Water.
18	McKim, H. L., T. L. Marler, and D. M. Anderson, The Use of ERTS-1 Imagery in the National Program for the Inspection of Dams.

12. MAP COMPILATION

BRACKETT, W. R., Zoom Transfer Scope, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Engineer Design Test Report ETL-ETR-72-5, December 1972, NTIS AD 908 942L.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This report covers the acceptance and engineer design tests and evaluation of the Zoom Transfer Scope, an instrument designed primarily for map revision, map completion, and map compilation.

The report concludes that:

a. With the exception of the frame design and a slight reduction in achieved resolution at the higher magnifications, the instrument meets or exceeds the requirements of the technical characteristics.

b. The Zoom Transfer Scope appears to be an excellent instrument for many planimetric compilation and map revision operations when using vertical or near vertical frame photography.

c. In the stereoviewing mode, the Zoom Transfer Scope provides a means for limited contour compilation and intensification and permits a comparative analysis of a wide variety of photographic products.

d. Because of the severe reduction in the usable field of view, the instrument is not as beneficial for rectification purposes as originally envisioned, particularly when photographic inputs with tilts of 15 degrees or more are used.

BURZYNSKI, E. F. and G. Ference, Universal Automatic Map Compilation Equipment, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report 51-TR, December 1969, NTIS AD 870 698L.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This report presents the results of engineer design tests of the Universal Automatic Map Compilation Equipment (UNAMACE). This equipment is designed for the production of contoured orthophotomaps from aerial photography which, in turn, may be used as a base manuscript for the production of topographic line maps. The system components, operation, test procedures, and test results are described in detail. The objectives of the test were to ascertain the operating capabilities, accuracy, speed, limiting parameters, reliability, and overall suitability of the equipment as a production instrument for the automatic compilation of contours and orthophotomaps.

The report concludes that the UNAMACE is accurate, reliable, easy to operate, fast, flexible, and suitable as a production instrument for use with a wide range of photography of varying focal length, format, flying height, and tilt in the compilation of orthophotomaps and contour data and that the design objectives have been achieved.

CLARK, R. A. Digital Planimetric Compiler, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Engineer Test Report ETL-ETR-72-1, February 1972, NTIS AD 894 826L. (USAETL, Fort Belvoir, Va.)

Author Abstract - This report covers the Engineer Design Test and Evaluation of the Digital Planimetric Compiler. The tests were conducted to determine the suitability of this instrument for performing simultaneous compilation and digital recording from orthophotographs. The Digital Planimetric Compiler is capable of utilizing a wide range of supplementary photography for reference: roll film, 15 inches wide maximum for one, or 7 inches wide each for two, and chips or plates up to 9 inches square.

The report concludes that:

a. The Digital Planimetric Compiler is satisfactory for simultaneous compilation and digitizing of planimetry from orthophotographs. Future work on the instrument should consider the replacement of the bar and slider type coordinatograph with a free floating cursor type unit.

b. The unit complies with the technical characteristics.

c. Stereo viewing of supplementary films is awkward, especially for side overlap stereo models. Consideration should be given, in future work on the instrument, to widening the viewing station or handling stereo viewing in a different manner.

d. The unit would not be cost effective in quantity purchases, and reconfiguring the equipment to remove the supplementary viewer/projector from the unit should be considered.

SECTION	REPORT TITLE
20	DiCarlo, C., and J. Quick, Infrared Mapping of Liberia.

13. MULTISPECTRAL IMAGING SYSTEMS

ARTSYBASHEV, P. S., Study of the Spectral Brightness of some Landscape Elements for Interpretation of Ground Water on Aerial Photographs (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 209, June 1969, NTIS AD-692 647.

Author Abstract - This article presents experience in the study of the spectral reflectivity of some landscape elements (primarily vegetation and soils) which are ground water indicators and describes the use of these data for the hydrogeological interpretation of aerial photographs. The studies were made during 1958-1960 in the desert (Turkmenia) and semi-desert (Caspian Lowland). The method for interpreting ground water described in this paper was checked by making similar studies in the forest zone of the northwestern regions of the USSR. Particular emphasis was on study of the role of vegetation and soils as indicators of ground water, their relationship to the depth at which such water is found, mineralization of ground water and the regions in which it occurs. One section is devoted to an analysis of the different types of aerial film and light filters which can be used in such work and conclusions are drawn as to their applicability under different climatic, meteorological and other conditions.

BROOKE, R. K., Jr., A Single-Lens, Four-Channel Multiband Camera, (Report No. 3 in the ETL Series on Remote Sensing), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-ETR-74-4, November 1974, NTIS A008 351. (USAETL, Fort Belvoir, Va.)

Author Abstract - A single lens, four-channel multiband aerial camera was designed and fabricated for the U. S. Army Engineer Topographic Laboratories by the Boller and Chivens Division of the Perkin-Elmer Corporation. A multi-element beam-disperser with dichroic filters separates the incoming energy into four spectral bands, nominally blue, green, red, and near infrared, and images each on an individual 70-mm black and white film frame. The camera was subjected to laboratory, ground, and aerial tests to evaluate its performance characteristics. Although the camera did not meet all the performance objectives, particularly in terms of resolution and registration, it was judged adequate for most intended applications.

BROOKE, R. K., Jr., and T. C. Vogel, Multispectral Photography with a Single Lens, Four-Channel Aerial Camera, presented at the American Society of Photogrammetry Fall Convention, 10-13 September 1974. (USAETL, Fort Belvoir, Va.)

Author Abstract - The U. S. Army Engineer Topographic Laboratories (USAETL) is currently investigating possible military applications of multispectral photography, particularly as an instrument for the acquisition of terrain information and, incidentally, for the evaluation of camouflage materials. As a part of this program, a unique single-lens, four-channel aerial camera was designed and fabricated under contract to the Boller and Chivens Division of The Perkin-Elmer Corporation. The USAETL multiband camera uses a beam-dispersing system of dichroic filters to separate the incoming illumination into blue, green, red, and infrared spectral bands. The camera has been flown over a series of test sites that typify a variety of terrain and environmental conditions. It was also used in several camouflage evaluation experiments. Comparisons have been made between the multispectral data and conventional panchromatic, color and color IR imagery. Test results show promise for the use of multispectral techniques in gathering terrain information and camouflage detection.

DALKE, G. W., Multi-Image Correlation Systems Study for MGI - Phase I Technical Report, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., December 1967, NTIS AD 833 569. (The University of Kansas, Lawrence, Kansas)

Author Abstract - The purpose of this contract is to develop a clearer understanding of the capabilities and limitations of systems in which several images of the same scene must be combined for viewing and analysis. The investigation is organized according to the following phases:

I. Problem Definition

II. Experimental Investigation

III. Equipment Improvements

IV. Systems Analysis

This report describes the work accomplished during Phase I and is organized into the following sections which define the concepts, the variables involved, and the state-of-the-art techniques for multi-image systems. The sections also provide a lead into subsequent phases by describing the data, the data controls, the experiments, and the experimental equipment to be used.

1. The scope of the Phase I Investigation includes concept development, component part analysis, system element description, data base development, equipment description, and description of planned experiments.

2. Concept development and description forms a basis for an understanding of the multi-image mission. These concepts include those of interpretation cues; discrete and continuous spectrances; hue; true, virtual and false color; target and area identification problems; and various possible approaches to the processing problem. Derived parameters, parameter estimation techniques, types of interpretation problems and congruencing considerations are also among concepts discussed.

3. An organization chart showing major systems and theories clarifies the relationships among multi-image mission components. Specific concept tree branches receiving attention are sensors, congruencing systems, processing theories, data format conversions, displays and display recording techniques.

4. A nomenclature is established for the various possible subsystems of a multi-image processing system. Descriptions, applications, and limitations are given for eight of these subsystems.

5. A firm data base must be established if meaningful results and system evaluations are to be achieved. Ground truth recording methods are given, followed by descriptions of the selected test sites, descriptions of test site ground control, and examples of images from these test areas available for experimentation during Phase II.

6. Processing equipment available at the University of Kansas and the University of California at Berkeley is described. Schematics and system diagrams are included for equipment to be used in this contract.

7. A brief description of the experimental environment is followed by descriptions of currently planned Phase II experiments.

DUNKLE, R. V. and R. V. Gier, Spectral Reflecting of Certain Minerals and Similar Inorganic Materials, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TR 16/4, January 1954, NTIS AD-026 394.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Of particular interest to investigators in the problems of radiative exhange and over-all heat balances of the natural environment, is the emission characteristics of the different constituents of what is loosely termed the earth. Thus, the spectral reflectivity characteristics of minerals and associated materials is of prime importance. The following report is the result of a preliminary investigation of the spectral reflectivity of certain minerals and other similar materials.

EGBERT, D. D., Spectral Reflectivity Data: A Practical Acquisition Procedure, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., November 1970, NTIS AD 880 049L.
(Center for Research, Inc., University of Kansas, Lawrence, Kansas)

Author Abstract - In planning remote sensing missions with multiband photography in the visible and near infrared regions, few investigators have ready access to the spectral information needed to choose the appropriate filter combinations. If the mission is aimed toward mapping a specific type of target the optimum choice of filters will depend not only on this target's spectral characteristics but also on the background's spectral properties. However, these data are not generally available for target-background combinations. This paper describes a technique whereby one may inexpensively pre-test to determine the optimum filter combinations and the feasibility of such a multiband mission. The test provides multispectral reflectivity curves not only for the targets or categories to be identified but also for those backgrounds against which they are usually encountered. The budgetary requirement for the test involves only about two hundred dollars for equipment. This cost is an order of magnitude less than the least expensive spectrometer and yet the results have been shown to be comparable. The potential accuracy of this technique is ± 1.5% reflectance.

This procedure also incorporates a method for determining spectral reflectance as a function of solar altitude, incidence look angle, and azimuth look angle. This angular dependence of reflectivity can be significant and might be used as an aid in detecting certain targets. It was found that for one target-background pair (asphalt and grass) the contrast ratio can range from 2:1 to 0.5:1 under different angle conditions.

HANSON, D. S. and D. R. Morganstein, Analysis of Multispectral Scanner Data for Location of Sand and Gravel Deposits, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., January 1970, NTIS AD 705 673.
(The Bendix Corporation, Ann Arbor, Michigan)

Author Abstract - Data were collected with an 8-channel multispectral line scanner covering the UV, visible and near IR. A test site near Lake Charles, Louisiana, was chosen as representative of river delta terrain in which the target materials, sand and gravel suitable for engineering construction, could be easily located for ground truth. Digital samples of tape recorded video were computer analyzed by a factor analysis program. The results of the analysis identified three basic terrain types, one of which is associated with the target materials, and permits automatic classification at real data rates to map extended areas of similar terrain.

KASTEN, F., A New Table and Approximation Formula for the Relative Optical Air Mass, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TR 136, November 1964, NTIS AD-610 554. (USACRREL, Hanover, New Hampshire)

Author Abstract - A new table of the relative optical air mass as a function of solar altitude is computed from the air density profile of the ARDC Model Atmosphere, 1959, up to 84 km; refractive index of air at ground level equal to 1.000276 corresponds to air of 15 deg C and 1013.25 mb and to the wavelength 0.7 micron. This wavelength is more representative for the whole solar spectrum than 0.54 micron (peak of the visibility spectrum) because it divides the solar spectrum into 2 parts of equal energy. The new approximation formula contains constants which were calculated from the new tabulated values of the relative optical air mass as a function of solar altitude (deg) by successive approximation, applying the method of least squares to obtain each approximation. The values from this formula are in very good agreeement with the tabulated values. The deviation is less than 0.1 percent for solar altitude greater than 4 deg. The highest deviation, 1.25 percent, occurs at solar altitude equal to 0.5 deg. The formula can also be applied to the old Bemporad table and to the table of relative optical water vapor mass computed by Schnaidt (1938).

KNIPLING, E. B., Leaf Reflectance and Image Formation of Color Infrared Film, Remote Sensing in Ecology, P. L. Johnson, Editor, Athens Univ of Georgia Press, MP 227, 1969.

Author Abstract - False color aerial photography with Ektachrome Infrared Aero film has been found useful for distinguishing vegetation types and assessing plant vigor. However, considerable misunderstanding exists about the process of color formation on this visible- and infrared-sensitive film and about the way changes in leaf reflectance in these spectral regions account for differences in the color imagery of plant foliage. Healthy green leaves have a low visible and high infrared reflectance and characteristically appear bright red on color infrared photographs. Physiological disturbances to plants generally are accompanied by increases in the visible reflectance but the direction of change in infrared reflectance is quite variable. Thus, deviations from the red color on photographs are not always explained by a decline in infrared

reflectance. Disease, damage, and physiological stresses in plants influence the extent of red coloration by changing the geometry and density of foliage as much as by changing the reflectance characteristics of individual leaves.

LIND, A. O., An Evaluation of Multiband and Color Aerial Photography for Selected Military Geographic Intelligence in a Subtropical Desert Environment, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report 54-TR, January 1970, NTIS AD 707 429.
(USAETL, Fort Belvoir, Va.)

Author Abstract - The objective of the work included in this report was to evaluate multiband and color photography with several film/filter combinations for their application to information extraction for Military Geographic Intelligence.

Two studies were performed on aerial photography for which ground truth data was obtained in the Phoenix, Arizona, test area. One study concerned the derivation of terrain data from four film/filter combinations (Plus X with 47B, 58, and 25A filters; and Infrared with 89B filter). The second study was an evaluation of black-and-white, normal-color, and false-color imagery with regard to their information content.

Details for each type of film/filter combination are given as well as a summary of the findings.

LOHSE, Karl-Heinz, Investigation of Multiband Photographic Techniques, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., November 1965, NTIS AD 479 300L.
(Aeronutronic Division, Philco-Ford Corporation, Newport Beach, CA)

Author Abstract - A feasibility demonstration of photographic extraction techniques as applied to various multiband photographic acquisitions. The acquisition photographs represented photography from a 150-foot tower and from a 7000-foot mountain of targets selected for their military significance. Included are those tasks concerned with the handling of variables, as well as laboratory control experiments.

LUKES, G. E., Analytical Sampling of Multiband Photography, presented at the USAETL-ASP Workshop for Environmental Applications of Multispectral Imagery, Fort Belvoir, Va., November 11-13, 1975.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Analytical procedures have been developed that provide an automated technique for extracting data representing specified terrain locations from multiband aerial photography. Grounded in principles of analytical photogrammetry, this technique is called projective sampling. It vigorously accounts for camera orientation, position, and scale. It can incorporate corrections for atmospheric refraction, lens distortion, film deformation, and earth curvature. The results of projective sampling pointing accuracy experiments conducted on small-scale (1:450,000), non-metric, multiband photography are presented. The application of projective sampling to multiband/multidate photography for crop classification is discussed. The use of projective sampling with digital elevation data for landform classification and the potential for analytical control of hybrid pattern recognition systems is suggested.

MILLER, G. H. and D. W. Berg, An ERTS-1 Study of Coastal Features on the North Carolina Coast, Coastal Engineering Research Center, Fort Belvoir, Va., MR 76-2, January 1976, NTIS AD A022 236.
(CERC, Fort Belvoir, Va.)

Author Abstract:

Unenhanced imagery recorded by the multispectral scanner (MSS) of the NASA Earth Resources Technology Satellite (ERTS-1) was analyzed to determine how satellite imagery may be applied to specific coastal engineering problems. The study area is a segment of the North Carolina coast comprising Wrightsville Beach, Masonboro Inlet, Masonboro Beach, Carolina Beach Inlet, and Carolina Beach, which are areas of ongoing research by CERC. Analysis was supplemented by underflight imagery supplied by NASA and ground-truth data.

Several significant coastal features are visible in the ERTS-1 imagery. Among those are plumes of suspended sediment emerging from inlets, changes in water coloration possibly due to effects of temperature change, inlet bars and cape bars. In addition, morphological changes in selected coastal land features were determined by comparing ERTS-1 films obtained about 1 year apart.

Limited water depth penetration is afforded by examining the lower MSS spectral bands. Maximum penetration can be expected to measure in tens of feet, depending on the physical characteristics of ocean water. Although inadequate for deeper penetration, this capability is adequate for exposure of backshore and near-shore underwater features.

Image resolution capability is sufficient for observation of gross coastal features and processes but may not be adequate for viewing smaller features such as wave patterns, morphological features on beaches, and many engineering structures.

MOWER, R. D., The Discrimination of Tropical Land Use in Puerto Rico: An Analysis Using Multispectral Imagery, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., October 1971, NTIS AD 733 472.
(Center for Research, Inc., University of Kansas, Lawrence, Kansas)

Author Abstract - During the past decade, the technique of remote sensing has received considerable attention within the scientific community and outside of it as well. Many practical applications of remote sensing have been developed, and a great deal of research is now in progress. It seems appropriate that geographers should be actively engaged in the development and refinement of remote sensing techniques - techniques that must be designed by geographers if they are to be utilized as tools for geographic research.

At the present time, remote sensing does not represent a new information system, complete with hardware, software and know-how, capable of providing all of the data that geographers previously listed under the heading "potential uses of remote sensing in geography." Although remote sensing has not yet reached the level of capability predicted for it by early enthusiasts, it has shown considerable promise. This study is just one of many that was conceived and designed to bridge the gap between abstract theoretical concepts on one hand and user oriented products on the other.

O'BRIEN, H. W., et al, Red and Near-Infrared Spectral Reflectance of Snow, Proceedings of a Workshop, Operational Applications of Satellite Snowcover Observation, Waystation, South Lake Tahoe, CA, National Aeronautics and Space Administration, Wash, DC, MP 872, August 18-20, 1975.
(USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

O'BRIEN, H. W. and R. H. Munis, Red and Near-Infrared Spectral Reflectance of Snow, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 332, March 1975, NTIS AD-A007 732.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The spectral reflectance of snow in the range of 0.60 to 2.50 μm wavelengths was studied in a cold laboratory using natural snow and simulated preparations of snow. A white barium sulfate powder was used as the standard for comparison. The high reflectance (usually nearly 100%) of fresh natural snow in the visible wavelength declines rapidly at wavelengths near and beyond 0.80 μm, as the spectral absorption coefficients of ice increase. Aging snow becomes only somewhat less reflective than fresh snow in the visible region and usually retains a reflectance greater than 80%. In the near infrared, aging snow tends to become considerably less reflective than fresh snow. The rate of decline of near-infrared reflectance due to aging is strongly affected by the history of the snow during aging. Snow aged under certain conditions may retain 90% or so of its reflectance in the visible red, yet may be only about 10% as reflective as the original fresh snow beyond 2.2 μm. Several environmental factors such as ambient temperature and wind effects contribute to the variability in snow reflectance are discussed.

ROEDEL, R. K., Manual for Maintenance and Operation of the MB-1 Multiband Aerial Camera (Report No. 7 in the ETL Series on Remote Sensing), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-0040, January 1976, NTIS AD-A022 586.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This report describes the origin, operation, and maintenance of a one-of-a-kind, experimental, single-lens, multispectral camera and is to be used as the applicable manual for users of this camera.

TELEKI, P. G., CERC, Fort Belvoir, Va.; J. W. White, Photo Science, Inc., Gaithersburg, MD; and D. A. Prins, CERC, Fort Belvoir, Va.; A Study of Oceanic Mixing with Dyes and Multispectral Photogrammetry, Proceedings of the ASP Symposium on Remote Sensing in Oceanography, Lake Buena Vista, Florida, October 1973, NTIS AD 775 561.

Author Abstract - The possibility of studying coastal currents and turbulent mixing by remote sensing is investigated. In mixed regions, it is essential to identify the sources of constituent water masses, their rate of propagation and discharge. The spectral responses of water tracing dyes to various film-filter combinations were investigated under field and laboratory conditions. Preliminary results indicate that conservative tracers which are spectrally stable can be recorded isolated from others in b&w multispectral imagery, and can also be reconstructed in color composites, providing a label for water masses of varying origin.

VINOGRADOVA, A. I., Using Aerial Photography in Different Spectrum Intervals to Study Vegetation and Soils (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 182, 1969, NTIS AD-693 225.

Author Abstract - In recent years, in our nation there has been a significant increase in the number of specialists in different areas who make extensive use of aerial photography in their work. Along with broadening the sphere for using aerial methods, we can also clearly note a general move toward greater specificness in the technical and natural conditions of aerial photography. Various departments have ceased to be satisfied with the available finished materials from an aerial photographic survey which have been obtained for different purposes. They are working out their own requirements upon the conditions of aerial photography in terms of the survey scale, the type of film and the light filter, the focal length of the camera and the type of camera, as well as in terms of the season of photographing, and are conducting the corresponding aerial photographic surveys.

VOGEL, T. C., Capabilities of Multispectral Aerial Imagery for Military Geographic Information (MGI), Proceedings (Vol. 79) of the Society of Photo-Optical Instrumentation Engineers, Reston, Va., March 24-25, 1976.
(USAETL, Fort Belvoir, Va.)

Author Abstract - To meet Army requirements for a more efficient method of obtaining terrain and environmental data, the U. S. Army Engineer Topographic Laboratories (ETL) designed and fabricated a unique multispectral aerial camera. This experimental camera employs a single lens, a beam dispersing system, and dichroic filters to divide the reflected light energy into four broad spectral bands: Blue, green, red and near infrared. The resulting four spectrally separated images can be reconstituted into a number of displays using a four-channel, optical, additive color viewer. Over the past three years, the camera has been flown over the ETL remote sensor test areas to compare this system with conventional types of aerial photography for acquisition of MGI. During the test, multispectral imagery was obtained simultaneously with color, color IR, color negative and panchromatic emulsions. In addition, ground data was also acquired during the overflight to ascertain the validity of imagery derived data. The initial results of the comparison indicate that the multispectral imagery provides the image interpreter with a highly flexible imaging system and a number of advantages over conventional emulsions. The advantages include better determination of drainage channels, better shoreline delineation, and better recognition of different vegetation species.

VOGEL, T. C., R. K. Brooke, Jr., and G. Schwarz, Military Applications of Multiband Aerial Photography (Report No. 5 in the ETL Series on Remote Sensing), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0030, September 1975, NTIS AD B008 114L.
(USAETL, Fort Belvoir, Va.)

Author Abstract - In the continuing evaluation of remote sensor capabilities to provide Military Geographic Information (MGI), the U. S. Army Engineer Topographic Laboratories (USAETL) designed and fabricated a single lens, four-channel multiband aerial camera. The camera was used for camouflage detection and evaluation, target detection, and collection of specific elements of terrain data. For the Army, the multiband aerial camera provides the following capabilities: (1) color imagery without changing or augmenting present film processing (black and white) equipment or personnel training and skill levels; (2) aerial photography during a single overflight that is equal to at least three existing standard film types; (3) spectral enhancement of targets; and (4) continuous spectral sensitivity from 380 to 840 nanometers.

WHEELER, C. C. and J. F. Hall, Jr., Design and Fabrication of an Experimental Multiband Camera, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-71-28, December 1971, NTIS AD 894 868L.
(Boller and Chivens Division, The Perkin Elmer Corporation)

Author Abstract - An experimental multiband camera was designed and manufactured. Only one lens and shutter was used to eliminate problems caused by differences between lenses, differing exposures and boresighting errors. Four photographs are taken on four separate films, in blue, green, red and IR light. Color separation was achieved by the use of thin film reflecting coatings. Although the camera was not designed for military service, it will be adequate to demonstrate the feasibility of the system.

SECTION	REPORT TITLE
3	Magoon, O. T., and D. M. Pirie, Remote Sensing in the Study of Coastal Processes.
3	Teleki, P. G., and D. A. Prins, Photogrammetric Experiments on Nearshore Mixing and Diffusion.
5	Dunkle, R. V., J. T. Gier, Spectral Characteristics of Wet and Dry Snow Between 0^{o} and 60^{o} C.
6	Smith, M. H., Feasibility of Monitoring Flora Patterns and Sediment and Pollutant Dispersion of Water Bodies with 24-Channel Spectral Data.
9	Hecht, A. S., and J. S. Odell, Image Quality Analysis and Control of Color and Multiband Photography.

14. PATTERN RECOGNITION

LEIGHTY, R. D., A Logical Approach Toward Automated Terrain Pattern Recognition for Engineering Purposes, presented at the USAETL-ASP Workshop for Environmental Applications of Multispectral Imagery, Fort Belvoir, Va., 11-13 November 1975. (USAETL, Fort Belvoir, Va.)

Author Abstract - Automated pattern recognition techniques have predominantly exploited the statistical nature and the two-dimensional shape characteristics of photographic tone patterns. For a given terrain-related engineering problem, qualitative information is manually derived mainly from geomorphological inferences drawn from pattern analysis of surface configuration, and only secondarily from tone inferences. This paper outlines a logical approach toward automated terrain pattern recognition for engineer purposes. This approach models that used by the engineer terrain analyst to derive information from stereoscopic, multiband aerial imagery in solving his terrain-related problems. Predicate logic is used to formulate decision rules that operate on a matrix of terrain elevation data and data form multiband photography. The decision rules are implemented in boundary mapping algorithms for partitioning the terrain into information classes for engineering problems.

LEIGHTY, R. D., Optical Power Spectrum Analysis (OPSA) (Report No. 1, Recording Optical Spectrum Analyzer System Hardware), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-TR-74-11, May 1975, NTIS AD A016 131. (USAETL, Fort Belvoir, Va.)

Author Abstract - The optical spectrum analyzer hardware used in pattern recognition research at the Research Institute, US Army Engineer Topographic Laboratories, is discussed in detail. This system involves detection of signals by a segmented spatial frequency plane detector in a coherent optical system when selected portions of an aerial image are illuminated. These signals are then electronically processed and formatted for digital computer processing with pattern recognition software. It is anticipated that the system will lead to applications for automated information extraction from aerial imagery which include cloud screening, extraction of selected planimetric information, image quality analysis, and techniques for automated selection of image preprocessing requirements.

15. PHOTOGRAMMETRY

ACKERMAN, D. L. and M. A. Crombie, Computing a Line-of-Sight Using Digital Image Matching and Analytical Photogrammetry, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0027, March 1975, NTIS AD-A018 147. (USAETL, Fort Belvoir, Va.)

Author Abstract - This report presents a method for computing a line-of-sight by using digital gray shade data, analytical photogrammetry, and computer software. The computer program combines a digital image matching process with stereo-triangulation to produce a profile between the end points of the line. A 1,192 meter line-of-sight profile has been computed. The probability of computing an entire line in one program execution is low. This is due to matching problems in areas of sparse imagery and steep slopes. This experiment created more questions than answers. The questions involved patch size, pixel size, pixel spacing, computation time, computer memory, and quantization of the digital gray shade data. The profiling technique could be used for engineering jobs such as cut and fill, profiling for dam planning, volume determination of piles of earth from excavations, and profiling craters.

ANSON, A., Prototype Automatic Mosaicking System, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Report 17-TR, November 1963, NTIS 840 869L.
(USAEGIMRADA, Fort Belvoir, Va.)

Author Abstract - Report covers test and evaluation of Automatic Mosaicking System which is designed for preparation of controlled gridded photo-mosaics for which orientation elements have been determined. Tests were conducted to determine operational characteristics of prototype systems, to compare accuracy of rectification with attendant resolution for rectifier, and to compare accuracy of positioning with resolution for printer, as well as overall resolution for system. Block coverage of Arizona Test Area was used in tests. Photographs were taken from 20,000 feet with a KC-1 camera, and position determinations were made from Hiran and photogrammetric procedures. Report concludes: (a) Automatic Mosaicker is capable of producing controlled gridded photo-mosaics. (b) Accuracies are within range of those specified in AR 117-5, 2 February 1959. (c) Accuracy is dependent upon nature of orientation data which are used. (d) Time required for operation in producing a 1:100,000-scale mosaic of 55 aerial photographs is approximately one-seventh of that required for a completely manual operation. (e) Increased accuracy and greater resolution will result when improvements are made on Automatic Mosaicker. (f) With small amount of additional training, individuals with map compilation technique can produce successful mosaics.. (g) Periodic maintenance of Automatic Mosaicker is required by an electronic technician.

ANSON, A., Significant Findings of a Stereoscopic Acuity Study, Photogrammetric Engineering, Vol. XXV, No. 4, September 1959. (Research and Development Laboratories, Fort Belvoir, Va.)

Author Abstract - A study was performed under contract with the U. S. Army Engineer Research and Development Laboratories, by the University of Rochester Institute of Optics, New York. The comparison of operator stereoscopic acuity was made under a variety of viewing conditions chosen as representative of those found in present-day photogrammetric stereo-plotting instruments. Thirty observers performed 47,000 stereoscopic elevation readings from which comparisons were obtained. The results are given and some significant interpretations are made.

ANSON, Abraham, Color Photo Comparison, Photogrammetric Engineering, Vol. 32, No. 2, March 1966. (GIMRADA, Fort Belvoir, Va.)

Author Abstract - As the result of action by the Color Photography Committee of the American Society of Photogrammetry, panchromatic, color and Ektachrome IR photography of the same area were compared under essentially identical conditions. The study includes the identification and interpretation of drainage, vegetation, soils, and map features such as roads, railroads, and buildings. As a control, the same features were identified on the ground. In addition, the photointerpreters were required to identify 42 selected photo-points that appeared on the photographs. On the basis of the limited study, Ektachrome IR photography proved to be superior to color and to panchromatic photography for mapping, vegetation and drainage. Color photography was found to be superior to panchromatic and Ektachrome IR for mapping soils and culture.

ANSON, Abraham, The Stereoscopic Effect of Color, Photogrammetric Engineering, Vol. 33, No. 4, April 1967. (GIMRADA, Fort Belvoir, Va.)

Author Abstract - During a study for the development of Objective Color Sensors, experiments were performed at the U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency in order to determine the quantitative stereoscopic effect obtained from exaggerating the differential refraction of light frequencies in the visible spectrum. The exaggeration was obtained by the attachment of optical wedges to standard photographic cameras. This approach employs the physical property of the differential refraction of light frequencies in a pair of prisms to cause a visual stereo image in which the spectral elements are displayed in a relative parallax, apparent as Z-coordinates. The exposure of a group of color chips was projected through an optical wedge with the base toward the right side, then the wedge was rotated for the second exposure with the wedge base toward the left. The resulting dispersion

of the spectra in opposite directions created normal and color parallax from a single (monocular) camera position.

BALASUBRAMANIAN, N. and V. P. Bennett, Investigation of Techniques to Generate Contours from Stereo-Pairs, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0029, October 1975, NTIS AD-A019 132.
(The Institute of Optics, Rochester, New York)

Author Abstract - Detection of the regions of conjugate image coincidence between two transparencies through correlation forms the basis for automated stereo-compilation systems. In this report, a method of detecting the coincidence of conjugate images from a stereo pair of transparencies using heterodyned optical correlation techniques is described in detail. Other methods of coincidence detection, based on optical processing system concepts, are also proposed and demonstrated. The theoretical basis for each of these methods is described and the experimental results are presented to substantiate the basic concepts. A critical evaluation of these systems from the point of view of operational requirements is also presented.

BALDINI, A. A., Formulas for Computing Atmospheric Refraction of Objects Inside or Outside of Atmosphere, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Research Note No. 8, January 1963, NTIS AD 403 710.
(USAEGIMRADA, Fort Belvoir, Va.)

Author Abstract - Report presents derivation of new equations for determining changes in direction of a ray of light as it passes through the atmosphere from an object to observer. Equations here are applicable to objects inside or outside the atmosphere. Equations are also derived for obtaining topocentric distance of object as function of object's height and observed zenith distance.

BERNDSEN, C. E. and M. W. Onushco, The Business of Looking Down is Looking Up, presented at the American Society of Photogrammetry Meeting on March 12-17, 1972. (USAETL, Fort Belvoir, Va., and ACGS USAF, Forbes AFB, Kansas)

Author Abstract - The ultimate objective of every photogrammetrist is to recover the latitude, longitude, altitude and attitude of aerial mapping photographs. The ASQ-92 portion of the AN/USQ-28 mapping and geodetic surveying system installed in an Air Force RC-135A aircraft obtains and records all of these data in conjunction with every mapping photograph. The accuracy of these data permits the compilation of 1:50,000 scale Class A maps. The system has been tested and has been in use for nearly three years.

BODNAR, B. J., Analytical Aerial Triangulation, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., USAERDL Report No. 1510-TR, March 1958. (USAETL, Fort Belvoir, Va.)

Author Abstract - This interim report describes the studies and investigations accomplished in developing an effective analytical aerial triangulation system for military use. The work was performed from March 1954 to April 1957. Progress thus far includes development of a system for cantilever extension of ground control, preliminary investigations of its behavior and effectiveness through the use of fictitious photographic data, and a study of requirements for a more practical, general computational system. In addition, the report states requirements for effective instrumentation, available equipment and equipment under development, and test plans for evaluation of both equipment and methods. Investigations revealed that analytical methods offer an effective military system for aerial triangulation and target location with aerial photography. Analytical methods offer the following advantages over conventional methods: (a) greater adaptability for use with convergent photography and airborne data; (b) simplification of methods and equipment; and (c) higher accuracy. The process of selecting, marking, and measuring pass-points is the crux of a successful analytical system. Studies indicated that a general-purpose analytical procedure is required to remove the restrictions from the cantilever method and to gain full benefit from the analytical approach.

BROWN, D. C., Advanced Methods for the Calibration of Metric Cameras, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Final Technical Report, Part I, December 1968, NTIS AD 706 870.
(DBA Systems, Inc., Melbourne, Fla.)

Author Abstract - A new analytical approach to the problem of the accurate calibration of metric cameras is developed and specific applications are reported. The method permits an indefinitely large number of frames from a given camera to be reduced simultaneously, yet efficiently, to produce common parameters of the inner cone for all frames, as well as independent elements of exterior orientation for each frame. Because control points may be exercised repeatedly in a common reduction, very large sets of well distributed residuals can be generated from a relatively small set of control points (in principle, a complete and accurate calibration could be performed from as few as three control points). From such large sets of residuals empirical functions can be derived to account for persistent, unmodelled systematic error. In addition, it becomes feasible to establish the variation in the accuracies of the radial and tangential components of plate coordinates throughout the format and thus to establish appropriate empirical weighting functions for subsequent applications. The method is of universal applicability and encompasses (a) calibrations from aerial photographs, (b) calibrations from stellar photographs, and (c) calibrations from multicollimator photographs. Applied to stellar calibrations, the method leads to improved accuracies and convenience by completely doing away with conventional requirements for precise timing of the shutter and for stability of the camera throughout successive exposures. Applied to multicollimator calibrations, the method has far reaching implications concerning both the use of existing multicollimators and the design of future multi-collimators.

CLAVELOUX, B. A., Evaluation of High Precision SHORAN-Controlled Photography, U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., Report 1484-TR, June 1957.

Author Abstract - An evaluation and analysis of high precision Shoran (Hiran)-controlled photography to determine its accuracy and suitability for use in military mapping. Analysis of high precision Shoran-controlled photography of the Phase II Hiran Photographic Tests of 1952 was made by comparison of reduced Shoran distances and Shoran positions with corresponding photogrammetrically computed distances and nadir positions. Mean errors and standard deviations of Shoran distances and circular probable errors of Shoran positions were determined and all systematic errors were statistically isolated. Mapping accuracy

was determined by a series of engineering tests using Shoran-Multiplex procedures as outlined in ERDL Report 1168. Multiplex tests were conducted also to determine the accuracy of control point location when Hiran control point photography was employed. The primary conclusions were: (a) ninety percent of horizontal positions can be established with a relative accuracy of 16 ft., exclusive of overall positioning error, by Multiplex methods when Hiran control point photography is used; (b) Multiplex-mapping procedures as outlined in ERDL Report 1168 are suitable for use with high precision-Shoran-controlled photography; (c) synchronization and correlation of recorded airborne data is still a major problem and requires positive action to improve operational capability for handling Shoran data; and (d) the Hiran equipment is a precise navigational and surveying tool which will provide adequate photographic and horizontal control to satisfy most military mapping requirements.

COLCORD, J. E., K. Lund and M. Hussain, A Study of the Accuracy of Visual Planimetric Pointings to Photographic Edges with Different Characteristics, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-71-19, September 1971, NTIS AD 734 328.
(University of Washington, Seattle, Washington)

Author Abstract - The basic variations and parameters tested and discussed concern Mean Pointing Values in Relation to the Physical Edge, Precision of Pointing with Various Edges, and Mach Band Measurements. Most observers show greater consistency with a sharp edge target of high contrast. While the position obtained in a tangent pointing task varies with observer by almost 30 seconds of arc, most tend to a systematic bias with pointing to the bright field most common. Further observer variation is apparently psycho-physiologically dependent and various significantly with time. The influence of color is rather insignificant as again individual observers had large differences, however, a slightly better correlation and more pleasant working conditions were felt to occur in the yellow-green region of the spectrum. For grey edges, the yev proves to be a very adaptable instrument as results of 70% grey levels are not greatly different from the sharp edge, but pointings are generally into the grey region. Variable grey edges also cause pointing into the grey and if a point of inflection occurs the pointing is in this vicinity. For the standard deviations, the results vary from 5 to 20 seconds of arc, with the usual value in the order of 10 seconds of 1 m in a 12x comparator. Again the color is not significant and the values of σ for the observer are a rather constant value with time and physical conditions. For low contrast levels, the standard deviation increases, as one would expect, as does the difficulty of pointing. The Mach band location appears to play a significant role in the visual perception of the edge contours and, hence, affects the pointing accuracy and position.

CROMBIE, M. A., Mapping Camera Image Errors due to Star Camera Identification and Measuring Errors, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-RN-73-1, January 1973, NTIS AD 759 491.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This Research Note presents a completely general method for evaluating the performance of a mapping camera which is locked to one or more stellar cameras. Image errors in the mapping camera are expressed as functions of a variety of system errors which include star camera format size and shape, star camera focal length, star image identification and measuring errors, number of measured images, the attitude of the star camera with respect to the mapping camera, and, finally, the attitude of the mapping camera with respect to the local vertical.

CROMBIE, M. A., Semiautomatic Pass Point Determination Using Digital Techniques, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-0051, December 1975, NTIS AD-A026 082.
(USAETL, Fort Belvoir, Va.)

Author Abstract - A semiautomatic pass point determination method is analyzed using nine stereo scenes digitally extracted from 1:50,000 scale aerial imagery. The method proves to be feasible and the extension of the method to target determination and transfer from similar and dissimilar sensor records seems promising.

CROMBIE, M. A., Stereo Analysis of a Specific Digital Model Sampled from Aerial Imagery, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-0072, September 1976, NTIS AD-A033 567.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Approximately 160,000 points were matched over a digitized stereo model using correlation algorithms coded in FORTRAN for the CDC 6400. Each of the digitized stereo pair was represented by over 4 million pixels, which were measured on a micro-densitometer and stored on disc in the Image Processing Center at ETL. The matched point coordinates and the associated local coordinates were also stored on disc. The derived digital model will be used in the Interactive Processing Center to evaluate a variety of problems in digital image processing of stereo photography.

CROMBIE, M. A., Image-Processing Precision as Affecting Relative Orientation, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-RN-71-6, December 1971, NTIS AD 737 673.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Formulas which represent errors in relative orientation parameters determined by least squares are presented. The parametric errors are expressed as functions of format size, focal length, percentage of overlap, number of measured images, and the experimental error. The analysis pertains to vertical photography; a numerical example is provided.

ELASSAL, A. A., R. K. Brewer, G. Gracie and M. A. Crombie, MUSAT IV - Volume I - Final Technical Report, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-70-6, November 1970, NTIS AD 717 105.
(Raytheon Company, Equipment Division, Autometric Operation, Alexandria, Va.)

Author Abstract - An efficient, general analytical triangulation program for frame photography was developed and programmed in FORTRAN V for the UNIVAC 1108 computer. The program features a free formatting technique for ease of data input and offers a wide variety of input/output options to cover the needs of both research and production oriented users.

Preprocessing of image coordinates, including corrections for film deformation, radial and tangential lens distortion, and atmospheric refraction, is provided in several forms. Blunder and data editing features are incorporated, and diagnostic and error messages are given with each phase of the triangulation process.

A rigorous least squares adjustment with error propagation facility is provided to handle blocks of virtually unlimited size. The mathematical model, based primarily on the collinearity condition, can be constrained by range measurements between any two points in object space and by groups of points having equal elevation, as well as by conventional ground control. Data weighting is provided, whereby input parameter precision estimates dictate the influence the input parameters will have on the least squares adjustment. The solution of the normal system of equations is accomplished with the AUTORAY algorithm.

Recommendations are given for further development of the MUSAT IV program. Additional constraints, useful for special cases, are suggested, and a data management facility to dynamically expand bandwidth limitations of the computer configuration is recommended.

GRIFFIN, E. P., D. R. Barnes and J. E. Stilwell, Photogrammetric Applications to Field Artillery, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report 56-TR, March 1970, NTIS AD 870 951L. (USAETL, Fort Belvoir, Va.)

Author Abstract - The purpose of this report is to examine the potential of stereophotogrammetric techniques, equipment, and products for field artillery survey and point-positioning applications and to suggest possible basic operational concepts employing such devices. Should sufficient potential be indicated, it is intended that the report serve as a basis for the establishment of a military requirement supporting the assembly of photogrammetric equipment and the establishment of techniques suitable for field deployment.

Photogrammetry can be applied to the Artillery problem in many ways and with varying degrees of sophistication. To be effective, a facility should be designed specifically for Artillery applications and deployed organic to Artillery units. The facility, while not being overdesigned, should posssess characteristics commensurate with realistic accuracy, response-time, and mobility requirements. It is envisioned that the primary equipment components would be stereophotogrammetric devices in which stereomodels would be pre-set, at Division or Brigade level, and that survey points and target coordinates extracted as needed. Weapon and target coordinates, as well as any other points of interest, could be identified by verbal descriptions or by correlation against more recently acquired reconnaissance photography containing such points and their coordinates "read out" or computed. The advent of future real-time or near-real time photographic data acquisition systems providing reconnaisssance imagery directly to such a facility shows considerable promise and places added importance on its target positioning potential. The facility would also contain topographic product utilization aids that would facilitate greater exploitation of photographic inputs of various types as specialized topographic products such as orthophotos and orthopictomaps.

GOLDFISCHER, L. I. and R. Vesper, Automatic Stereo Perception of Aerial Photography by Means of Optical Correlation, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., December 1962, NTIS AD 406 363.
(GPL Division, General Precision, Inc., Pleasantville, NY)

Author Abstract - This is the final technical report on a study of Automatic Stereo Perception of Aerial Photography by Optical Correlation. It includes a discussion of the principles of optical correlation and the application to stereo measurements; a description of some potential stereo correlator instrumentations; a study of the behavior of the autocorrelation function as the sample size is reduced; a comparison of stereo measurements under three different conditions, and an investigation of improved configurations.

The principal result is that optical correlation is suitable for stereo measurements. It is felt that optical stereo correlators will ultimately prove superior to electronic versions because the bulk of the computation is performed in the compact optical front end.

HALBROOK, J. W., A Proposed Stereophotogrammetric System for Topographic Mapping from Photography Taken at Altitudes up to 100,000 Feet, U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., Technical Report 1518-TR, April 1958.
(USAERDL, Fort Belvoir, Va.)

Author Abstract - It is recognized that higher ceilings of aircraft will entail mapping for military purposes from photography taken above 50,000 ft. It is known that present day plotting equipment is not sufficiently precise to permit plotting of accurate large-scale military maps from photography taken at such altitudes. The system proposed as having a chance of meeting the requirements consists of convergent, 18-in. focal length, 9- by 9-in. format cameras with an optical projection plotting instrument to match. Magnification will be such that operator errors are smaller, percentage-wide. It is expected that the effect of reducing errors from all sources will result in sufficient accuracy to draw 20-ft. contours approaching national map accuracy standards from 100,000-ft. photography. It is concluded that: (a) it is possible to prepare topographic maps with 20-ft. contours from photographs taken at altitudes up to 100,000 ft., (b) the proposed system is expected to produce maps that will meet emergency accuracy standards and possible peacetime standards, and (c) the analytical method offers the best solution to the problem of triangulation.

HALLERT, K. B., Practical Tests of the Theoretical Accuracy of Aerial Triangulation, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Research Note No. 1, May 1962, NTIS AD 288 296.

Author Abstract - Report describes an experiment conducted to test effectiveness of method developed by the author for predicting accuracy of aerial triangulation by means of theoretical analysis. Method involves summation formulas of aerial triangulation, measured residual y-parallaxes in individual models, elevation discrepancies in scale transfer points, and general statistical procedures. Parallaxes and elevations were first corrected for known and specially determined regular (systematic) errors of fundamental operations (image coordinates of photographs, projection devices of instrument, and operator). Accuracy of corrections were determined as standard errors. Discrepancies between final photogrammetric coordinates and corresponding (true) geodetic coordinates in check points were determined and compared with theoretically predicted values of standard errors. Statistical methods were finally applied for test of significance of deviations between theory and practice. Agreement between theory and practice was found to be so good that the basic theory can be accepted. It was also concluded that further experiments are necessary, particularly for investigation of fundamental operations and sources of errors and discrepancies.

HALLERT, K. B., Investigation of the Geometrical Quality of the Relative and Absolute Orientation Procedures and the Final Results of the Photogrammetric Procedure, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Research Note No. 6, August 1962, NTIS AD 297 352.

Author Abstract - Report covers a theoretical investigation of the determination of the basic geometrical quality of the relative and absolute orientation procedure and the propagation of the errors from these operations to the final results of the photogrammetric procedure, including the elements of the exterior orientation. The geometrical quality is determined as standard errors from the standard error of unit weight of the basic data image coordinates, parallaxes, and model coordinates. The principle of compensation between the elements of the absolute and the relative orientations is applied. Comparisons between the geometrical quality to be expected from normal-angle, wide-angle, and superwide-angle photographs have been made. Conclusions: (a) The method of least squares and its laws of error propagation allow a well-defined theoretical determination of the geometrical quality to be expected in the final results of the photogrammetric procedure in terms of the standard errors of the y-parallaxes (b) the theoretical geometrical quality of the elments of the exterior orientation after double- and single-point resections in space can be determined in this way only; (c) the influence of the errors of the interior orientation must be

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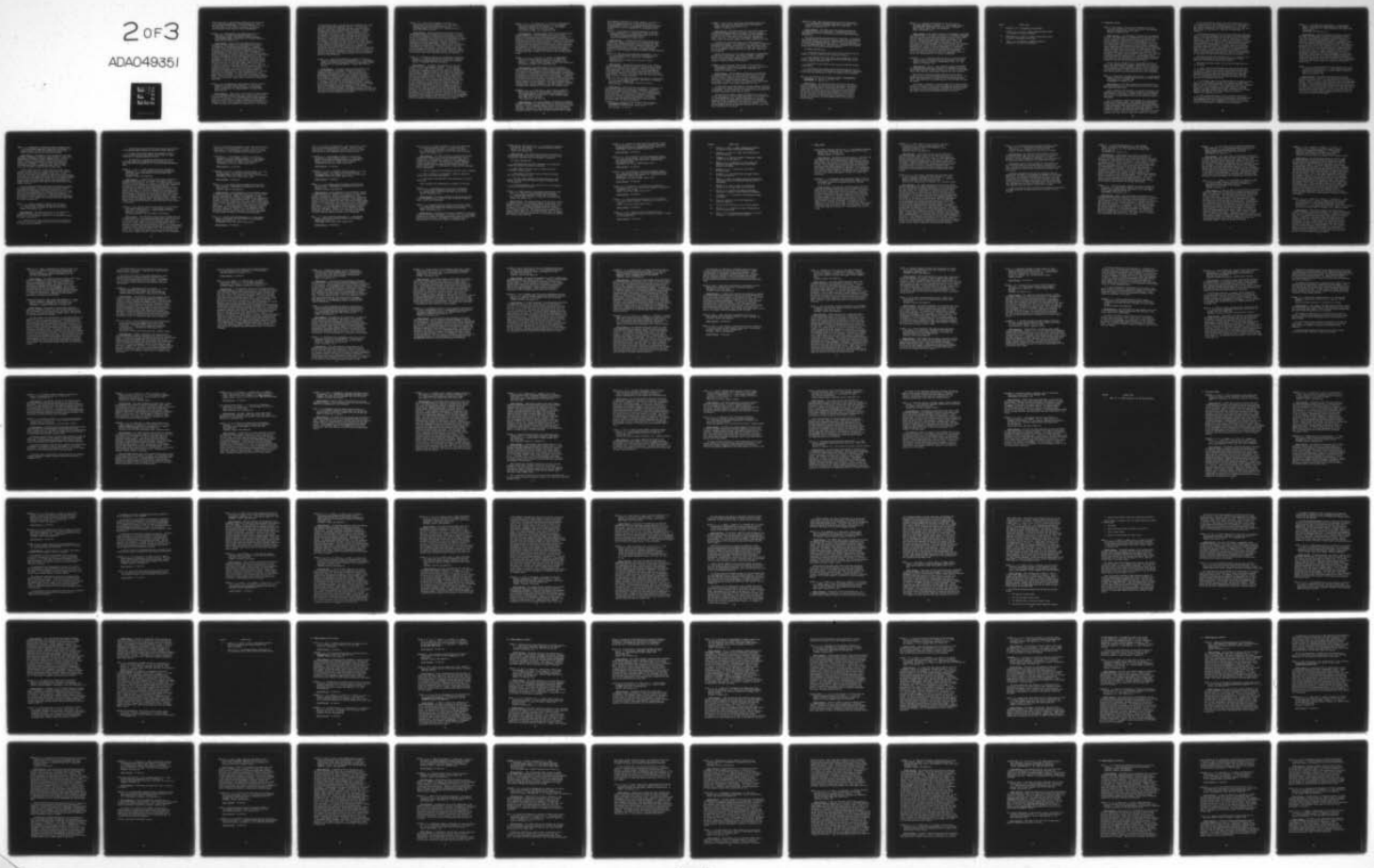

taken into account. A well-defined procedure for the calibration of the camera and photographs is therefore necessary. Also, here the method of least squares is of basic importance. And (d) tolerance limits for the relative and absolute orientations can be derived from the results of these investigations.

HALLERT, K. B., Determination of the Geometrical Quality of Comparators for Image Coordinate Measurements, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Research Note No. 3, August 1962, NTIS AD 297 137.

Author Abstract - Report covers development and practical application of test procedures to determine geometrical quality of comparators for image coordinate measurement. Procedures are founded upon grid coordinate measurements under operational conditions. First, basic principles for determination of accuracy of measurements have been treated under different assumptions concerning number and positions of test points. Principles of the method of least squares have been applied throughout, for determination of regular (systematic) errors of measured data as well as for estimation of a statistical value of irregular errors and for error propagation in functions of basic observations. Derivations have been made for grids, the given coordinates of which can be regarded to be errorless and for grids where certain regular errors are assumed to be present in the given coordinates. In the latter case no absolute scale can be determined and basic geometrical quality is in principle the precision. In a series of practical applications theoretical derivations have been used for testing a number of comparators of different types. Also some determinations of absolute scales have been performed. The lowest standard error of unit weight found in a comparator is of the order of magnitude 1 micron. Normal distribution tests of residuals have been performed throughout. From studies of residuals further regular errors may be detected and determined.

HALLERT, K. B., Investigations of Basic Geometric Quality of Aerial Photographs and Some Related Problems, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Research Note No. 4, August 1962, NTIS AD 297 351.

Author Abstract - Paper covers a series of tests of basic geometric quality of photographs obtained from aerial camera calibration in a multicollimator and from aerial photography obtained under operational conditions. The elements of interior orientation and most important regular (systematic) errors of image coordinates are determined as parameters in least squares adjustments, and remaining irregular errors of image coordinates are estimated as standard errors of unit weight.

In multicollimator tests, film and glass plate negatives were tested and compared concerning geometrical quality. A criterion for tangential distortion is developed, and some correlation effects between residual image coordinate errors are studied. A variation of geometrical quality (weight) of image coordinates was found, and some possible reasons for this variation are more closely investigated. The resolving power, thickness variations of films, and locations of developed grains within emulsion were studied. Some tests of diapositive printers were made. Paper concludes: (a) method of least squares proved to be of value for tests of basic geometrical quality; (b) after correction for certain regular errors, image coordinates from glass plates and from films proved to be approximately of same geometrical quality; (c) geometrical quality and resolving power were found to be correlated; (d) considerable variations of film thickness were found; (e) illumination intensity and exposure time seem to influence position of details in emulsion; and (f) basic geometrical quality of reduction printers and influence upon geometry from dodging procedures can be conveniently tested with derived methods.

HALLERT, K. B., Some Relations Between the Geometrical Quality of Topographic Mapping and Aerial Photogrammetry, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Research Note No. 7, August 1962, NTIS AD 298 737.

Author Abstract - This paper covers an investigation of the relation between the requirements on geometrical quality of topographic mapping according to U. S. National Map Accuracy Standards and the geometrical quality to be expected from aerial photogrammetric mapping procedures under different conditions. Basic geometrical prerequisites of photogrammetry are expressed in terms of the map requirements, primarily the contour interval. A "variable" C-factor has been determined where attention is paid to the geometrical quality of the fundamental operations, primarily the relative orientation. The results have been applied to different types of photography and plotting procedures. Under assumed conditions, convergent wide-angle photogrammetry is more effective than any kind of vertical methods. The results obtained are of particular value for the relation between required geometrical quality on one hand and economy and time consumption on the other.

HALLERT, K. B., Tests of Basic Geometrical Qualities of Photogrammetric Plotting Instrument, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Research Note No. 5, August 1962, NTIS AD 292 970.

Author Abstract - Some basic geometrical qualities of various photogrammetric plotting instruments were investigated. From tests of interior orientation of different projectors according to grid method, the basic geometrical quality of the reconstruction of bundles of rays was determined. Weight variations were determined, and the statistical distribution of residual errors was tested after comprehensive practical measurements. Numerical procedures for determination and adjustment of certain regular errors in projectors with mechanical projection were derived and applied to practice. Significance tests were applied. Through y-parallax tests, some relations between varying image resolutions and geometrical quality were investigated in a superwide-angle plotter. Similar tests were also applied to some other instruments with optical projection.

HALLERT, K. B., Geometrical Quality of Lunar Mapping by Photographic Methods, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Research Note No. 9, September 1962, NTIS AD 409 156.

Author Abstract - At present, the preparation of lunar maps requires the aid of photogrammetric methods. For such mapping as well as for all other kinds of mapping, it is most important to determine the geometrical quality to be expected in planimetry and elevation. Topographic mapping of the earth can be checked with ordinary geodetic methods, but for obvious reasons, the geometrical quality of lunar mapping can be checked in a similar manner only after man has landed on the moon. Therefore, the only possibility is to determine the basic accuracy of the photographic material and the operations to be used for the mapping, and then apply the laws of error propagation. In this paper, an attempt has been made to apply ordinary photogrammetric theory of errors and statistical methods for the determination of the final geometrical quality to be expected. Since no information is available concerning the accuracy of the image coordinates of the lunar photographs, the condition of the intersection of reconstructed rays has been used in a manner similar to that which has been successfully applied for the determination of the geometrical quality of ordinary aerial photography. The derived formula systems and the procedures used are of an approximate character but give information about the quality to be expected under different assumptions concerning the basic geometrical data.

HARTWELL, J. G., F. M. Loveless and G. E. Morduch, A Photogrammetric and Tracking Network Analysis Program, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Final Report ETL-CR-73-17, October 1973, NTIS AD 774 809.
(Old Dominion Systems, Inc., Gaithersburg, MD)

Author Abstract - The Photogrammetric and Tracking Network Analysis Program (FOTONAP) is a rigorous general purpose long arc multi-satellite orbit determination and parameter estimation program. It is capable of simultaneously processing photogrammetric observations collected by an orbiting camera along with observations from conventional ground based and satellite tracking systems. In addition to the recovery of satellite orbits, the program estimates for the relative location of ground points (observed by the orbiting camera), various camera error model parameters, the location of ground based tracking systems, plus an ensemble of error model parameters associated with the various tracking instruments. The entire program is written in FORTRAN and is operational under the SCOPE 3.3/3.4 system on the CDC 6600 computer system.

HARTWELL, J. G., J. J. Lynch and G. E. Morduch, A Photogrammetric and Tracking Network Analysis Program for the UNIVAC 1108 Computer, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0018, May 1975, NTIS AD-A024 229.
(Old Dominion Systems, Inc., Gaithersburg, MD)

Author Abstract - The Photogrammetric and Tracking Network Analysis Program (PHOTONAP) is a rigorous general purpose long arc multi-satellite orbit determination and parameter estimation program. It is capable of simultaneously processing photogrammetric observations collected by an orbiting camera along with observations from conventional ground based and satellite to satellite tracking systems. In addition to the recovery of satellite orbits, the program provides estimates for the relative location of ground points (observed by the orbiting camera), various camera error model parameters, the location of ground based tracking systems, plus an ensemble of error model parameters associated with the various tracking instruments. The entire program is written in FORTRAN and is operational on the UNIVAC 1108 computer system.

HOUBROUGH, G. L., G. A. Wood and A. J. Adler, Study of Panoramic-Metric Image Matching for Photogrammetric Instrumentation, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Final Technical Report, April 1965, NTIS AD 474 839L.
(Itek Corporation, Palo Alto, CA)

Author Abstract - This study encompasses the testing of electronic correlation techniques for the determination of feasibility of matching panoramic and metric photograph images differing considerably in angular resolution. The end of the application of this idea is to enhance the angular resolution of a metric photograph by superimposing high-resolution panoramic imagery upon the lower resolution metric imagery

and consequently constraining it to metric geometry. The results of tests, which were positive, were utilized in the definition of system requirements necessary to the implementation of this technique in photogrammetric practice. Two approaches to implementation were investigated to arrive at recommendations for future work in this context.

JONAH, M. V., The Systematic Correction and Weighting of Analogue Aerial Triangulation, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Final Report, September 1965, NTIS AD 476 273L.
(The Ohio State University, Columbus, Ohio)

Author Abstract - A complete electronic computer program using SCATRAN source language is developed for strip and block adjustments, utilizing basic analogue data output of strip triangulations. The program is specifically designed to accommodate the AN/USQ-28 system under development by the U. S. Air Force. The printout includes, in addition to the adjusted coordinates, the expected standard errors at all point coordinates, misclosure on control and some statistical analysis.

KARARA, H. M., Mono Versus Stereo Analytical Photogrammetry - Part I, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Final Report, February 1, 1967.
(Department of Civil Engineering, University of Illinois, Urbana, Illinois)

Author Abstract - The precision of point transfer in the monocular and the stereoscopic approaches in analytical photogrammetry is compared. Basically, the problem is the elimination of y-parallax, whether in the point tranfer device during dual transfer, or in the stereocomparator during measurement. The results seem to indicate that the precision of the monocular approach is significantly lower than that of the stereoscopic approach. This loss of accuracy is mainly due to the point marking system in the point transfer device used.

KARARA, H. M. and G. W. Marks, Mono Versus Stereo Analytical Photogrammetry - Part II, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Final Report, December 1967.
(Department of Civil Engineering, University of Illinois, Urbana, Illinois)

Author Abstract - The precision of point transfer in the monocular and the stereoscopic approaches in analytical photogrammetry is compared. Basically, the problem is the elimination of y-parallax, whether in the point transfer device during dual transfer, or in the stereocomparator during measurement. The results of this investigation indicate that the error of point transfer in the monocular approach is significant. The effect of this error decreases the precision of the parallax obtainable through the monocular approach significantly below that obtainable through the stereoscopic approach.

LIVINGSTON, R. G., A History of Military Mapping Camera Development, Photogrammetric Engineering, Vol. 30, No. 1, January 1964.
(USAEGIMRADA Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

O'CONNOR, D. and P-F Chen, A New System of Measurement Using Sensor Arrays, presented at the American Society of Photogrammetry Meeting, 7-12 March 1971, Washington, DC. (USAETL, Fort Belvoir, Va.)

Author Abstract - The dynamic theory of vision offers a basis for explaining how a comparatively gross network of retinal receptors is capable of performing visual acuity tasks such as photogrammetric settings with a precision which is much finer than the smallest retinal receptors. The involuntary eye movements, combined with complex neural interactions, appear to be largely responsible for this.

A sensing array system which makes use of these concepts has been designed and tested. The introduction of a mechanical or electronic perturbation has enabled the position of a light-point image on the array to be determined with a resolution 20 times finer than the size of an array element. Relative positions of light-point images have been determined.

Possible applications of array sensing techniques in photogrammetry and metrology are considered. The system is capable of detecting position, area, shape, and velocity, and may provide a substitute for film in stellar cameras, automatically yielding a real-time readout of stellar and satellite coordinates.

O'CONNOR, D. and Pi-Fuay Chen, Applications of Sensing Arrays to Photogrammetry and Metrology, presented at the American Society of Photogrammetry Meeting, 7-12 March 1971, Washington, DC. (USAETL, Fort Belvoir, Va.)

Author Abstract - The performance and function of the human eye are reviewed from the point of view of the dynamic theory of vision. The theory offers a basis for explaining how a comparatively gross network of retinal receptors can be used for discriminating tasks many times finer than the individual receptors. The involuntary eye movements of tremor, flick and drift, combined with complex neural interactions, appear to be largely responsible for this.

A sensing array system which makes use of these concepts is devised. In this electronic system, "perturbation" corresponds to the involuntary eye movements. A zero sensing error is obtained by the introduction of an optimal perturbation signal into the system.

The sensing array system is capable of detecting area, position, velocity and shape of a moving object-image either in a two-dimensional or a three-dimensional form. Possible applications of the array sensing techniques to photogrammetry and metrology are considered. Advantages of the techniques over the conventional array methods are given. Extensions of the idea of the future are suggested. Finally, the relationship between the suggested techniques and the state-of-the-art of electronics is discussed.

NORVELLE, F. Raye, Tests and Evaluation of the AS-11A Stereoplotter, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report 50-TR, November 1969, NTIS AD 870 695L. (USAETL, Fort Belvoir, Va.)

Author Abstract - This report covers the engineering tests and evaluation of the AS-11A Stereoplotter, an instrument designed for map compilation and aerial triangulation with both frame and panoramic photographics.

The engineering tests were designed, for the most part, to determine the inherent accuracy of the AS-11A. However, some tests were performed using typical photographic materials whose distortions as opposed to AS-11A accuracy, dominated the final results. These tests were performed to provide "experience tables" from which one can predict AS-11A product accuracy when using typical photographic materials.

The report concludes that:

a. The internal accuracy of the AS-11A is equal or better than the geometric fidelity of most precision cartographic cameras.

b. Given adequate 6-inch focal length, frame photography, 20-foot contours could be drawn from 60,000-foot photos and would meet Class A accuracy standards using the AS-11A.

c. The AS-11A is more versatile than previously developed analogue stereoplotters.

d. The concept of the computer-controlled stereocomparator provides a satisfactory instrument for accommodating frame and panoramic photographs or any other type photography for which the computer can be programmed.

ROOS, M., Variscale Stereo Point Marking Instrument, Photogrammetric Engineering, Vol. 33, No. 11, November 1967. (USAEGIMRADA, Ft. Belvoir, Va.)

Author Abstract - The Variscale Stereo Point Marking Instrument fills in the special need for accurate point marking at high operation speeds on photographs with different scales and formats. The results of engineer tests show that: no visible error exists in the marking system; that calibration errors are in proportion to magnification; and that the scale ratio between two photographs of similar quality and resolution seems to have no effect on the accuracy of parallax removal. The tests also show that apparent image motion as seen by the operator must have a sufficient speed range to allow accurate parallax removal.

ROSTON, J. P., Equipment and Techniques for the Utilization of Convergent Photography in Mapping, U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., Technical Report 1583-TR, August 1959, NTIS AD 226 689. (ERDL, Fort Belvoir, Va.)

Author Abstract - This report summarizes the development of equipment and techniques for the utilization, in mapping, of convergent photography taken with a camera installation consisting of two 6-inch focal length precision mapping cameras tilted approximately 20 degrees from the vertical, fore and aft respectively, in the line of flight. The benefits or disadvantages of convergent photography are compared with those of vertical photography. The report concludes: (a) convergent photography has a higher vertical accuracy potential and about the same horizontal accuracy as vertical photography; (b) convergent photography is suitable for base-plant operations and should be fully exploited at the Army Map Service, especially during peacetime; and (c) conditions are seldom such that field topographic units can realize the inherent benefits of convergent photography.

UNVERFERTH, J. E. II, Analytical MUSAT Evaluation of AN/USQ-28 SHIRAN-Controlled Aerial Photography (70-105), Proceedings, 36th Annual Meeting of American Society of Photogrammetry, March 1-6, 1970. (USAETL, Fort Belvoir, Va.)

Author Abstract - The U. S. Army Topographic Command (USATOPOCOM) has completed a photogrammetric evaluation of 20 AN/USQ-28 controlled aerial photographs and the MUSAT program using that data in three modes--single plate resection, single model resection, and strip resection.

When analyzed according to flight direction, the test results indicated a bias in the USQ-28 SHIRAN-determined nadir positions. The USQ-28 system requirement of 24-foot accuracy for positioning photo nadirs, when operating in the SHIRAN mode, was fulfilled when this bias was removed.

All 20 nadirs, regardless of the MUSAT mode used to determine these, were well within the 41-foot horizontal triangulation accuracy required for Class A, 1:50,000 scale mapping. USATOPOCOM has therefore planned operational tests to determine whether the map accuracy standards can be met using USQ-28 system determined nadirs as control.

SECTION	REPORT TITLE
7	MacAnally, R. B., Holography and Stereoscopy.
7	Kurtz, M. K., Jr., et al, Study of Potential Applications of Holographic Techniques to Mapping.
8	McCrickard, J. T., and G. H. Glaser, Stereoscopic Terrain Display for Measurement Applications.
18	Vogel, T. C., An Analysis of LANDSAT Systems for Cartographic and Terrain Information.

16. PHOTOGRAPHIC SYSTEMS

ANSON, A., Developments in Aerial Color Photography for Terrain Evaluation, presented at the American Society of Photogrammetry 34th Annual Meeting, March 10-15, 1968.
(USAETL, Fort Belvoir, Va.)

Author Abstract - The development of hardware for the employment of aerial color photography is proceeding more rapidly today than in the past to keep pace with the realization of the potential gain in terrain information. Manufacturers of photographic film in the United States have produced 9-1/2 inch wide Aerographic films on an Estar base (Eastman Kodak) and a Gafstar base (General Aniline and Film Corporation). High performance, precision aerial cartographic cameras manufactured by Fairchild, Wild Heerbrugg and Zeiss companies produce photographs which are corrected for a wide range of the visible spectrum in color reversal films as well as color negative films. Plotting equipment, not originally designed to accept aerial color photographs, for example, the dichromatic plotters, are being modified to enable stereoscopic viewing in color. New equipment such as stereocomparators are now designed for corrected viewing illumination. Light sources for existing plotters are being modified to take full advantage of the wide spectrum captured on color films.

The most obvious information gap is the optimum utilization of aerial color photography which requires special emulsions, precise cameras and special viewing equipment. Several tests in which aerial color photography supplied unique information for terrain evaluation are discussed in detail as well as the need for a set of standards which can be applied to the acquisition of aerial color photography.

ANSON, A., Feasibility of Objective Color Systems, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., September 1964.
(USAEGIMRADA, Fort Belvoir, Va.)

Author Abstract - This report describes the experimentation for determining the feasibility of objective sensing of color for manned space geoscience application.

Several approaches were explored in the research performed in the implementation of this task. Literature listed in the bibliography, which includes 17 international patents (1) was reviewed to avoid duplication of previous efforts in the field of optics and spectral measurements.

The first approach involved the development of a small spectrum analyzer and tristimulus sensor. The spectrum analyzer employed the principle of passing white light reflected from a sample through a wedge interference filter, then comparing its reflectance to that of a reflecting standard. By repetition of the above procedure in small increments, a spectral curve was generated for the sample in percent reflectance vs wave length of light. Comparison with Federal standards 595 curves served as comparison standards for evaluation.

In the second approach, three filters were fabricated for use in a tri-stimulus sensor. The transmission of the filters duplicated the tri-stimulus values of the CIE standard observer (2). The filters were used with incandescent light and photovoltaic barrier layer cells. Both systems are described by K. Robertson, Co-investigator, in Appendix II.

A third approach explored was in the color stereo-effect experiment which required the attachment of optical wedges to standard photographic cameras. This approach employed the physical property of differential refraction of light frequencies in a pair of prisms causing a visual stereo image in which the spectral elements were displaced in a relative parallax, apparent as "Z" coordinates. The method described employed the exposure of two photographs of a group of color chips through an optical wedge, with the base of the wedge toward the lens and the wedge angle toward the right, then rotated for the second photograph toward the left. The resulting diffraction of the spectra were in opposite directions, thus both normal and color parallax were created from a single (monocular) camera position. Details of the experiments and the hardware designed during experimentation are presented.

Multispectral experiments performed with Dr. R. N. Colwell at the University of Berkeley, for the National Aeronautics and Space Administration Photography Team, are also discussed.

Among the conclusions reached from this group of experiments are the following:

1. Small, hand carried, reasonably accurate, spectrum analyzers for the visible, possibly near ultra-violet and near infrared areas can be built. Review of the classified image intensifier work now in progress (Reference 3) shows that they can operate with high light gains and, by including their own illuminant, be used in darkness. It is also probable that they can yield emission spectra if a spark generator is included with the device.

2. Tri-stimulus sensors can be made portable and reasonably accurate. Their value is diminished since they yield chromaticity rather than spectra. Based on the foregoing work, an additional approach is suggested which merits full investigation. This concept envisions a TV type sensor with a special purpose computer which computes an algorithm capable of assigning objective color values to the sensor field viewed, despite a wide range of fluctuating illuminating conditions (Appendix III) References (4, 5 & 6).

3. Color stereo-effect sensors do not presently seem realistic in that the parallaxes are about the same magnitude as the random errors. This phenomenon constitutes a dramatic visual effect and could have other applicability, such as enhancement of visibility and the recognition of colored objects in unfamiliar visual environments.

BENTON, J. R., Low Light Level Photography, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Technical Report 32-TR, August 1966, NTIS AD 642 167.
(USAEGIMRADA, Fort Belvoir, Va.)

Author Abstract - This report presents an analysis of passive, low light level photographic systems using topographic cameras. This analysis was performed to evaluate the applicability of low light level photography to topographic mapping. A theoretical expression for the illumination threshold of a photographic system capable of producing photographs acceptable for map compilation at 1:50,000 and with 100-foot contours was derived. The theoretical expression was in fairly close agreement with an empirical formula developed at the Air Force Avionics Laboratory, Wright-Patterson Air Force Base, Ohio. The present technology-limited illumination threshold was calculated. Report concludes: (a) Present-day technology would permit the design and development of a twilight photographic system capable of taking photographs 30 minutes after sunset or before sunrise, (b) a practical moonlight photographic system would require that the present technology-limited illumination threshold be reduced by a factor of 40, and (c) a new film-developing process now under test may lower the illumination threshold by a factor of 10.

BROOKE, R. K., Jr., Total Optical Color System (Report No. 2 in the ETL Series on Remote Sensing), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-ETR-74-3, June 1974, NTIS AD A001 464.
(USAETL, Fort Belvoir, Va.)

Author Abstract - An unconventional photographic technique developed by Technical Operations, Incorporated, was evaluated for possible applications to U. S. Army Engineer Topographic Laboratories' programs. Areas of interest were aerial acquisition, image enhancement and display, color separation, map reproduction and data storage and retrieval. A special camera/viewer system was designed under Contract No. DAAK02-70-C-0135 and tested for a number of the above applications. The test results indicate applicability for aerial acquisition and enhancement and display; however, conclusive evidence verifying the utility of the technique requires equipment specifically directed at the aerial acquisition requirement.

BYBEE, J. E., Replacement of Photographic Imagery Equipment (RPIE), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0038, January 1976, NTIS AD-B010 398L. (Bendix Research Laboratories, Southfield, Michigan)

Author Abstract - Development has been completed on a new high-resolution, high-speed, large-format image restitution system called Replacement of Photographic Imagery Equipment (RPIE). The RPIE combines features of low resolution, high-accuracy photos with features of high resolution photos to obtain a high-resolution, high-accuracy orthophoto. It provides significantly greater resolution than previous orthophoto printers, prints at faster rates, and can handle a larger variety of format sizes.

The RPIE, which consists of a modified AS-11B-1 viewer unit, a new optical printer unit, and a single digital controller, normally produces the high resolution orthophoto in two steps. In the first step, the viewer unit automatically measures the input panoramic (pan) photo, using the geometrically accurate, low-resolution orthophoto (or the original frame photo) for control; and in the second step the optical printer uses the pan photo and the viewer measurements to produce the new orthophoto, which combines high resolution with high geometric accuracy.

Tests of system performance showed that the RPIE meets or exceeds all system requirements. The output resolution exceeds 100 lp/mm, the orthophoto image quality approaches the quality of a high-definition aerial photograph, the typical position error is less than 40 μm, and the average output rate is greater than 45 mm^2/sec. This performance considerably exceeds that of competing orthoprinters. The system can be readily modified to achieve even better performance. Most notable, certain changes could increase the system's output rate by a factor of almost two.

EASTES, J. W., Image Enhancement by Chemical Intensification, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0014, May 1975, NTIS AD A012 791. (USAETL, Fort Belvoir, Va.)

Author Abstract - This report covers the use and evaluation of a quinone-thiosulfate chemical intensifier to improve image characteristics on photographic negatives of low density and contrast. The report concludes that:

a. Apparent emulsion speeds of aerial films can be increased by a factor of as high as two with quinone-thiosulfate intensification as a post-processing treatment.

b. Quinone-thiosulfate intensification may improve the resolution of low density negative imagery, but not that of normal negatives.

c. As both a contrast and emulsion speed enhancing process, quinone-thiosulfate may greatly improve the usefulness of imagery to be used with image data-extraction devices.

d. The opportunity is presented, through intensification to save unique images with inadequate contrast and density, and to tailor densities and contrasts to fill a variety of human and machine needs.

JOHNSON, P. L. and T. C. Vogel, Evaluation of Forest Canopies by Photography, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 253, October 1968, NTIS AD-680 182.
(USACRREL, Hanover, New Hampshire)

Author Abstract - A technique for evaluating forest canopies was developed based on the use of a divergent lens system to obtain hemispherical photographs of tree crowns. The photography was processed from 35 mm film and enlarged as a silhouette, and the light transmission was measured with a specially fabricated macrodensitometer. It is concluded that the amount of forest canopy can be expressed as canopy closure index (CCI) at a precision of approximately 5 percent. It is shown by application to a variety of problems in diverse geographical areas that this technique can be used for measuring both temporal and spatial changes in the canopy, for estimating the shade light climate, and specifying the probability of target detection through a canopy. Data are presented to analyze changes caused by explosions, radioactivity, growing season, and vegetation types. The geometry of gaps in tree crowns is discussed and the nature of shade light quality under forests is illustrated.

LESINSKI, L. and P. Mueller, Design and Fabrication of a 70 Millimeter Interference Imaging System, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-71-8, March 1971, NTIS AD-884 155L.
(Technical Operations, Inc., Burlington, Massachusetts)

Author Abstract - The Interference Imaging System provided under this contract consists of a 70 mm format Hasselblad camera modified to accept a tricolor grid, and a reconstruction multispectral viewing system. This system displays imagery in color by recording several bands of the spectrum on a single frame of black-and-white photographic film by employing interference gratings and spectral filters. The system provided is based on similar systems designed and developed by Technical Operations, Incorporated, designated Total Optical Color. The Total Optical Color process uses an appropriately designed tricolor grating mounted in the film plane of a camera to provide a spatial coding of color information

on film. The coding is accomplished in such a way that the original color scene can be reconstructed in a viewer. Since this color reconstruction is accomplished by inserting filters in the viewer, false coloring or color enhancement may be readily obtained.

LIVINGSTON, R. G., The Attainment of Quality in the Military Development of Airborne Mapping Systems, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., TN 65-6, NTIS AD 815 307.
(USAEGIMRADA Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

LIVINGSTON, R. G. and C. E. Berndsen, The Aerial Camera, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., TN 64-1, NTIS AD 815 305.
(USAEGIMRADA Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

MARLAR, T. K., J. N, Rinker, Small Four-Camera System for Multi-Emulsion Studies, Photogrammetric Engineering, November 1967, 33(11), MP 278.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Aerial photography, with simultaneous exposure of different film/filter combinations, has proven to be very useful in photo interpretation. However, such photography is often expensive and beyond the facilities and budgets of many laboratories. For some of our work in environmental analysis, it was necessary to assemble a relatively inexpensive, small, four-camera airphoto system. The set has been successfully used on projects in arctic and temperate regions. It is light-weight, motor-driven, and has a self-contained power supply. It has a wide range of readily available accessories and features rapid interchangeability of film magazines, lenses, filters and viewfinders. The set is not only suitable for aerial photography (vertical and oblique) but is also easy to disassemble to provide hand-held cameras for ground control photography.

QUICK, J. R., Aerial Flashlight Photography, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va.
(USAEGIMRADA Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

on film. The coding is accomplished in such a way that the original color scene can be reconstructed in a viewer. Since this color reconstruction is accomplished by inserting filters in the viewer, false coloring or color enhancement may be readily obtained.

LIVINGSTON, R. G., The Attainment of Quality in the Military Development of Airborne Mapping Systems, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., TN 65-6, NTIS AD 815 307.
(USAEGIMRADA Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

LIVINGSTON, R. G. and C. E. Berndsen, The Aerial Camera, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., TN 64-1, NTIS AD 815 305.
(USAEGIMRADA Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

MARLAR, T. K., J. N, Rinker, Small Four-Camera System for Multi-Emulsion Studies, Photogrammetric Engineering, November 1967, 33(11), MP 278.
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Author Abstract - Aerial photography, with simultaneous exposure of different film/filter combinations, has proven to be very useful in photo interpretation. However, such photography is often expensive and beyond the facilities and budgets of many laboratories. For some of our work in environmental analysis, it was necessary to assemble a relatively inexpensive, small, four-camera airphoto system. The set has been successfully used on projects in arctic and temperate regions. It is light-weight, motor-driven, and has a self-contained power supply. It has a wide range of readily available accessories and features rapid interchangeability of film magazines, lenses, filters and viewfinders. The set is not only suitable for aerial photography (vertical and oblique) but is also easy to disassemble to provide hand-held cameras for ground control photography.

QUICK, J. R., Aerial Flashlight Photography, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va.
(USAEGIMRADA Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

REED, R. K. and J. N. Rinker, Evaluation of Color Test Photography for Military Geographic Analysis - A Literature Review, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-TR-70-6, July 1970, NTIS AD 884 356L. (USAETL, Fort Belvoir, Va.)

Author Abstract - This report provides an annotated bibliography of available literature on color aerial photography and closely related topics. Approximately 175 articles were reviewed and the findings of various authors were summarized. The bibliography is divided into two sections. The first section contains references listed by category and the second section contains abstracts of papers listed by author. The following is a summary of the advantages of color photography:

1. Color is accepted for photogrammetric and other types of mapping.

2. Color is superior for oceanographic, geologic, geographic, forestry and soils science applications.

3. Color reduces time required to train interpreters and reduce field costs.

Other advantages and disadvantages are presented in the report.

ROBERTSON, K. D., Instrumentation for Color Aerial Photography, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-RN-70-10, May 1970, NTIS AD 710 961. (USAETL, Fort Belvoir, Va.)

Author Abstract - This report describes the design and operation of two instruments built to provide a means for making an empirical study of color aerial photography.

ROEDEL, R. K., Controlled Color for Contact Printing Aerial Imagery, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Special Report ETL-TR-72-4, April 1972, NTIS AD 747 340. (USAETL, Fort Belvoir, Va.)

Author Abstract - This report covers tests of methods for recovering ground colors in aerial photographs. The results of trial and adjustment procedures are compared with those where neutral panels and other images were utilized for control. Measurements of integrated colors of photographs were also tested as a means of correcting colors.

SCHWARZ, Gunther, Agfa Contour Film, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-TR-73-1, May 1973, NTIS AD 913 269L.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This report covers the test to determine the characteristics and applications of Agfa Contour Film in the field of topographic mapping and military geographic information.

The report concludes that:

a. The Agfa Contour Film offers advantages over conventional photographic methods of equidensity isolation.

b. Agfa Contour Film can be used for contour extraction from UNAMACE linedrop outputs.

c. Agfa Contour Film cannot be used to enhance the present-day, radar-interferometer lines.

d. The color-coded, equidensity display produced with Agfa Contour film shows up details which are subtle or hidden on the original negative.

e. For edge enhancement, Agfa Contour Film is a simple method of producing high-quality outputs.

SPRIGGS, R. M., Modification of a Cartographic Mapping Camera from Type T-11 to Type KC-4B (with Automatic Exposure Control), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-TR-71-1, June 1971, NTIS AD 887 878L.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This report presents the modifications required to convert a Type T-11 Aerial Mapping Camera to a Type KC-4B. The Metrogon 6-inch f/6.3 lens was replaced with a Geocon 16-inch focal length f/5.6 lens. The Model B-2 Rapidyne shutter was replaced by a Model E-3-3 which is tripped electrically by "A" and "B" pulses from a separate control box. The vacuum platen was reworked for a flatness within 0.0002 inch over the entire format area. An Automatic Exposure Control (AEC) was incorporated to keep the exposure constant with changing light conditions.

SPRIGGS, R. M., Correlation of Data from Various Methods of Aerial Camera Calibration, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va. (USAEGIMRADA Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

SPRIGGS, R. M., The Calibration of Military Cartographic Cameras, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Technical Note 66-2, NTIS AD 489 208.
(USAEGIMRADA Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

SPRIGGS, R. M., The Calibration of Military Cartographic Cameras, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Technical Note 66-2, Addendum No. 1, NTIS AD 814 108.
(USAEGIMRADA Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

SPRIGGS, R. M., Considerations in the Design and Production of Cartographic Lenses, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., TN 68-2.
(USAETL Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

SPRIGGS, R. M., Photo Contrast Considerations for Aerial Mapping, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., TN 68-1.
(USAETL Field Office, WPAFB, Dayton, Ohio)

Author Abstract - No abstract.

SPRIGGS, R. M. and J. Rankin, Air Force Calibration Facility, presented at the ACSM-ASP Technical Conference at Denver, Colorado, on 7-10 October 1970.

Author Abstract - No abstract.

SECTION	REPORT TITLE
9	Hecht, A. S., and J. S. Odell, Image Quality Analysis and Control of Color and Multiband Photography.
9	Leighty, R. D., and G. E. Lukes, Cloud Screening from Aerial Photography.
9	Thompson, L. G., The Use of Edges of Photographic Images as Specifies of Image Quality.
10	McVey, E. S., E. A. Parrish, Jr., and G. Cook, The Application of Image Sensing Arrays to Metrology, Detection and Mapping.
13	Brooke, R. K., Jr., A Single-Lens, Four-Channel Multiband Camera.
13	Knipling, E. B., Leaf Reflectance and Image Formation of Color Infrared Film.
13	Vogel, T. C., and L. P. Murphy, Evaluation of Camouflage from Reconnaissance and Experimental Multiband Aerial Photography.
13	Wheeler, C. C., and J. F. Hall, Jr., Design and Fabrication of an Experimental Multiband Camera.
15	Baldini, A. A., Formulas for Computing Atmospheric Refraction for Objects Inside or Outside of Atmosphere.
15	Livingston, R. G., A History of Military Mapping Camera Development.
19b	Anson, A., Status of Aerial Color Photography in Government Agencies.
19c	Forcasting Trafficability of Soils Airphoto Approach.
19c	Mintzer, O. W., A Comparative Study of Photography for Soils and Terrain Data.
19d	Meier, G., et al, Decoding Aerial Photographs of Glacial Landscapes -- Indicators of Ground Waters.

17. RADAR SYSTEMS

Advanced Radar Topographic Application, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-73-2, February 1973, NTIS AD 908 394L.
(Raytheon Company, Arlington, VA)

Author Abstract - The objective of this report is to determine the full capability of a Reconnaissance Radar System (RRS) and, to a lesser extent, the Topo II Radar System for application to original map compilation, map revision, point positioning, mosaicking and gap filling. This investigation is essentially a test to determine how accurately target images, appearing on Reconnaissance and Topo II radar records, can be transferred to a data base. The investigation will include a study to determine the behavior of error propagation across the radar format based on a pre-assumed radar transformation, errors in radar imagery measurements, and errors in control point coordinates.

ANDERSON, V. H., High Altitude Side-Looking Radar Images of Sea Ice in the Arctic, Proceedings of 4th Symposium on Remote Sensing of Environment, University of Michigan, Ann Arbor, Michigan, 12-14 April 1966.

Author Abstract - High altitude, side-looking radar was used to image sea ice patterns between Greenland and Ellesmere Island and within the Arctic Ocean, during the spring of 1962. Concurrent low altitude visual reconnaissance of sea ice patterns was conducted by the author over much of the same flight path flown by the radar aircraft. A comparison of the Radar patterns with actual observed and photographed sea ice conditions is presented in this paper. A dramatic example of the eroding processes of polar ice as it moves southward to warmer environments is displayed by the radar imagery and is discussed in this paper. An example of radar imagery of sea ice in the Arctic Ocean, existing under a deteriorating environment during the summer of 1962, is also presented. Included is the radar image of Ice Island "T3" in the Beaufort Sea north of Alaska.

ANDERSON, V. H., Radar Imagery of Arctic Pack Ice, Kane Basin to North Pole, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 94, April 1968, NTIS AD-721 901.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The pictorial brochure has been compiled to show existing radar system's capability of imaging large areas of sea ice in relatively short periods of time. The radar imagery was obtained during the latter part of April 1962 by a USAF high-altitude reconnaissance aircraft equipped with a side-looking, scanner-type radar unit. USACRREL personnel made visual aerial observations of the ice imaged by radar utilizing USN ice reconnaissance aircraft active in the area during this period. Conventional hand-held aerial photography of the ice characteristics was obtained on these flights and some of these photographs are included to supplement the radar imagery.

AXLINE, R. M., Jr. and R. Mater, Theoretical and Experimental Study of Wave Scattering from Composite Rough Surfaces, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-74-4, April 1974, NTIS AD 787 540.
(University of Kansas Center for Research, Inc., Lawrence, Kansas)

Author Abstract - This report describes the results of an electromagnetic experiment which compares measurements of scattering coefficient (σ^0) with non-coherent and coherent theories for two, two-dimensional, two-scale targets; one a good conductor (aluminum), and one a lossy dielectric (plaster). Included are 1) a detailed description of the construction of the two-scale scattering targets; 2) a description of the experimental 25 GHz radar system used to make scattering coefficient measurements, 3) a statistical analysis of the roughness parameters of the surface; 4) the results of the scattering coefficient measurements for the VV, HH, VH and HV polarization states; and 5) a comparison of the measurements with scattering coefficient predictions of two-scale non-coherent and coherent backscattering theories. It is found that both of the composite theories accurately predict the change in the scattering coefficient curve caused by changes in the dielectric constant when the roughness of the target remains constant. In addition, the theory is found to compare well to the measurements for each target (metal, plaster) both in absolute value and in variation with the incident angle. Computed confidence intervals allow a meaningful comparison between theory and measurements. The controlled nature of the surface parameters (statistics of the roughness, and dielectric constant) lends significance to the results. Results indicate the possibility of using the composite theory as an interpolating and extrapolating aid in such areas as reduction of terrain data, simulation and interpretation and extrapolation of radar imagery, and the design of experiments and experimental equipment.

CLARK, R. A., Universal Radar Signal Processor Correlator, Report Number Two, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., September 1968, NTIS AD-841 545L. (Goodyear Aerospace Corporation, Litchfield Park, Arizona)

Author Abstract - The installation and acceptance testing of the Universal Radar Signal Processor (Correlator) at Fort Belvoir during the spring of 1968 marks the completion of a program designed to provide the Topographic Laboratories with the capability to process the signal histories of all current radar systems.

An anamorphic optical system, designed for prime operation in the tilted plane mode, was the method chosen to accomplish this task. An auxiliary lens pair was also provided for operation in the tilted lens mode for those systems requiring nonrealizable tilted plane angles.

Correlator performance during the final acceptance tests has demonstrated conformance to the geometry requirements of the purchase description. The resolution requirement for 58 line pairs per millimeter on-axis has been met for tilted plane processing. The fixed 3x magnification in azimuth of the auxiliary lens pair necessitated a 40 line pairs per millimeter requirement for the tilted lens mode. This requirement was satisfactorily demonstrated. Resolution in both modes degraded toward the edge of the four-inch test swath.

A week-long training course was presented to Topographic Laboratories personnel by Goodyear Aerospace Corporation instructors in early May 1968.

CRANDALL, C. J., Radar Sketching Device, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Final Report 20-TR, January 1965, NTIS AD 459 534.
(USAEGIMRADA, Fort Belvoir, Va.)

Author Abstract - Report covers the testing and evaluation of a lightweight radar sketching device which can be attached to the autofocus reflecting projector for use in transferring detail from radar transparencies to map compilation manuscripts. Test results are tabulated or recorded in sufficient detail to enable a complete analysis of the equipment capability. Report concludes: (a) The radar sketching device meets the requirements as set forth in the purchase description except for fungus-proofing of the lens and the accuracy when 10-percent scale differential is introduced. (b) The radar sketching device is suitable for projecting any type of transparency (radar or aerial photographs or graphics) for transfer of detail, subject to the inherent limitations of the equipment as established during the engineer design tests and set forth in the requirements. (c) The radar sketching device is suitable for field and base plant operations. (d) In the event of future procurement, the engineer test model of the radar sketching device should incorporate increased magnification and other design features found lacking in the engineer design model.

CRANDALL, C. J., Side-Looking Radar Presentation Viewing and Measuring Instrument, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Final Report 22-TR, January 1965, NTIS AD 460 325.
(USAEGIMRADA, Fort Belvoir, Va.)

Author Abstract - Report covers the testing and evaluation of the prototype Side-Looking Radar Presentation Viewing and Measuring Instrument to determine its capability for making accurate measurements on radar film transparencies. Data on the accuracy of the instrument are presented. Report concludes: (a) The prototype instrument, in general, meets the requirements as specified. In the event of future development, however, many design improvements will be necessary. (c) Instrument accuracies for both the right and left side measuring systems are comparable to the required accuracy. (c) The measuring reticles are inadequate for measuring conjugate points on film transparencies. This is partially due to the frosted glass stage plates. (d) Either positive or negative film transparencies may be used in the instrument.

CRANDALL, C. J., Test and Evaluation of the Prototype Side-Looking Radar Restitutor, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., Technical Report 29-TR, April 1966, NTIS AD 633 610. (USAEGIMRADA, Fort Belvoir, Va.)

Author Abstract - This report covers the testing and evaluation of the prototype Side-Looking Radar Restitutor to determine its capability to correct for distortions caused by slant range, including earth curvature, systematic errors, sweep delay, tracking of the flight line, and line-of-flight deviations and presents data on the accuracy of the instrument. The report concludes that: (a) The prototype instrument does not meet the accuracy requirements specified in the contract; however, conclusive tests could not be conducted; (b) this instrument is definitely not an operational item; (c) the electronics are reliable; (d) the design can be improved in many places. These have been noted in the event of future development. With these improvements it may be possible that restitution can be accomplished within the prescribed horizontal accuracy requirements for 1:250,000-scale planimetric maps.

DAVIS, B. R., J. R. Lundien, A. N. Williamson, Jr., Feasibility Study of the Use of Radar to Detect Surface and Ground Water, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-TR-3-727, April 1966, NTIS AD 483 864. (USAEWES, Vicksburg, MS)

Author Abstract - A study was made of the feasibility of using radar sensors as a remote means of detecting the presence and measuring the depth of surface water, and detecting the presence and measuring the depth to ground water. Also, previously begun studies were continued to relate radar returns, and the electrical soil constant they provided, to soil moisture content. Large laboratory soil samples were prepared at various moisture contents and with various depths of surface water and various depths to ground water. Standard pulsed radar sensors operating with frequencies of 297, 5870, and 9375 MC through various angles of incidence were employed. Results indicate that the standard pulsed radar sensors can provide information to permit detection of surface water and an estimate of the moisture content of deep homogeneous soil samples, however, such sensors do not permit prediction of depth of surface water, presence of ground water, or depth to ground water. Systematic variation of surface water depths and depths to ground water permitted an analytical solution for measuring surface- or ground-water depths, and led to the conclusion that properly designed radar systems could measure surface- and ground-water depths. Three such systems are proposed.

DELLWIG, L. F., B. C. Hanson, N. E. Hardy, P. L. Hulen, J. R. McCauley, and R. K. Moore, Use of Radar Images in Terrain Analysis: An Annotated Bibliography, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0024, September 1975, NTIS AD A020 598. (University of Kansas Center for Research, Inc., Lawrence, Kansas)

Author Abstract - An annotated bibliography of articles, papers and reports dealing with the application of imaging radar systems to the geosciences has been prepared to meet the needs of both the potential user of radar imagery and the researcher in the field of tactical terrain analysis. To aid the uninitiated, the principles of imaging radars are described in an introductory section. Following are bibliographic entries which have been prepared for those pertinent publications produced since the earliest days of imaging radars up to the present time (May 1975). When available, the author's own abstract has been reproduced; in other cases summaries have been prepared by the reviewer of the entry. In many cases, comments of the reviewers are included in order to point out publications of major importance; to underscore significant conclusions and to expose those conclusions which are unfounded based on the research described. When actual radar imagery has been used in a publication, the location and date of the imagery as well as the system which acquired it are noted in the bibliographic entry. Author affiliations at the time of publication are also included with each entry and current affiliations (1975) of the principal authors are listed in a separate section. An extensive cross-reference index has been prepared to aid in identifying those papers which are even in a small part pertinent to any geoscience discipline, system parameter evaluation, or imaging radar system.

DELLWIG, L. F., B. C. Hanson, N. E. Hardy, J. C. Holtzman, P. L. Hulen, J. R. McCauley, and R. K. Moore, A Demonstration and Evaluation of the Utilization of Side Looking Airborne Radar for Military Terrain Analysis, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Final Report ETL-0023, October 1975, NTIS AD A033 557. (University of Kansas Center for Research, Inc., Lawrence, Kansas)

Author Abstract - Side looking airborne radar (SLAR) imagery acquired in diverse terrains and environments, was studied to demonstrate its value in military tactical terrain analysis. Capabilities unique to SLAR, such as all-weather and day or night image acquisition, are highlighted. In addition, other capabilities and limitations are also stressed to permit the utilization of SLAR with other sensors for maximum data retrieval. Imagery studied was selected on the basis of geographic location and data content, not system characteristics, and estimates are made of the improved data content that could be realized by modification of system parameters. By using a broader range of the electro-magnetic spectrum than most sensors and by operating under many controllable parameters, the appropriate radar system and system configuration can be selected for any mission by the user to realize maximum target information.

DUNBAR, M., W. F. Weeks, Interpretation of Young Ice Forms in the Gulf on St. Lawrence Using Side-Looking Airborne Radar and Infrared Imagery, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 337, July 1975, NTIS AD-A015 457.

Author Abstract - Ice conditions during mid-January 1974 in the Gulf of St. Lawrence and in the estuary as far upstream as Rimouski are described utilizing side-looking airborne radar, infrared and photography imagery. The interpretations were verified by simultaneous surface observations on the ice by investigations operating from the CSS Dawson. The ice examined was undergoing rapid drift and deformation and showed a wide variety of thin ice (0-40 cm) features formed under the influence of strong winds and currents. These observations should serve as a guide in interpreting ice conditions in similar areas where ground truth data are not available.

Digital Rectification of Side-Looking Radar (DRESLAR), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Final Report ETL-CR-73-18, September 1973, NTIS AD-913 646L. (Raytheon Co., Autometric Operation, Arlington, Va.)

Author Abstract - The purpose of this task was to develop a capability to digitally rectify side looking radar imagery, and to test this capability using data supplied by the TOPO II radar system. The two basic tasks were to develop a computer program, and then test this program using the data supplied.

The basic concept of the rectification of side looking radar can be explained as follows. For each point on a side looking radar image, there is a unique corresponding ground point. The determination of this ground point requires that the position and velocity of the radar vehicle be established, that the range to the object be known, and that the height of the ground at the point be known. The position and velocity of the aircraft are determined from fitting an interpolation function to the HIRAN fix data. This function can then be evaluated at the time at which the point was imaged by using the time as computed from the film coordinates of the point. The film coordinates also can be used to derive the range to the target. The elevation of the ground at the point can be determined from a digital terrain model which in turn can be derived from the interferometric data supplied from the radar equipment. Obviously, the position of the point on the ground is not known before rectification as then there would be no need for rectification. Thus an iterative method is used for the rectification process.

After rectification, the terrain features are plotted using a digital plotter. Upon option, a magnetic tape of these terrain features may also be output.

The results of the test of the program indicated that, using the data furnished, accuracies approaching 1/250,000 Class A National Map Accuracy Standards could be obtained. The computer run times would indicate that this process would be competitive with conventional mapping methods for map production from side looking radar.

FARNSWORTH, S. W., Developmental Optical Correlator, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Contract Report ETL-0033, October 1975, NTIS AD-B008 599L. (Goodyear Aerospace Corporation, Litchfield Park, Arizona)

Author Abstract - The installation of the Developmental Optical Correlator of the U. S. Army Engineer Topographic Laboratories (USAETL) in August 1975 marks the completion of a program to develop a Laboratory Optical Reformatting Equipment (LORE). The goal of the program was to develop, design, and build such equipment to apply techniques of optical correlation and computer restitution to remove the distortions and parallax from a high-resolution aerial photo. Landmark developments of the program were the image transfer optical system and the optical-digital image sampling and correlation technique. The program resulted in a laboratory brassboard equipment which is useful for experimentation on the optical correlation and computer restitution approach, and which has the potential of modification to give full reformatted image transfer capability.

FUNG, H. S. and A. K. Fung, An Application of Scalar Renormalization to the Scattering of Electromagnetic Waves from a Three-Dimensionally Inhomogeneous Medium with Strong Dielectric Fluctuations, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Final Report ETL-0020, August 1975, NTIS AD-A022 097.
(University of Kansas Space Technology Center, Lawrence, Kansas)

Author Abstract - A theory of polarized radar scattering from a three-dimensionally randomly inhomogeneous lossy medium with strong dielectric fluctuations has been developed using the scalar renormalization method. Satisfactory agreements were obtained when theoretically computed backscattering coefficients were compared with scattering data taken from soybeans and alfalfa over incident angles from 10^{o} to 70^{o}. In view of the assumed inhomogeneous medium and the comparisons made with data, it appears that the theory is applicable to those vegetations which can be modeled as a volume of air with randomly embedded leaves. Extension of the present theory to include depolarization effects is possible. However, the complete treatment of such a problem is very complicated.

Geoscience Potentials of Side-Looking Radar, National Aeronautics and Space Administration, Washington, DC, NTIS AD 650 498. (Raytheon/Autometric, Alexandria, Va.)

Author Abstract - No abstract.

GRACIE, G., R. K. Brewer, J. W. Bricker, and R. A. Johnson, Stereo Radar Analysis, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., May 1970, NTIS AD 903 321L. (Raytheon Company, Autometric Operation, Arlington, Va.)

Author Abstract - The topographic accuracy of the AN/APQ-102(XA-2) side-looking radar and its specific applicability to 1:50,000 and 1:250,000 scale topographic mapping were tested using stereo radar techniques with real data. The two basic stereo configurations, opposite-side and same-side, were tested. Also tested was the geometric fit of each individual radar record to the established ground control. Although original plans called for a test area 25 miles long by 4 miles wide, shortcomings in the data actually acquired led to adoption of a much smaller test area. Moreover, lack of certain collateral data required development of a special reduction technique based upon ground control in the test area. Photogrammetric aerotriangulation of aerial photography flown simultaneously with the radar provided a means of defining the flight path. Ground points in the test area were also aerotriangulated, and used as control and as the standard for measuring radar accuracy. The test results were surprisingly good, with the opposite-side stereo configuration providing the better accuracy. Average root mean square (RMS) values of 7.7 meters, 12.1 meters and 13.2 meters in X (across-track), Y (along-track) and Z (elevation), respectively, were obtained for the opposite-side case; corresponding RMS values of 9.5 meters, 20.0 meters and 16.7 meters were obtained for the same-side case. Results from fitting the individual radar records to the aerotriangulated positions also demonstrated excellent geometric fidelity in the radar imagery. Although based upon limited data, the test results indicate that the AN/APQ-102(XA-2) radar, using stereo techniques, has much promise for all-weather day-night mapping at scales to 1:50,000 and 1:250,000.

HEVENOR, R. A., A Mathematical Analysis of the Propagation and Reflection of Plane Electromagnetic Waves in a Nonhomogeneous Isotropic Medium, Army Science Conference Proceedings, Vol. II, 16-19 June 1970, Office, Chief of Research and Development, Department of the Army, NTIS AD 713 539.
(USAETL, Fort Belvoir, Va.)

Author Abstract - In the area of Military Geographic Intelligence (MGI) there exists a need to determine subsurface phenomena by the use of remote sensors. This can be done efficiently only when an understanding of the propagation of electromagnetic waves in natural terrain surfaces has been achieved. The understanding can be aided by solving the vector wave equation for the case when the conductivity, the dielectric constant and the magnetic permeability are functions of soil depth. The problem to be analyzed in this paper is that of a nonhomogeneous half space where the conductivity and dielectric constant are arbitrary functions of depth. The basic approach employed is that of the geometrical optics solution of the wave equation. The final results of the paper yield expressions for the magnitude and phase of an electromagnetic field propagating in the nonhomogeneous medium for horizontal and vertical polarizations.

HEVENOR, R. A., A Relation Between the Spectrum of Surface Slopes and the Spectrum of Surface Elevations and its Usefulness in the Theory of Electromagnetic Wave Scattering from Rough Surfaces, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-RN-70-2, July 1970, NTIS AD 711 537.
(USAETL, Fort Belvoir, Va.)

Author Abstract - The purpose of this research note is to show that a simple relation exists between the spectrum of surface elevations and the spectrum of surface slopes. This relation is useful when working on the problem of electromagnetic wave scattering from rough surfaces. When using the small perturbation theory to compute scattered fields from a rough surface, both the spectrum of surface elevations and the spectrum of surface slopes can appear in the final equations. The spectrum of the surface elevations is easy to work with and can be determined from measurements made on the surface. The spectrum of the surface slopes, however, is more difficult to work with. It would be very beneficial if a relation between the two spectrums could be obtained.

HEVENOR, R. A., Backscattering of Electromagnetic Waves from a Surface Composed of Two Types of Surface Roughness, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-TR-71-4, October 1971, NTIS AD 737 675.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This report presents a vector theory for the backscattering of electromagnetic waves from a random, rough surface. The basic technique used is that employed by Dr. Adrian K. Fung in an earlier work. The surfaces used in the report are those that are generated by a stationary gaussian random process as opposed to surfaces generated by a random array of objects. The former type of surface is assumed to simulate many of the vegetation-free sections of the earth. It is important to understand the basic characteristics of scattering from such surfaces for the purpose of aiding military geographic analysis by radar.

HEVENOR, R. A., Backscattering of Electromagnetic Waves from a Slightly Rough Surface with a Lossy Layer, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-TR-74-10, December 1974, NTIS AD A013 863.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This report presents a vector theory for the backscattering of electromagnetic radar waves from a slightly rough lossy layer. Both sides of the layer are allowed to be slightly rough. The layer medium and the medium below the layer are both allowed to be lossy. The incident wave is assumed to enter from free space onto the layer. Both horizontal and vertical polarizations of the incident wave are considered. The method of solution uses the small perturbation theory along with the Fourier transform. Results up to first order in perturbation are obtained for both polarizations. Application to terrain elements is shown in examples of road surfaces and layers. A means is suggested whereby the physical thickness of a road layer could be calculated from broad-band radar data if the layer dielectric was known. An important application of the theory is that for known surfaces, layer depths, and dielectrics, radar backscatter coefficients can be calculated for horizontal and vertical polarizations. The application of the theory to the problem of radar simulation is also indicated.

HEVENOR, R. A., A Mathematical Analysis of the Propagation and Reflection of Plane Electromagnetic Waves in a Nonhomogeneous Isotropic Medium, published in AGARD (Advisory Group for Aerospace Research and Development) Conference Proceedings No. 90.
(USAETL, Fort Belvoir, Va.)

Author Abstract - In the area of Military Geographic Intelligence (MGI) there exists a need to determine subsurface phenomena by the use of remote sensors. This can be done efficiently only when an understanding of the propagation of electromagnetic waves in natural terrain surfaces has been achieved. The understanding can be aided by solving the vector wave equation for the case when the conductivity, the dielectric constant and the magnetic permeability are functions of soil depth. The problem to be analyzed in this paper is that of a nonhomogeneous half space where the conductivity and dielectric constant are arbitrary functions of depth. The basic approach employed is that of the geometrical optics solution of the wave equation. The final results of the paper yield expressions for the magnitude and phase of an electromagnetic field propagating in the nonhomogeneous medium for horizontal and vertical polarizations.

HOEKSTRA, P. and P. Cappillino, An Analysis of Nondestructive Sensing of Water Content by Microwaves, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 295, July 1971, NTIS AD-728 831.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Microwave instrumentation is used for nondestructive measurement of the water content of materials. The basis of all microwave moisture sensors is that the dielectric constants of material that contains water are a strong function of water content. The microwave moisture sensors based on a reflection or transmission principle are shown to have the disadvantage of requiring that a calibration be made for each sample thickness. Several alternative routes for developing reliable microwave moisture sensors are discussed.

HOEKSTRA, P., and D. Spanogle, Radar Cross-Section Measurements of Snow and Ice, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TR 235, November 1972, NTIS AD 752 900.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The radar backscatter from undisturbed snow surfaces was measured at 10 GHz, 35 GHz, and 95 GHz and at grazing angles of 1 to 0.4^{o}. For horizontally polarized radiation the ground clutter per unit area (m^2) at 10 GHz from a flat snow terrain decreased from -50 db at 1^{o} to -70 db at 0.4^{o}. The return was approximately 10 db lower for vertically polarized radiation. The ground clutter depended on the free water content of the snow. The return at 35 GHz was approximately 10 db higher than that at 10 GHz at horizontal and vertical polarizations and at a grazing angle of 0.4^{o}. The difference between the return at 10 GHz and that at 35 GHz decreased at high grazing the terrain and no meaningful number for the terrain radar cross section could be obtained. The radar cross section of ice blocks placed on the snow surface was roughly proportional to the square of the area of the ice blocks facing the radar at 10 and 35 GHz and was about 20 dbsm below the return expected for a perfectly reflecting plane surface. At 95 GHz the ice blocks became diffuse reflectors. The power reflection coefficient at normal incidence for ice blocks with carefully prepared surfaces measured in free space was from 0.005 to 0.08 at 10 GHz and from 0.009 to 0.031 at 35 GHz.

HOEKSTRA, P., P. V. Sellman, and A. J. Delaney, Airborne Resistivity Mapping of Permafrost Near Fairbanks, Alaska, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 324, September 1974, NTIS AD-A000 694. (USACRREL, Hanover, New Hampshire)

Author Abstract - Airborne resistivity methods using radio waves in three frequency bands were tested in the vicinity of Fairbanks, Alaska. The test sites were selected because much ground control is available for this area. The objectives of this study were to determine the ability of these methods to map permafrost and other soils and to investigate the advantages of multifrequency mapping. Investigations in permafrost regions for such geotechnical endeavors as route selection for roads and pipelines and site investigation for building and dam construction often require that a careful assessment be made of the presence or absence of frozen ground, of the ice content of frozen ground, and of the depth of frozen ground. The airborne resistivity data obtained in this study were contoured and the contour maps were compared with surficial geological maps and other ground truth data available. The following conclusions were reached: 1) in areas where the near-surface sediments are relatively uniform, VLF resistivity best delineates permafrost, and 2) in areas where surface sediments vary widely (e.g., recent flood plains), resistivity at all frequencies gives little information on permafrost conditions, but provides other important information, such as bedrock type, depth to bedrock, soil type and layering.

HOLTZMAN, J. C., V. S. Frost, V. H. Kaupp, E. E. Komp and R. L. Martin, Radar Image Simulation Project: Development of a General Simulation Model and an Interactive Simulation Model, and Sample Results, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Contract Report ETL-0047, February 1976, NTIS AD-A027 151. (University of Kansas Space Technology Center, Lawrence, Kansas)

Author Abstract - This document reports the results of a radar image simulation study performed at the Remote Sensing Laboratory, the University of Kansas, Lawrence, Kansas. The work was sponsored by the U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia. The purpose of this study was to develop radar image simulation and feature extraction techniques. A general model for simulating radar imagery is developed. This model is applicable to both SLAR (Side-Looking Airborne Radar) and PPI (Plan Position Indicator) radar system image formats. It can produce simulations from both flat and mountainous terrain. The model requires as input a completely specified digital ground truth data base. The radar reflectivity data calculated for each image simulation can be determined from a variety of input data sources. The results presented in this document have all been produced using for input reflectivity data, empirical radar backscatter data from a large agricultural/soil moisture data bank available at the Remote Sensing Laboratory.

Also reported is a technique for automating feature extraction, creation of data bases, and interactive radar simulation. A model is developed which incorporates an image analyst (human) in the decision process as the computer simulation program runs. Automatic pattern recognition software is used to pre-process the data base and the interpreter/simulator is given the flexibility to specify or alter previous specifications in real-time in synthesizing the radar image.

KOVACS, A. and A. J. Gow, Brine Infiltration in the McMurdo Ice Shelf, McMurdo Sound, Antarctica, Journal of Geophysical Research, Vol. 80, No. 15, 20 May 1975.
(USACRREL, Hanover, New Hampshire)

Author Abstract - In recent trials near Hut Point Peninsula an impulse radar profiler was used successfully to monitor the depth characteristics and lateral extent of brine soaking in the McMurdo Ice Shelf. The success of the profiler can be attributed in large part to the significant difference in dielectric properties of dry firn and firn that has become brine soaked by infiltrating seawater. In addition to furnishing a continuous trace of the top of the brine layer, the impulse radar profiler has also revealed the existence of cracks, relict brine horizons, and deformational features within the ice shelf. Data tend to favor lateral infiltration of seawater, either through the seaward edge of the ice shelf or via tensile cracks at the bottom of the ice shelf.

KOVACS, A. and A. J. Gow, Subsurface Measurements of the Ross Ice Shelf, McMurdo Sound, Antarctica, Antarctic Journal, September 1977.
(USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

KOVACS, A. and A. J. Gow, Dielectric Constant and Reflection Coefficient of the Snow Surface and Near-Surface Internal Layers in the McMurdo Ice Shelf, Antarctic Journal, September 1977.
(USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

KOVACS, A., Grounded Ice in the Fast Ice Zone Along the Beaufort Sea Coast of Alaska, U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratories, Boulder, Colorado, CRREL Report 76-32, September 1976.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Four large grounded multi-year shear ridge formations were found in the grounded ice subzone of the fast ice zone near the Harrison Bay/Prudhoe Bay area of Alaska. A 166-m long cross section of one of these formations was obtained by leveling and sonar measurements. These measurements revealed that the maximum ridge height was 12.6 m and that the formation was grounded in 17-18 m of water. The salinity, temperature, brine volume and density of the ice were determined on samples obtained by coring. The physical characteristics of the formations as observed in satellite, SLAR and aerial imagery indicate that these formations have not moved between the time of their formation in the fall of 1974 and August of 1976. Evidence of significant aeolian debris discoloring the ice is discussed.

KOVACS, A., Sea Ice Thickness Profiling and Under-Ice Oil Entrapment, presented at the 9th Annual Offshore Technology Conference (OTC) in Houston, Texas, May 2-5, 1977.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Results obtained with a unique dual-antenna impulse radar system used to profile first- and multi-year sea ice near Prudhoe Bay, Alaska, are discussed. A description of the radar system is given along with representative field data. Continuous ice thickness profiles are required for studies related to modeling and understanding the dynamics of the sea ice cover, heat exchange between the ocean and the atmosphere and mass balance of the ice cover. Ice thickness profiles are also required for studies related to the determination of ice load distribution and force analyses, and the subsurface roughness as it pertains to under-ice sound propagation and to the quantity of oil that would be trapped in the undulating bottom relief of first-year and multi-year ice should an oil blowout occur in an ice-covered sea. From the radar impulse travel times obtained with the use of dual antennas, calculations of thickness, electromagnetic impulse velocity and effective dielectric constant of the ice were made. Ice thicknesses determined by direct measurements and those calculated using the radar impulse travel times were found to be in good agreement. Continuous ice thickness profiles obtained with the radar were analyzed to provide representative cross sections of first-year and multi-year sea ice. These cross sections reveal the undulating bottom surface relief of both ice types. Calculations are presented that indicate a significant amount of oil could be trapped within this bottom relief should be oil be released under the ice from a sea-floor oil-production system.

KOVACS, A., Iceberg Thickness Profiling, 4th International Conference on Port and Ocean Engineering Under Arctic Conditions, St. Johns, Newfoundland, September 1977.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Results obtained with an impulse radar system used to profile the thickness of a tabular iceberg in McMurdo Sound, Antarctica, and an ice island in the Beaufort Sea near Flaxman Island, Alaska, are presented. Graphic records are shown of the radar impulse travel time which clearly reveal, for the first time, the bottom relief of each ice formation. Also detected and shown are echo signatures from internal cracks and an infiltration-brine layer. The time of flight of the radar impulse in the ice island is compared with a 24.05-m drill hole measurement of the ice thickness. The effective velocity of the radar impulse in the ice island was found to be 0.16 m/ns and the effective dielectric constant of the ice to be 3.5.

KOVACS, A. and G. Abele, Crevasse Detection Using an Impulse Radar System, Antarctic Journal of the United States, Jul-Aug 1974, 9(4), MP 800.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The design and operation of an impulse radar system for use as a crevasse detector are described. The system consists of a pulse transmitter, a transmit-receive switching section, a receiver, and a graphic recorder. The components are mounted inside a tracked vehicle and occupy about 1/2 cu m of space. The beam of the antenna is designed to be broadest in the forward and aft plane of the hull. The system appears to consistently detect crevasses or cracks at least 3 m ahead or to the side of the antenna and is considered adequate for field party use. It is suggested, however, that the system be modified to include two antennas positioned 3 m apart and extended to distances at least 9 m in front of vehicles for better radar coverage of crevasses being approached at angles to travel routes.

LEIGHTY, R. D., Terrain Information from High Altitude Side-Looking Radar Imagery of an Arctic Area, Proceedings of 4th Symposium on Remote Sensing of Environment, University of Michigan, Ann Arbor, Michigan, April 12-14, 1966, MP 268.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Radar imagery was obtained at altitudes of 30,000 to 60,000 feet over arctic terrain with an AN/APQ56 (XAA) side-looking radar (high altitude) set during two flight programs (November-December 1960 and March 1962). Generalities of terrain information retrieval from radar imagery are presented with background information on the regional terrain characteristics in northwest Greenland and discussion of representative project imagery.

LEWIS, A. J., Geomorphic Evaluation of Radar Imagery of Southeastern Panama and Northwestern Colombia, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-71-2, February 1971, NTIS AD 724 118.
(Center for Research, Inc., The University of Kansas, Lawrence, Kansas)

Author Abstract - No abstract.

MACCHIA, R. P., Engineering Tests of the PPI Radar Presentation Restitutor, U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., Technical Report 1629-TR, May 1960.
(USAERDL, Fort Belvoir, Va.)

Author Abstract - This report describes the principles, design, development, construction, testing, and evaluation of the engineering test model of the PPI radar presentation restitutor. The report concludes that: (a) The principle and operation of the engineering test model radar presentation restitutor with minor modifications would meet the requirements under which it was developed and could serve as the guide for development of a PPI radar restitutor; (b) under the revised Corps of Engineers radar mapping concept, which was conceived after development of the PPI restitutor, there is no requirement for this instrument; and (c) U. S. Air Force developments in the PPI restitutor field be followed in the event the Corps of Engineers will have to rely on the USAF radar system, which utilizes both PPI and side-looking photography, to accomplish the Engineers mapping mission.

MacDONALD, H. C., Geologic Evaluation of Radar Imagery from Darien Province, Panama, Advanced Research Projects Agency, Washington, DC, CRES Technical Report 133-6, June 1969.
(The University of Kansas, Lawrence, Kansas)

Author Abstract - The availability of extensive radar imagery covering approximately 17,000 sq. km. in eastern Panama and northwestern Colombia has provided geologic data for an area where previous geological investigations have been extremely limited because of inaccessibility and perpetual cloud cover. In previous radar-related geologic studies, most of the radar imagery was collected from areas within the continental United States where temperate climatic conditions prevail and where detailed geologic information was available. The radar imagery of eastern Panama, however, represents not only unique terrain information from the tropical environment, but the first practical mapping application of side-looking radar systems.

The primary objectives of this study were to 1) determine the utility of radar in the compilation of geological reconnaissance maps, 2) define and analyze radar-linears (joint systems and faults) and infer the nature of the tectonic forces responsible for certain types of local structures, 3) examine the effect of radar look-direction (direction orthogonal to ground track of the aircraft) and determine if there is a factor of directional dependency with radar systems, and 4) evaluate the potential of radar as a single geological reconnaissance tool in the tropical environment and what application these imaging systems may possess for future geological reconnaissance surveys in similar geographic areas.

As in aerial photographic interpretation, the analysis of tone, texture, shape, and pattern are recognition elements on radar imagery which contribute to the interpretation of geologic data. These recognition elements as well as the distortions inherent to radar imagery are evaluated in this study.

McANERNEY, J. M., Terrain Interpretation from Radar Imagery,
Proceedings of 4th Symposium on Remote Sensing of Environment,
University of Michigan, Ann Arbor, Michigan, 12-14 April 1966,
MP 280.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The interpretation of physiographic and cultural terrain features from imagery obtained with high resolution, side-looking radar alone is demonstrated.

Two areas in the central United States are used as examples. Through a deductive process similar to that used in interpretation of visual aerial photography, it is shown that a trained interpreter can describe the physiography, geology and soil of a land surface and provide a reasonable assessment of the geography of a populated region. The discussion includes an example of measuring terrain relief from radar shadows.

McQUILLEN, H. R., Report Number One - Universal Radar Signal Processor (Correlator), U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va., June 1966, NTIS AD 487-144L.
(Goodyear Aerospace Corporation, Litchfield Park, Arizona)

Author Abstract - This technical report describes the preliminary design definition of the prototype Universal Radar Signal Processor (Correlator) system to be fabricated and installed by Goodyear Aerospace Corporation, Litchfield Park, Arizona Division, for the U. S. Army Engineers, GIMRADA, Photogrammetry Division, Fort Belvoir, Virginia. All major technical problems and solutions of the definition phase are summarized and details of these efforts are referenced.

The development program is on schedule, having completed the system design definition, and entered the detail lens design and mechanical design. A summary of current and anticipated technical problems indicates that the program will remain on schedule. Final installation check-out performance at Fort Belvoir is to be completed by 8 November 1967, and familiarization of GIMRADA personnel by 8 December 1967.

MEYER, W. D., Analysis of Radar Calibration Data, Report Number One, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., November 1967, NTIS AD-827 858L.
(Goodyear Aerospace Corporation, Litchfield Park, Arizona)

Author Abstract - The purpose of the Analysis of Radar Calibration Data program was to analyze calibrated radar data and ground truth information to determine how the application of radar calibration can be used to increase the capability of extracting terrain intelligence from radar imagery. The data used were obtained by the AN/APS-73(XH-4) radar system during the flights over the Phoenix, Arizona, area during the multisensor 665A program. The AN/APS-73(XH-4) system was modified to incorporate calibration techniques during the flight test program. This radar is a coherent, synthetic aperture system using horizontal polarization for both transmission and reception. The calibration method used was to record calibrated synthetic signals on the image film as reference densities for comparison with the radar return densities. The reference densities appear as "gray scale" wedges on the image film.

Computational techniques were devised to compare the effect of various crop conditions and ground parameters on the radar backscatter coefficient. Computer programs were written to catalog the approximately 8000 data points and to perform the routine computations. These computer programs were delivered to the contracting agency. An eigenvalue matrix method of decision-making was devised to group the various crops and conditions into similar categories.

The program results show that a calibrated radar system is useful for extracting terrain intelligence information from radar imagery. They also show that the type of crop, and in some cases, the condition of the crop, have the most significant effect on radar backscatter coefficient at the same depression angle. For the range of soil types found in the Phoenix, Arizona, test area, the soil type did not significantly affect the amount of radar energy reflected.

MIRANDA, F. F., Radar Stereo Equipment Program, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., May 1971, NTIS AD 732 875.
(Goodyear Aerospace Corporation, Litchfield Park, Arizona)

Author Abstract - The purpose of the Radar Stereo Equipment Program was to design and fabricate equipment for the compilation of map contours *from side-looking* radar imagery. This is the final report and describes the progress made during the course of the program.

The equipment was designed to use an analytical stereo plotting concept. A general-purpose computer is used to solve the radar stereo model equations, to control the equipment, and to plot contours on a digital plotter.

The optical system of the equipment was specifically designed for radar stereo. To accomplish this end, an appropriate range of zoom magnification was provided, in addition to an anamorphic zoom capability.

A positive-negative photo carriage was also provided to allow operation with either same-side or opposite-side stereo.

NORVELLE, F. R., AS-11A Radar Program, presented at the American Society of Photogrammetry Meeting, 7-12 March 1971. (USAETL, Fort Belvoir, Va.)

Author Abstract - The computer with the AS-11A stereoplotter has been programmed to accommodate the geometry of side-looking radar photographs. The program provides the mathematical model to transform model (or ground) coordinates into corresponding photograph coordinates for conjugate radar presentations. The photo coordinates become electrical signals, which, via a servo system, position the photographs for stereoviewing and, therefore, stereocompilation of map manuscripts. Relative and absolute orientation procedures have been developed to aid the operator in establishing the radar stereomodel.

OGBURN, R. H., Base Plant Correlator, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-73-3, February 1973, NTIS AD 759 512. (Goodyear Aerospace Corporation, Litchfield Park, Arizona)

Author Abstract - The installation and acceptance testing of the Base Plant Correlator at the Defense Mapping Agency Topographic Center (DMATC) during the fall of 1972 marks the completion of a program designed to provide DMATC with the capability of processing the phase histories of side-looking interferometric coherent radars.

The coherent optical system of the Base Plant Correlator provides the capability of processing a single channel of radar data in the tilted plane mode, or simultaneously processing one high-resolution channel and the corresponding interferometric channel in the dual-channel mode.

Correlator performance during the final acceptance tests demonstrated conformance to the geometric fidelity requirements of the purchase description. The resolution requirement of 56 line pairs per millimeter was met for both the dual-channel and tilted-plane modes.

A training course of approximately two weeks duration was presented to DMATC personnel by Goodyear Aerospace Corporation instructors in December of 1972.

PARASHAR, S. K.; A. K. Fung and R. K. Moore, Simulation of Radar Image for Garden City Test Site, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0007, February 1975, NTIS AD A012 267.
(University of Kansas, Lawrence, Kansas)

Author Abstract - This report documents and demonstrates in detail the procedure to be followed in digitally simulating a radar image for Garden City test site. The type of information needed for simulation and the method of actual construction of the image are presented. Simulated images both with and without fading are included. These images are produced for system parameters corresponding to Westinghouse AN/APQ-97 radar system. The simulated image is compared with the actual radar imge of the area. The simulation of images for Garden City represents a first simulation effort for comparatively simple scene using relatively few system parameters.

PARASHAR, S. K.; A. K. Fung and R. K. Moore, Digital Simulation of a Radar Image of Pisgah Crater Test Site California, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Contract Report ETL-0019, September 1975, NTIS AD A025 755.
(University of Kansas Space Technology Center, Lawrence, Kansas)

Author Abstract - This report documents and describes the procedure in digitally simulating two radar images of the Pisgah Crater test site; one of which is of an essentially flat area while the other has a significant amount of relief. The type of information needed for simulation and the method of actual construction of the images are presented. Simulated images both with and without fading are included. For simulating the region with significant relief, a method for establishing shadow regions is given. Comparisons are made between the real radar image of the area and the simulated images. It is believed that the major source of error in simulation lies in the ground truth information, especially height and slope. Documentation of computer programs utilized is provided.

Study performed indicates that future research efforts should include (1) more data collection on targets of interest, (2) development of theoretical models to fill gaps in the experimental data and to facilitate automation of simulation, (3) establishing what is the acceptable quality of a simulated image for a given case,(4) simulation of areas with man made features and (5) accessing the sensitivity of theoretical models and data base to inputs of varying accuracy.

PETERSON, R. M., G. R. Cochrane, S. A. Morain and D. S. Simonett, A Multi-Sensor Study of Plant Communities at Horsefly Mountain, Oregon, reprinted from Philip Johnson, ed., Remote Sensing in Ecology, Athens: University of Georgia Press, 1969, NTIS AD 698 098.

Author Abstract - No abstract.

Radar Mapping Beacon Analysis, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-73-22, August 1973, NTIS AD B003 044L.
(DARE Technology, Inc., San Diego, CA)

Author Abstract - The report summarizes current radar beacon configurations and recommends a radar beacon design that can be emplaced by air drop and which will provide a long-range identification function at a reasonable cost.

RINKER, J. N., et al, Radar Ice Thickness Profiles Northwest Greenland, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 103, May 1967, NTIS AD 654 985.
(USACRREL, Hanover, New Hampshire)

Author Abstract - In June and July of 1964, extensive field trials of radar ice sounding equipment were held on the ice sheet in northwest Greenland. The results, in the form of profiles over 350 km of trail, made from seismic depth measurements along the Tuto-Century trail and Project 42 trails provide a good representation of surface and subsurface topography. A continuous trace of the ice/bedrock interface was obtained for over 97 percent of the route traveled, through ice up to 1400 meters thick. The film record obtained by the Scott Polar Research Institute, as a result of providing the Scott Polar Research radar set with continuously moving photographic film to record echo traces, shows a richness of detail (internal structure of the ice sheet) not portrayed by the manual plot. A sample of this film is given. References are made to project work on previous seasons.

SAUCIER, R. T., and J. D. Broughton, A Technique for Mapping Terrain Microgeometry, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-TR-3-612, November 1962, NTIS AD 295-473. (USAEWES, Vicksburg, Mississippi)

Author Abstract - Overall slopes, slope reversals, relief and percentage increase of area over plannel length are determined through methods of microgeometrical classifications.

SAXE, R. E., Orthographic Radar Restitutor Engineer Design Test, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-ETR-74-6, December 1974, NTIS AD A008 955. (USAETL, Fort Belvoir, Virginia)

Author Abstract - The report describes the operation and details of the Engineer Design Test results of an Orthographic Radar Restitutor (ORR). Imagery derived from synthetic aperture radar data provides the primary input and is combined with terrain elevation data and other aircraft flight parameters to provide orthographically restituted imagery. The equipment contains a minicomputer which calculates positioning of the input image scan to provide the restituted output imagery.

SELLMAN, P. V., A. J. Delaney, and P. Hoestra, Radiowave Resistivity Measurements in Northern Maine for Identifying Bedrock Type, U. S. Army Research and Engineering Laboratory, Hanover, New Hampshire, SR 238, October 1975, NTIS AD-0117 944.

Author Abstract - A preliminary ground resistivity survey using the VLF radiowave method was conducted in northern Maine near the site of the proposed Dickey-Lincoln dam and Hydroelectric project. This survey was intended to establish if adequate resistivity contrasts exist between bedrock types in the area to warrant further bedrock distribution studies by airborne resistivity techniques. A more complete understanding of the geology of this area was considered necessary in an attempt to locate rock types suitable for construction purposes near the proposed construction sites. Field observations were made on all rock types commonly found in the area, including the dominant gray slates and the less common orthoquartzites and granodiorites. The granodiorites are considered most suitable for construction purposes. Results of this field study suggest that an airborne survey could differentiate between the granodiorites and the surrounding gray slates in areas of shallow overburden, although resistivity contrasts between the slates and the orthoquartzite were probably not great enough to differentiate between these rock types. More than 70% of the resistivity values from the granodiorite sites exceeded 10,000 ohm-m; in contrast; approximately 8% of the slate values and none of the orthoquartzite values exceeded 10,000 ohm-m. A VLF resistivity profile was also obtained along a segment of the southern section of the proposed dam centerline. Resistivity values correlated well with subsurface information obtained during earlier Corps of Engineer drilling investigations. Major breaks in the resistivity data agreed with variations in ground conditions such as increases in till thickness over bedrock and the occurrence of silt and clay in the valley of the Saint John River. Resistivities ranged from 100 to 9000 ohm-m along the line. The lowest values were associated with the silts and clays and the highest with areas where bedrock is near the surface.

SELLMAN, P. V., W. F. Weeks and W. J. Campbell, Use of Side-Looking Airborne Radar to Determine Lake Depth on the Alaskan North Slope, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 230, May 1975, NTIS AD-011 249.

Author Abstract - Side-looking airborne radar (SLAR) imagery obtained in April-May 1974 from the North Slope of Alaska between Barrow and Harrison Bay indicates that tundra lakes can be separated into two classes based on the strength of the radar returns. Correlations between the areal patterns of the returns, limited ground observations on lake depths, and information obtained from ERTS imagery strongly suggest that freshwater lakes giving weak returns are frozen completely to the bottom while lakes giving strong returns are not. Brackish lakes also give weak returns even when they are not completely frozen. This is presumably the result of the brine present in the lower portion of the ice cover limiting the penetration of the X-band radiation into the ice. Although the physical cause of the difference in radar backscatter has not been identified, several possibilities are discussed. The ability to rapidly and easily separate the tundra lakes into these two classes via SLAR should be useful in a wide variety of different problems.

SHELTON, C., Program Maintenance Manual for the Reference Scene Software (RSS), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Contract Report ETL-0067, October 1976, NTIS AD-033 480.
(PRC Information Sciences Co., McLean, Va.)

Author Abstract - The Reference Scene Software (RSS) is a set of eleven CDC 6400 computer programs used in-house at the U. S. Army Engineer Topographic Laboratories (USAETL), Fort Belvoir, Virginia, to produce simulated Plan Position Indicator (PPI) radar scenes. The two inputs required by RSS are a matrix array (raster format) of digital terrain elevations and a corresponding vector digitized list of planimetry features (roads, lakes, railroads, cities, rivers, etc.). The output of RSS is a raster format magnetic tape image of the circular PPI scene, which is later formatted onto 35 mm film and machine compared to the actual PPI scene of the area to determine the "goodness" of correlation.

These programs were originally developed by the Naval Training Equipment Center (NTEC), Orlando, Florida, for visual flight simulation. They were converted to run on the ETL CDC 6400 computer, new input and output routines were developed, and the radar modeling algorithm was changed to produce a better machine readable rather than better human readable scene.

RSS is being used to determine the data base input requirements and the radar modeling algorithm parameters necessary for producing "correlatable" reference scenes.

SWEENY, B. D. and S. C. Colbeck, Measurements of the Dielectric Properties of Wet Snow Using a Microwave Technique, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 325, October 1974, NTIS AD-001 550.

Author Abstract - An accurate method of measuring liquid water in snow covers is required to determine the properties of wet snow. The dielectric properties of wet snow must be utilized to adequately measure its liquid water content. In this study, the effect of liquid water on the complex dielectric constant of natural snow is determined in the microwave frequency range. Deloor's method for calculating the dielectric constants for mixtures and the results of waveguide experiments on samples of wet snow and glass beads are used to construct a calibration curve relating the measured dielectric loss factor directly to the water content of wet snow. The results are independent of porosity, past history and chemical impurities. A relation between the effective dielectric constant and the porosity and water content is proposed and tested experimentally. The general nature of this relation is described and suggestions are made for the development of a more precise relation. It is concluded that the dielectric constant is a function of porosity and water content only.

ULABY, F. T. and R. K. Moore, Project THEMIS: A Center for Remote Sensing, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-74-10, June 1974, NTIS AD A003 266.
(University of Kansas Center for Research, Inc., Lawrence, Kansas)

Author Abstract - This report summarizes the technical work accomplished under Project THEMIS, A Center for Remote Sensing at the University of Kansas during the period 16 September 1967 through 15 September 1973. The highlights of the four major areas forming the remote sensing system are presented. A detailed description of the latest radar spectrometer results is presented since the findings have not been reported previously.

ULABY, F. T., Interim Technical Progress Report, Ninth Semi-Annual Technical Report, September 1971 - March 1972, Project THEMIS: A Center for Remote Sensing, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-72-4, March 1972, NTIS AD 743 234.
(University of Kansas, Lawrence, Kansas)

Author Abstract - This report summarizes the technical progress under the subject contract on a broad interdisciplinary effort for the involvement of user utility of remotely sensed data. This effort involves theoretical work, sensor development processing and display, and data analysis for specific user application. A number of technical reports and memoranda describing work underway are attached.

ULABY, F. T., A. K. Fung and S-T Wu, The Apparent Temperature and Emissivity of Natural Surfaces at Microwave Frequencies, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., March 1970, NTIS AD 872 878L.
(Center for Research, Inc., The University of Kansas, Lawrence, Kansas)

Author Abstract - The effect of surface roughness on the emissivity of natural surfaces has attained considerable importance in the fields of passive microwave remote sensing of environment and planetary surface emissions. Between the plane surface model and the Lambert surface model, which describe the two extreme cases of a perfectly flat surface and a very rough surface respectively, two statistical surface models have recently been considered: the geometric optics type surface and the physical optics type surface.

This paper examines the behavior of the microwave emissivity of some natural surfaces as a function of nadir angle and polarization. This examination includes a comparison between measured and calculated values of the apparent temperature of the ocean surface at 19.4 and 37 GHz.

Utility of Radar Imagery in the Production of Tactical Terrain Data, Military Capabilities Report, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Final Report ETL-0045, July 1975, NTIS AD-B011 920L.
(Defense Mapping Agency Topographic Center, Washington, DC)

Author Abstract - This report describes the approach and procedures used to produce Tactical Terrain data from radar imagery. The interpretation capability afforded by radar imagery was examined and evaluated in terms of generating a terrain data base which includes analysis for vegetation, surface configuration, lines of communication, soils, drainage and inland hydrography, and geology. The data base products were synthesized into trafficability determinations for cross-country movement and estimated limits of horizontal visibility. In addition, a package of products was developed to demonstrate the applicability of radar imagery to the Pershing II program.

It was concluded that: (1) Tactical support products can be generated from radar imagery; (2) the imagery has the capability of producing data reasonably compatible to the amounts and quality offered by conventional vertical photography provided the scales are approximately the same and parable collateral sources are used to support the interpretations; (3) accuracy and completeness of the derived data is dependent upon the analyst's training in the interpretation of radar imagery, and the capability to rectify the imagery, and the supportive data available; (4) stereoscopic coverage and interferometer data are essential to all facets of the analysis; and (5) additional study in the methods and technology should improve the number and quality of the products.

WAITE, W. P., Broad-Spectrum Electromagnetic Backscatter, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., August 1970, NTIS AD 878 341L.
(Center for Research, Inc., The University of Kansas, Lawrence, Kansas)

Author Abstract - An experimental investigation of broad-spectrum electromagnetic backscatter was performed. Continuous spectral responses of natural and manmade targets and surfaces were measured to examine the fine grain and gross variations with frequency of the backscattered return. The frequency variation of a discrete scatterer model was examined for a variety of illuminating conditions. Experimental measurements of return variance for several effective bandwidths were compared with the predictions of the theoretical model. The spectral response variations remaining after the removal of fading affects were normalized and compared with similar response characteristics from the visual and infrared regions. Monochromatic and panchromatic images were produced to illustrate the improvement obtainable with frequency averaging.

The results of this experiment graphically illustrate the improvement in return variance possible with panchromatic illumination. In addition, the spectral response variations remaining after the removal of fading effects were shown to be comparable to the variations encountered in the visual and infrared regions.

WING, R. S., Structural Analysis from Radar Imagery, Eastern Panamanian Isthmus, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., August 1970, NTIS AD 715 322.
(University of Kansas, Lawrence, Kansas)

Author Abstract - The Panamanian Isthmus where three major crustal plates have apparently long interacted, records a strain pattern that can be used to help advance knowledge of global tectonics. Recent radar coverage has provided this previously unobtainable surface geologic data. A belt of (individually) north-trending left-lateral en echelon anticlines nearly bisects Darien Province, extends northwestward across the Pacific Hills, and culminates in compound large-scale faulted folds adjacent to the east end of the Maje Range. Observed distortion within this belt is compatible with postulated left-lateral movement at depth between longitudinal blocks which constitute the Isthmus and parallel in trend. A similar strain pattern is in evidence in the Maje Range.

The Panamanian Isthmus is situated in the southwest corner of the Caribbean plate which it is postulated, has been subject to compression from active translation of the South American plate. Eastern Panama has apparently been subject to left-lateral simple shear deformation because of the oblique orientation of the principal compressive stress relative to the nonhomogeneous make-up of the Isthmus. In addition, the Caribbean plate has been moving slightly eastward, relative to South America, and the drag between them may account for observed right-lateral transisthmian distortion, notably from San Miguel Bay northward to the Caribbean.

YORITOMO, K., All-Weather Mapping, presented at the ASP Semi-Annual Convention, Dayton, Ohio, 22-24 September 1965.
(USAEGIMRADA, Fort Belvoir, VA)

Author Abstract - Despite significant advancements in the precision and rapidity of mapping from aerial photography, the problem of inclement weather remains as a major and constant obstacle to topographic mapping. This paper will describe the present research efforts being conducted by GIMRADA in the field of all-weather mapping. All-weather mapping will be defined and the results of a survey of all-weather mapping sensors will be described. The basic concepts of all-weather mapping systems will be outlined along with the expectations and known limitations of such a system.

ZABAGLO, S. A., Part A - Side-Looking Radar Data Requirements for Automated Mapping on the UNAMACE. Part B - Technical Report for Automatic Line Follower, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-CR-72-18, August 1972, NTIS AD 909 745L.
(Bunker Ramo Corp., Westlake Village, CA)

Author Abstract - Part A of this report describes the data requirements of side-looking radar to compile class A and class B maps on the Universal Automatic Map Compilation Equipment (UNAMACE). The equations implemented by the UNAMACE program are defined, and test models are shown which were generated to verify program operation. An analysis of the side-looking radar parameters was made to determine the maximum allowable horizontal and vertical error induced by each parameter both individually and collectively. Part B of this report describes the hardware and software required to implement an Automatic Line Follower on the UNAMACE. The line follower is capable of accurately measuring the X-Y coordinates of the interferometer traces on the side-looking radar photograph.

SECTION	REPORT TITLE
5	Meyer, M. A., Remote Sensing of Ice and Snow Thickness.

18. SATELLITE SYSTEMS

ANDERSON, D. M. and H. L. McKim, Application of the Landsat Data Collection System in Alaska, presented at the International Telemetering Conference, Silver Spring, Maryland, 14-15 October 1975.

Author Abstract - LANDSAT data collection platforms have been interfaced with a variety of environmental and water quality sensors to test performance, reliability and versatility of the LANDSAT data collection system. Signal conditioning interfaces were required for sensors selected to measure: ground, soil and air temperatures; wind passage and speed; snow accumulation and ablation; pore water pressures; salinity; pH; dissolved oxygen; and water stage. System performance was found to be excellent; system reliability was high. Considering technical aspects only, exploitation of this satellite system for automated environmental and water quality data collection is hindered most by the relatively immature state of sensor and interface development. Notwithstanding, well prepared, two man field parties had no difficulty in deploying DCPs with their associated antennae and sensor subsystems in remote subarctic location. Environmental data acquired at the various sites are being used in the assessment of the environmental impacts associated with the proposed construction of two hydropower dams on the Susitna River in interior Alaska, on the effects of impoundments over permafrost, and in assessing the effects associated with the construction and operation of the trans-Alasks pipeline.

ANDERSON, D. M., W. K. Crowder, L. W. Gatto, R. K. Haugen, T. L. Marlar, H. L. McKim, and A. Petrone, An ERTS View of Alaska, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TR 241, June 1973, NTIS AD 765-442/9.

Author Abstract - A preliminary study has been made of the value of satellite imagery in synoptic survey of the distribution and environmental interrelationships of permafrost terrain and of coastal sedimentation and related processes in Cook Inlet, Alaska. Earth Resources Technology Satellite multispectral scanner (MSS) imagery was the primary data source for this investigation. Aerial underflight imagery and ground observations of selected sites were secondary data sources. Emphasis has been placed on evaluating the feasibility of mapping permafrost terrain from textural and tonal patterns related to surficial geology and vegetation. A mosaic of a 153,400-km^2 area in north-central Alaska has been prepared at a scale of 1:1 million. Seven surficial geology, eight vegetative cover and four permafrost terrain units were defined and delineated. Many geomorphic features were recognized: thaw lakes, stream drainage patterns, glacial moraines, cirques, abandoned glacial valleys and volcanic cones. Preliminary analysis of the regional hydrologic and oceanographic processes in Cook Inlet has been accomplished. It is evident that the distribution of sediments and regional circulation patterns can be monitored using imagery.

ANDERSON, D. M., L. W. Gatto and F. Ugolini, An Examination of Mariner 6 and 7 Imagery for Evidence of Permafrost Terrain on Mars, presented at the Second International Conference, National Academy of Science, MP 523, 1973. (USACRREL, Hanover, New Hampshire)

Author Abstract - The Mariner 6 and 7 satellite imagery of Mars was processed by computer techniques for maximum discriminability and examined for geomorphic evidence of permafrost. Particular attention was given to the region lying between 10 - 70 long. and 20 N to 20 S lat., a region described as chaotic terrain by Leighton et al. For comparison, the alas thermokarst topography in Yakutia, Siberia, was identified as the best known terrestrial analog. The geomorphic features characteristic of the ice-cemented permafrost adjacent to receding portions of the polar ice caps at Thule, Greenland, and Beacon Valley, Antarctica, were also studied as analogous to Martian permafrost terrain. The environmental conditions characteristic of these areas were compared with those thought to be generally characteristic of Mars. The periglacial area at Thule receives 144 mm of precipitation yearly and has abundant surface water during the summer melt season. In contrast, Beacon Valley has little precipitation, drier air, and lower temperatures and, of the two, is considered the most apt analogy for the cold desert environment of Mars.

ANDERSON, D. M., Remote Analysis of Planetary Water, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 154, April 1971, NTIS AD 722 782. (USACRREL, Hanover, New Hampshire)

Author Abstract - The analysis of the various forms of water occurring in the surficial material of planetary bodies is a requirement of high priority in extraterrestrial explorations. It was an initial requirement of the 1973-75 Viking project to explore the planet Mars. A scheme for identification and analysis of ice, free or absorbed water, and water of construction based on scanning calorimetry and found suitable for the Viking missions is described and critically examined from the point of view of sensitivity and freedom from ambiguity and interferences. It is concluded that a thermal method, for example, differential thermal analysis or differential scanning calorimetry combined with effluent gas analysis is well suited for surveying the amounts and states of water at the surface of Mars.

ANDERSON, D. M., H. L. McKim, and L. W. Gatto, The Use of ERTS-1 Imagery in Regional Interpretation of Geology, Vegetation, Permafrost Distribution and Estuarine Processes in Alaska, Remote Sensing of Earth Resources Institute of Tullahome, University of Tennessee, Vol. 2, MP 644, 1973. (USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

ANDERSON, D. M., et al., Application of ERTS-1 Imagery to Terrestrial and Marine Environmental Analyses in Alaska, presented at the Third ERTS-1 Symposium, Vol. 1, Technical Presentations MP 769, NASA Special Publication 351, December 1973. (USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

AXELROD, J. and R. Ludwig, Research in Space Photogrammetry, U. S. Army Engineer Research and Development Laboratory, Fort Belvoir, Va., Final Report 855, NTIS AD 722 789.

Author Abstract - A design study for a systematic experimental investigation into atmospheric optics is presented.

The parameters of terrain and atmosphere which affect the intensity of the upwelling radiation in or above the atmosphere are derived. It is shown that simultaneous measurements of the upwelling radiance at the earth's level and at altitude, and certain other measurements, are required in order to find the relevant atmospheric parameters.

The measurements should be made spectrally, and it is argued that a photoelectric spectrophotometer is the best instrument. An auxiliary boresighted camera will identify the field of view of this instrument. It is preferable to work over prepared targets at first, and so a high altitude airplane is the best vehicle.

The response of a photographic system may be computed if the upwelling spectral intensity is known, and this may be checked by means of the auxiliary camera. It would be desirable to be able to pre-select the best filter and film for a mapping mission, knowing the general type of terrain, amount of haze, and solar elevation. There is a theoretical way of computing the spectral upwelling intensity, which would therefore allow the best photographic system to be predicted.

The experimental program proposed here would serve as a systematic check on the theory, and conversely the theory would aid in interpreting the experiments.

A theoretical study and a suggested experimental procedure in stellar photography is also presented.

The expression for the threshold of photographic visibility is derived in terms of the parameter of the optical and photographic systems and the spectral radiation of the sun and sky background. It is assumed that the star will have a GO spectral distribution and can therefore be referred to the sun. The incremental variation in the photographic threshold as a function of the fractional variation of the optical and photographic system parameters is shown qualitatively.

A calculation for a particular system is carried out. The choice among panchromatic film is made on the basis of figure of merit which is derived from the basic expression for the photographic visibility threshold while that of camera is made among readily availabile standard aircraft reconnaissance equipment. When the selections are determined, it becomes possible to calculate the spectral width necessary, the filter required, the numerical values for sun and sky background radiation, and therfore the expected stellar magnitude at the photographic threshold.

In the last section an experimental procedure is suggested that would provide a check on the theory and the assumptions made therein.

CAMPBELL, W. J., R. O. Ramseier, R. J. Weaver, and W. F. Weeks, SKYLAB Floating Ice Experiment, National Aeronautics and Space Administration Science and Applications Directorate, Lyndon B. Johnson Space Center, Houston, Texas, December 1975, MP 842. (USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

GATTO, L. W., Cook Inlet, Alaska, Bay Processes, Remote Sensing for Environmental Analysis, Reference Document for Planners and Engineers, Office of Chief of Engineers, Washington, D. C.

Author Abstract - No abstract.

GATTO, L. W., H. L. McKim, and A. Petrone, Sediment Distribution and Coastal Processes in Cook Inlet, Alaska, presented at the Second ERTS-1 Symposium, Vol. 1, NASA Special Report 237, 1973. (USACRREL, Hanover, New Hampshire)

Author Abstract - Regional hydrologic and oceanographic relationships in Cook Inlet, Alaska have been recognized from sequential ERTS-1 MSS imagery. Current patterns are visible in the inlet because of differential concentrations of suspended sediment. The circulation patterns within Cook Inlet are controlled primarily by the interaction between the semi-diurnal tides and the counter clockwise Alaska current. In general, heavily sediment laden water is seen to be confined to portions of the inlet north of the Forelands and west of Kalgin Island. Tongues of clear oceanic water are observed to enter the inlet through Kennedy Channel along the east shoreline in the vicinity of Cape Elizabeth. A recurring counter-clockwise circulation pattern observed around Kalgin Island seems to result from the interplay of the northerly moving water along the east shore and the southerly moving, sediment laden, water along the west side of the inlet. Prominent fresh water plumes, heavily laden with sediment are visible at the mouths of all major rivers. Reflect plumes from as many as three tidal stages have been recognized.

GRABAU, W. E., Pixel Problems, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, WES-MP-M-76-9, May 1976, NTIS AD A026 598.
(USAWES, Vicksburg, Mississippi)

Author Abstract - The exploitation of airborne and satellite-mounted multispectral cameras for the acquisition of terrain information depends upon a detailed understanding of the way in which images are formed by scanner systems, and upon methods of manipulating the radiance values that actually comprise the primary record from which the image is derived. Items discussed include: geometric distortions of the images; relations among pixel size, resolution, and contrast; variations in image geometry caused by mismatches in phase and alignment of pixel arrays; variations in image geometry caused by scanning geometry; and variations in image geometry due to pixel shape.

HAUGEN, R., L. W. Gatto, C. W. Slaughter, H. McKim, and T. L. Marlar, ERTS-1 Imagery Arctic and Subarctic Environmental Analysis, Army Research and Development News Magazine, December 1972.
(USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

HAUGEN, R. K., H. L. McKim, L. W. Gatto, and D. M. Anderson, Cold Regions Environmental Analysis Based on ERTS-1 Imagery, presented at the 8th International Symposium on Remote Sensing of the Environment, University of Michigan, 2-6 October 1972.
(USACRREL, Hanover, New Hampshire)

Author Abstract - An overriding problem in arctic and subartic environmental research has been the absence of long-term observational data and sparseness of geographical coverage of existing data. Studies of synoptic environmental events over regional-size areas have been either impossible or prohibitively expensive. The launching of ERTS-1 on July 23, 1972 provides for the first time a means of accomplishing many types of investigations that were not feasible previously. Presented here is an analysis of the Upper Koyukuk-Kobuck River area located in NW Alaska. The image analyzed (1003-21355-457) is a color composite made from data acquired in the green, red and infrared bands of the multispectral scanner. The area is devoid of cultural features except for several small villages and bush airstrips near the rivers. Documented information on the environment of the area is limited, consisting largely of statewide coverage of geology, vegetation, permafrost and climate. Therefore, a substantial challenge is provided in the interpretation of regional permafrost distribution and regimes in Alaska.

HIBLER, W. D., III, S. F. Ackley, W. K. Croser, H. L. McKim, and D. M. Anderson, Analysis of Shear Zone Ice Deformation in the Beaufort Sea Using Satellite Imagery, presented at the Symposium on Beaufort Sea Coast and Shelf Research, Arctic Institute of North America, MP 793, 1974.
(USACRREL, Hanover, New Hampshire)

Author Abstract - A series of ERTS images from the coastal zone of Alaska are analyzed to give the deformation and drift of the nearshore pack ice. Points were followed for a 4-day period during March 1973 using sets on about a 15-km grid spacing. Least squares strain calculations yielded shear and divergence rates as large as 1.3/1,000,000/sec (0.5 percent per hour). Continuous deformation measurements through the fast icepack ice boundary indicated that the velocity profile has a maximum relatively close to the boundary and that the vorticity changes sign as the distance from the boundary increases. This effect was also verified by Very High Resolution Radiometer (VHRR) imagery. These deformation results suggest that, to a large extent, the arctic pack ice in the Pacific Gyre is behaving as a relative cohesive mass with slippage over a naroow region (about 50 km) at the boundaries. In terms of drift models, this means that the assumption of no slip at the boundary coupled with a single viscosity model is not tenable. However, either a two-viscosity model or a model allowing slip at the boundary provides a reasonable explanation for the observed behavior. As a corollary to such a slip model, shear stresses should be less for a given differential velocity near the shore than for the same differential velocity in the interior of the pack ice.

HIBLER, W. D., III, W. B. Tucker, and W. F. Weeks, Measurement of Sea Ice Drift Far From Shore Using LANDSAT and Aerial Photographic Imagery, presented at the Third International Symposium on Ice Problems, August 1975.
(USACRREL, Hanover, New Hampshire)

Author Abstract - This paper discusses recent work on the development of analysis procedures for obtaining drift and deformation measured from sequential visual imagery of sea ice that is located far from land. In particular for LANDSAT images far from land a semi-automatic procedure for transferring the location coordinates of a common set of ice features from the Earth coordinate system of one image to another is discussed. Necessary inputs for the transfer are the location coordinates (latitude and longitude) of the center of each image and the location of two arbitrary points on a known line of longitude; all this information is available from LANDSAT, although with some error. With regard to measuring strain from sea ice aerial imagery without ground control, errors in such measurements are examined using uncorrected photographs. The errors in using such uncorrected imagery and using common undeformed ice floes to establish a common scale are found to be of the order of 1% whereas typical maximum differential motion are as large as 5%.

HIBLER, W. D., III, W. B. Tucker, and W. F. Weeks, Techniques for Studying Sea Ice Drift and Deformation at Sites Far from Land Using LANDSAT Imagery, presented at the Tenth International Symposium on Remote Sensing, MP 866, October 1975.
(USACRREL, Hanover, New Hampshire)

Author Abstract - In order to estimate sea ice drift and deformation using LANDSAT imagery far from shore, it is necessary to transfer the location corrdinates of a common set of ice features from one image to another. The accuracy of the drift rate and the vorticity determination is dependent upon the accuracy of the coordinate transfer. The strain rate, on the other hand, is, with certain important exceptions, dependent only upon the accuracy with which common ice features on a pair of images can be brought into coincidence. The key exception here is that errors in the rotation of the coordinate system that are incurred during the transfer process will induce spurious strain rates if velocities are estimated by merely substracting location coordinates in a rectangular coordinate system. This important effect will also occur if a given rotating floe is used to establish a common coordinate system. Such spurious effects can be avoided by using an appropriate least-squares strain program in polar coordinates.

A semi-automatic procedure for rapidly and accurately transferring ice coordinates from one LANDSAT image to another and for simultaneously estimating all linear measures of the ice deformation is described. The procedure takes into account the non-parallel nature of the longitude lines and the finite curvature of the latitude lines, factors which are particularly critical in the polar regions. Necessary inputs are the location coordinates (latitude and longitude) of the center of each image and the location of two arbitrary points on a line of longitude on the image. This input information is then utilized in a set of equations which give the effective rotation and translation needed to transfer the north-south, east-west axes centered on one image onto similar axes on another image. These equations, which are valid over distances of several hundred kilometers, bypass the complex and time-consuming procedure of projecting points on the spheroid. After the transfer of common ice feature locations (on successive days) is completed, a least-squares program yields the average strain rate and vorticity with strain rate being independent of errors in the transfer of the coordinate system. The accuracies of the various elements of the procedure are examined using imagery over land and are found to be dominated by deviations (as large as 8 km) of the actual position of the center of the image from its stated position. The average errors produced by these deviations are found to be less than typical one day ice drift distances observed in the Beaufort Sea. Similarly errors in the rotation of the coordinate system due to inaccuracies in longitude lines and in the center locations were found to induce vorticity errors on the order of 0.5%. Although these errors were also significant, they were less than typical sea ice vorticities observed in the same area. With regard to strain, distortions and non-linearities in images were found to cause spurious strains on the order of 0.1% per day. This is somewhat smaller than typical spatial variations in strain that are produced by non-linear nature of the ice velocity field when it is observed on the scale of a LANDSAT image.

KENNEDY, J. G. and A. N. Williamson, A Technique for Achieving Geometric Accordance of LANDSAT Digital Data, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, WES-MP-M-76-16, July 76, NTIS AD-B013 354L.
(USAWES, Vicksburg, Mississippe)

Author Abstract - This report presents techniques for precisely overlaying and registering LANDSAT digital data for analysis of time-dependent phenomena. A practical application of the technique is demonstrated by digitally overlaying two LANDSAT scenes of an area, detecting changes that occurred during the intervening period between scenes, and displaying the results as overlays to 1:250,000-scale maps having a UTM projection. Appendix A to this report presents a method for converting LANDSAT computer-compatible tapes to images on photographic film. Appendices B and C present documentation of two of the computer programs used in this study.

KOVACS, A., A. J. Gow, and W. F. Dehn, Islands of Grounded Sea Ice, prepared for Office of Naval Research,by U. S. Army Cold Regions and Engineering Laboratory, Hanover, New Hampshire, CRREL Report 76-4, April 1976.

Author Abstract - Large areas of grounded sea ice have been reported by early arctic explorers and more recently by the U. S. Coast Guard. The ESSA, ERTS, NOAA and DMSP satellites now provide multispectral imagery with sufficiently high resolution to allow detailed sequential observations to be made of the movement and spatial extent of arctic sea ice. This report discussed the location, formation and decay of five large (greater than 30 km^2) islands of grounded sea ice in the southern Chukchi Sea as observed for an extended period of time using satellite imagery. Measurements of the bathymetry around one grounded sea ice feature are presented along with observations made and photos taken from the ice surface. The potential use of these sea ice islands as research stations is also discussed.

MAGOON, O. T., CERC, Fort Belvoir, Va.; D. M. Pirie, U. S. Army Engineer District, San Francisco, California; and J. W. Jarman, Office Chief of Engineers, Washington, D. C.; Coastal Applications of the ERTS-A Satellite, presented at the 13th Coastal Engineering Conference, Vancouver, B. C., Canada, by the American Society of Civil Engineers for the U. S. Army Coastal Engineering Center, 10-14 July 1972, NTIS 770 183.

Author 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.

MCKIM, H. L., C. J. Merry, S. Cooper, D. M. Anderson, and L. W. Gatto, Applications of Remote Sensing for Corps of Engineers Programs in New England, presented at the Tenth Symposium on Remote Sensing of Environment, Ann Arbor, Michigan, 6-10 October 1975.

Author Abstract - The utility of satellite, high altitude and low altitude aerial imagery is presently being critically evaluated by the Corps of Engineers. When the application has been demonstrated and is cost effective, it is used to update or augment conventional methods and procedures. The most significant contribution to date has been to increase confidence limits by more accurately estimating parameters used in models.

Within the last three years several new cooperative remote sensing programs addressing environmental and hydrologic problems have been implemented by the Cold Regions Research and Engineering Laboratory (CRREL) and the New England Division (NED) of the Corps of Engineers. These efforts have enabled state-of-the-art remote sensing techniques and newly developed staellite technology to be evaluated by field personnel. The initial objective of these programs was to determine the availability, type, scale and resolution required. The second objective was to show how remote sensing methods can be utilized to augment or update conventional procedures.

Imagery from the LANDSAT mission provided valuable information for site evaluation, definition of geologic lineations and monitoring snow and ice accumulation and ablation. This information can have impact on the establishment of design criteria for new Corps facilities or on flood forecasting procedures.

The Skylab program has defined the detail of land use mapping that can be accomplished from the S190A and S190B photography. The results from the S190B data products compared favorably with those obtained from high altitude aircraft photography. The LANDSAT and Skylab S190A data products were not considered adequate for detailed land use mapping although the products were useful for rapid regional land use inventories.

Low altitude aircraft photography (scale 1:33,600) was used to determine the location of materials at a potential dam construction site. This site is located on the St. John River in Aroostook County, Maine, approximately 30 miles west of the town of Ft. Kent. A 335 ft earthen dam will be designed primarily for hydroelectric power, with secondary use for flood control. The results of the study have shown that the amount of material needed for construction of the earthen dam and dikes can be obtained within a six mile radius of the primary dam and four mile radius of the three dike sites. This should allow a large cost saving for transportation of material as compared to original design estimates.

In another program, the effect of inundation at six New England flood control reservoirs was investigated. The effects of the 1973 summer flood were assessed from low altitude color infrared photography and corroborative ground surveys. The extent and severity of tree damage was mapped and analyzed statistically. These results will be used by the Corps in the reservoir management program.

MCKIM, H. L., D. M. Anderson, R. L. Berg, and R. Tuinstra, Near Real Time Hydrologic Data Acquisition Utilizing the LANDSAT System, presented at the Conference on Soil-Water Problem in Cold Regions, Calgray, Alberta, Canada, 6-7 May 1975.

Author Abstract - The LANDSAT Data Collection System (DCS) provides the capability of rapidly collecting hydrologic, meteorologic and environmental data at remote sites throughout the United States and Canada. The coded signals are transmitted via satellite to NASA ground receiving stations where the data are compiled and teletyped to the user. The number of transmissions per day vaires considerably depending on the location of each data collection platform (DCP). In New England about twenty transmissions daily can be obtained; however, in Alaska without the Fairbanks ground station, only about 5 transmissions a day are being received. New data collection platforms that will provide a mechanism for recording up to 6 hours of information and then bursting the message at the time of a satellite overpass will be available within 6 months. This will greatly increase the number of data points that can be accumulated and will permit optimizations of their spread in time.

During the past two years, many sensors have been interfaced to the DCP; one of the most important is a porous cup tensiometer constructed so that a transducer provides a continuous reading of pore water pressure. Field tests have shown that the transmissions from the DCP are accurate and reliable. This system appears to provide a reliable means of measuring pore water pressure at freeze-up and thaw, critical data needed for validation of current hydrologic models.

MCKIM, H. L., L. W. Gatto, C. J. Merry, B. E. Brockett, M. A. Bilello, J. E. Hobbie, and J. Brown, Environmental Analyses in the Kootenai River Region, Montana, final report submitted to the Seattle District Corps of Engineers, Environmental Resources Section, CRREL Special Report 76-13, 1975.

Author Abstract - The purpose of this investigation was: (1) to compile and analyze climatic data for the past 10 years from all available weather observing stations in the East Kootenai River Basin,

(2) to analyze changes in ice and snow cover, and turbidity and plankton blooms on Lake Koocanusa, (3) to assess the present limnology of Lake Koocanusa and the potential for water quality problems, especially eutrophication, and (4) to demonstrate the reliability of the LANDSAT Data Collection Platform (DCP) - Martek Water Quality Monitor system for acquisition of data from a remote site. Results of the investigations indicate that the Kootenai region is about twice as cold as the Libby region in winter, and that reservoir ice first forms along the shore in the northern region in late November and in the southern part in mid-December, with total freeze-over usually occurring 2 to 4 weeks later. Ice break-up in the northern sections usually occurs 1-3 weeks later than in sourthern areas; average annual snowfall is 42 to 144 in., with ice thickness and snowfall varying with relief. Variations in areal distribution of snow within the basin and ice cover on the reservoir were observable for periods from January to October 1973, and reservoir turbidity was observed to increase south of Ellsworth and Stenerson Mountains. Low algae productivity observed was due to the algae being circulated most of the time below the depth of 1% light and due to high turbidity. The DCP - Martek system operated well and reliable data were received while the system was located in the pool above Libby Dam and downstream below the dam. Brief interruptions in data transmissions occurred in April, when the Martek sensor showed a few minor inconsistencies, but the system demonstrated the feasibility of this technique for data acquisition from remote sites.

MCKIM, H. L., L. W. Gatto, C. J. Merry, and R. K. Haugen, Skylab Imagery: Application to Reservoir Management in New England, final report submitted to NASA, CRREL Special Report 76-7, 1976.

Author Abstract - The purpose of this investigation was to determine the utility of Skylab S190A and B photography for providing reservoir management information in New England. LANDSAT, Skylab S190A and S190B and RB-57/RC8 images were reduced to a common scale of 1:63,360 for a mapping base to demonstrate the extent to which the imagery could be utilized in the preparation of reconnaissance land use maps. These types of maps are required in the baseline evaluation of areas for reservoir management planning and for future environmental planning activities, i.e. permit evaluation and impact statements. Visual interpretations were accomplished on original NASA color infrared S190A/B and RB-57/RC8 transparencies and a LANDSAT false color print made in-house. Ancillary data were not used during the mapping exercise to eliminate bias in the comparisons and to ensure that the results were derived strictly from interpretations of tones and textures on the photography. The classification scheme was a modified version of the U. S. Geological Survey Land Use Classification System for use with

remote sensor data. The mapping units delineated from each of the data products were as follows: LANDSAT-1 MSS-5 individual level I, 2 combined level I, and 8 level II; S190A-6 level I and 13 level II; S190B-6 level I, 17 level II and 1 level III; and RB-57/RC8-6 level I, 21 level II and 5 level III. This investigation demonstrates that for land use mapping the Skylab S190B photography compares favorably with the RC8 photography and is much superior to LANDSAT-1 MSS imagery and Skylab S190A photography. The relative utility of the multiband imagery in identifying and quantifying hydrologic factors was evaluated. The land use statistics for two small watersheds were determined and the effects of these land use factors were appraised for possible contribution to runoff potential. This appraisal indicated that basin topography and the nature of runoff may be more important factors in predicting volume of runoff from a watershed than land use factors. Significant findings of this investigation were as follows: (1) S190B imagery is superior to the LANDSAT MSS imagery for land use mapping and is as useful for category I and II land use mapping as the high altitude RC8 imagery. Detailed land use mapping at levels III and finer from satellite imagery required better resolution. However, the larger areal coverage available from the S190B imagery is a great advantage. Thus the S190B imagery was found to be nearly ideal for detailed, regional land use mapping; (2) for evaluating volume runoff potentials the S190B imagery was found to be as useful as the RB-57/RC8 imagery; (3) where regional hydrologic surveys and land use mapping are critical requirements in urban planning and natural resource development, the S190B imagery is of great potential value.

MCKIM, H. L., T. L. Marlar, and D. M. Anderson, The Use of ERTS-1 Imagery in the National Program for the Inspection of Dams, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 183, December 1972, NTIS AD 754 579.

Author Abstract - ERTS-1 imagery can be useful in locating circular water bodies over 152 m (500 ft) in diameter. Dams on streams can be identified by an abrupt change in stream width. A linear termination on a water body is a reliable indication of a dam, particularly when it is inconsistent with the normal drainage pattern. Care must be exercised to avoid confusing cloud shadows with water bodies. However, the association of a cloud with its shadow usually can be accomplished since the sun angle is noted in the data given on each ERTS image.

The following information generally can be derived from ERTS imagery:

1. The location of water bodies
2. The size and shape of water bodies
3. The identification of dam sites on major rivers
4. The direction of stream flow of major hydrologic networks

5. Relative water depths and/or gross sedimentation patterns.

ERTS-1 imagery, in general, does not supply information suitable for determining:

1. Dam height

2. Type of dam construction (concrete or earth fill)

3. Depth of water bodies

4. Location of water bodies less than 6 acres

MERRY, C. J., H. L. McKim, S. Cooper, and S. G. Ungar, Preliminary Snow Analysis Using Satellite Digital Processing Techniques for the Dickey-Lincoln School Lakes Project, Maine, presented at the Eastern Snow Conference, Belleville, Ontario, Canada, 3-4 February 1977.

Author Abstract - The primary emphasis of this analysis was to evaluate the accuracy of mapping the areal extent of snow and to determine the relationship between the water equivalent of the snowpack and the radiance obtained from the LANDSAT digital data. The test area selected for this task was the Dickey-Lincoln School Lakes Project located above the confluence of the St. John and Allagash Rivers in northern Maine.

The computer algorithm utilized in this study uses two features--"color" and "albedo" --of the LANDSAT digital data to classify the multispectral data into land and water categories. The "color" of each pixel refers to the relative energy distribution among the four spectral bands (0.5-0.6μ, 0.6-0.7μ, 0.7-0.8μ and 0.8-1.1μ), whereas, the "albedo" refers to the total radiant energy for the entire wavelength region of the four bands (0.5-1.1μ).

Three snow courses (Allagash B, Beech Ridge and Ninemile B) yielding snow depth and water equivalent data were located on the 11 February 1973 computer compatible tape (CCT). This task was accomplished using computer-generated gray scale printouts (scale 1:24,000) and topographic maps. The preliminary results indicated that the snow radiance values remained approximately the same for a similar water equivalent value of 9.5 inches. Extrapolation of these radiance values for the entire watershed can be used to map the areal extent of snow cover/vegetation with a water equivalent value of 9.5 inches which enables computation of potential water runoff.

Future work will include refinement of extrapolation techniques to map classes of snow cover related to water equivalent for a known vegetative cover, slope and aspect for sites located within and outside the Dickey-Lincoln School Lakes Project area. The sites used in the 11 February scene will be studied on the 26 November, 19 April and 23 July CCTs. The change in snow radiance with time will be related to the accumulation and ablation of the snowpack at individual sites. Establishing this relationship will provide techniques that will be useful in subsequent years for predicting spring runoff from snowmelt as long as the site characteristics do not change significantly.

O'NEAL, J. D. and J. R. Burns, Application of ERTS Data to Environmental Inventory and Assessment, presented at the American Society of Photogrammetry Fall Convention, 10-13 September 1974. (USAETL, Fort Belvoir, Va.)

Author Abstract - The use of ERTS imagery to supplement aerial photography and collateral source material has expedited the preparation of land use and vegetative cover maps included in environmental resources inventory studies. The studies are being prepared by the Engineer Agency for Resources Inventories (EARI), an element of the U. S. Army Engineer Topographic Laboratories, to satisfy Civil Works program requirements of Corps of Engineers Division and District offices for basic input for project planning and preparation of environmental impact statements. The paper describes recent experience gained by EARI in support of programs of District offices of the Lower Mississippi Valley Division and the Ohio River Division of the Corps.

PIRIE, D. M., U. S. Army Engineer District, San Francisco, California; and D. D. Stellar, Earth Science Consulting and Technology, Inc., Costa, Mesa, California; California Coastal Processes Study - LANDSAT II, Goddard Space Flight Center, Greenbelt, Maryland, Final Report, April 1977.

This study reports on the continued use of Landsat data in the analysis and description of long and short-term littoral and nearshore processes along the California coast. The effects of these processes on natural and modified shorelines and the capability to demonstrate the utility of Landsat derived information are important considerations of U. S. Army Corps of Engineers in coastal protection, coastal zone management and engineering planning. The processes studied include sediment transport, river discharge, nearshore currents, and estuarine flushing. Landsat data as well as aerial photography and surface data covering a four year period were analyzed to determine the variability of coastal processes.

The specific objectives of this investigation included the determination of sediment transport parameters measurable in the Landsat data and application of this information to everyday coastal planning and construction.

By using suspended sediments as tracers, other specific objectives were met by the qualitative definition of the nearshore circulation along the entire coast of California with special study sites at Humboldt Bay, the mouth of the Russian River, San Francisco Bay, Monterey Bay, and the Santa Barbara Channel. Although Landsat primarily imaged fines and silts in the surface waters, the distribution of sediments allowed an examination of upwelling, convergences, and coastal erosion and deposition. In Monterey Bay and Humboldt Bay these coastal phenomena were used to trace seasonal trends in surface currents. These charts may now be used as a source of basic trends and current patterns in establishing detailed surveys. Coastal managers may utilize these charts as a data source for planning locations of outfall structures or other coastal construction projects.

PIRIE, D. M., U. S. Army Engineer District, San Francisco, California; D. D. Stellar, Geoscience Division, Geosource, Inc., Long Beach, California; California Coastal Processes Study - Skylab, National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Texas, Final Report - EPN 492, June 1975.

Author Abstract - The Skylab imagery from S-190A, S-190B and S-192 experiments was analyzed for coastal and estuarine processes for the San Francisco Bay and the Northern California coast. In northern San Francisco Bay (San Pablo Bay) the sediment transport was traced to areas of known deposition. Information from the Skylab imagery interpretation was found to correlate closely with plots of sediment distribution obtained during the same period by boat surveys. Color composite enhancements of S-192 imagery, bands 4, 6 and 7 provided detailed current and sediment transport patterns. Off the Northern California coast, the surface current patterns from the California and Davidson Currents were mapped. The S-190B color photographs provided the most useful information for this study. Close correlation between the Skylab S-190A film/filter combination and Landsat 1 and 2 imagery provided detailed resolution of the study area not possible with Landsat alone.

PIRIE, D. M., U. S. Army Engineer District, San Francisco, California; D. D. Stellar, Geoscience Division, Geosource International, Inc., Seal Beach, California, California Coast Nearshore Processes Study, Goddard Space Flight Center, Greenbelt, Maryland, ERTS-A Experiment #088 Final Report, May 1974.

Author Abstract - This study analyzes the nearshore processes along the California coast utilizing the ERTS-1 imagery. Findings were confirmed using U-2 photography, low altitude aircraft remote sensing and sea truth data. The major objectives include the interpretation of nearshore currents, sediment transport, river discharge and estuarine surface characteristics. Current direction in the coastal area is detectable in such detail that it is now being used in coastal protection, harbor development and ocean engineering projects along the California coast. The surface current characteristics for the three ocean seasons (Oceanic, Davidson and Upwelling) and for each month were plotted. The majority of the information was interpreted from ERTS-1 MSS band 4 (5000-6000 Angstroms). Band 5 (6000-7000 Angstroms) also supplied much useful insight into the location and dynamic characteristics of the main sediment plumes. It is possible to determine river discharge characteristics including offshore plumes, pulsing effect, direction of sediment transport and general location of deposition. A detailed analysis of the Santa Barbara Channel indicated a close correlation between ERTS-1 image density and suspended sediment concentrations. Enhancement of NASA-supplied 70 mm transparencies and magnetic tapes for subtle nearshore features was successfully accomplished. Flying spot scanner density expansion and computer compatible tapes processing provided much useful information. Results of this study are now being utilized in U. S. Army Corps of Engineers operational coastal programs.

SOLLERS, S. C., The Application of ERTS-1 Data to the Corps of Engineers Civil Works Mission, presented at the American Society of Photogrammetry Fall Convention, 10-13 September 1974. (Office, Chief of Engineers, Department of the Army, Washington, D. C.)

Author Abstract - In support of its Civil Works function, the Army Corps of Engineers is constantly engaged in applied research to observe natural processes and ecological relationships in the interest of preservation of natural resources. Remotely sensed data facilitates this research. The application of remotely sensed imagery results in the saving of time and money and increased precision in gross evaluation of large ecosystems and provides a convenient method to monitor changes within such a system. Several projects are now underway employing remotely sensed data acquired from the NASA Earth Resources Technology Satellite (ERTS-1).

TELEKI, P. G., CERC, Fort Belvoir, Va.; G. A. Rabchevsky, Terratek, Inc., Lanham, Maryland; and J. W. White, Photo Science, Inc., Gaithersburg, Maryland; On the Nearshore Circulation of the Gulf of Carpentaria, Australia - A Study in Uses of Satellite Imagery (ERTS) in Remotely Accessible Areas, presented at the American Society of Photogrammetry Sumposium on Remote Sensing in Oceanography, Lake Buena Vista, Florida, October 1973, NTIS AD 775 651.

Author Abstract - The Gulf of Carpentaria has been studied from ERTS-imagery from August 1972 to January 1973. This inland sea was chosen to be the test site for assessing the usefulness of satellite imagery to the mapping of hydrologic parameters in areas of difficult access. The examination of the contents of MSS channels 4, 5 and 6, enhancements of these bands and density slicing in two test areas indicates that sediment dispersal can be studied and mapped on a seasonal basis. Transport directions for coastal sediments in the months August, November and January were found to corroborate Cresswell's hypothesis about the bidirectional nature of non-tidal currents along the east coast of the Gulf. Accordingly, this current is northerly during the influx of Type C water, changing to southerly when Type B water enters the Gulf.

VOGEL, T. C., An Analysis of LANDSAT Systems for Cartographic and Terrain Information (Report No. 9 in the ETL Series on Remote Sensing), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0103, June 1977, NTIS AD-A044 431. (USAETL, Fort Belvoir, Va.)

Author Abstract - The scientific and technical literautre is reviewed to analyze the capabilities of LANDSAT Systems 1, 2, 3, and 4 for hydrographic, topographic, planimetric, and thematic map compilation. The systems capabilities were analyzed according to the following qualitative code for a selected list of map and chart requirements: 0 - Not detectable, the map element cannot be discerned or located from either type of LANDSAT data; 1 - Detectable, map element can be detected but not identified from the type of LANDSAT data indicated; 2 - Identifiable, map element can be detected and recognized as a particular type of feature from the LANDSAT data indicated, e.g. road, canal, etc., collateral information may be required to reach this analysis level; 3 - Classifiable, LANDSAT data, with the use of all available collateral information, can provide the information required for the map element including all required measurements, e.g. width, length, and areas. It was concluded that LANDSAT 1, 2, 3 MSS data is compatible with National Map Accuracy Standards and can be used to update the map elements on map scales 1:1,000,000 through 1:250,000, although many of the cultural, hydrographic, and botanical elements may be unclassifiable. The improved systems capabilities of LANDSAT 4 may provide a method for updating map scales 1:1,000,000 through 1:50,000. However, many of the required cultural and hydrographic map elements may remain unclassifiable even with the Thematic Mapper system.

WORKSHOP FOR ENVIRONMENTAL APPLICATIONS OF MULTISPECTRAL IMAGERY, Fort Belvoir, Virginia, (Cosponsored by U. S. Army Engineer Topographic Laboratories and The American Society of Photogrammetry) 11-13 November 1975.

SECTION	REPORT TITLE
5	Ackley, S. F., and W. D. Hibler, Measurements of Arctic Ocean Ice Deformation and Fracture Patterns from Satellite Imagery.
5	Bilello, M. A., Surface Measurements of Snow and Ice for Correlation with Aircraft and Satellite Observations.

19a. TERRAIN ANALYSIS (COLD REGIONS)

ACKLEY, S. F. and T. E. Keliher, Antarctic Sea Ice Dynamics and Its Possible Climatic Effects, AIDJEX Bulletin #33, 1976, University of Washington.

Author Abstract - No abstract.

ANDERSON, V. H., Sea Ice Pressure Ridge Study: An Airphoto Analysis, Photogrammetria, December 1970, 26(5/6), MP 34. (USACRREL, Hanover, New Hampshire)

Author Abstract - Tested and proven techniques of terrain analysis using conventional aerial photography were applied to interpret the patterns associated with a sea ice environment. Ages and relative thicknesses of sea ice masses were determined from stereoscopic aerial photography. A classification scheme of sea ice pressure ridges is developed based upon their linear surface trace, their relative ages, their heights, widths and lengths, their location relative to recent ice movement, and the size of the material composing the ridges. The significance of sinuous ridges with respect to straight ridges is discussed relative to the forces involved in their formation. Estimates as to the underwater components of pressure ridges are deduced based upon elements of their surface configuration and pattern.

ANDREEV, V. N., Interpretation of Different Types of Tundra from Aerial Photographs and Their Aerovisual Description on the Basis of Frost Jointing (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 7, 1969, NTIS AD-692 646.

Author Abstract - No abstract.

CROWDER, W. K., H. L. McKim, S. F. Ackley, W. D. Hibler III, and D. M. Anderson, Mesoscale Deformation of Sea Ice from Satellite Imagery, "Advanced Concepts and Techniques in the Study of Snow and Ice Resources," Monterey, CA, National Academy of Sciences, 1974.

Author Abstract - No abstract.

HARTWELL, A. D., Airphoto Analysis of Ice Deformation in the Beaufort Sea, March 1971, Arctic Ice Dynamics Joint Experiment, AIDJEX Bulletin, May 1972, No. 13, MP 565. (USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

HIBLER, W. D. III, S. F. Ackley, W. K. Crowder, H. L. McKim, and D. M. Anderson, Analysis of Shear Zone Ice Deformation in the Beaufort Sea Using Satellite Imagery, in Coast and Shelf of the Beaufort Sea, J. C. Reed and J. E. Satier, Ed., pp. 285-299, AIWA, 1974.

Author Abstract - No abstract.

HOEKSTRA, P., et al, Ground and Airborne Resistivity Survey of Permafrost Near Fairbanks, Alaska, Geophysics, MP 832, August 1975.
(USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

KOVACS, A. and G. Abele, Blue Ice Runway Site Survey, Pensacola Mountains, Antarctic Journal of the United States, July-August 1974 9(4), MP 798.

Author Abstract - Aerial reconnaissance of potential blue ice runway sites for heavy, wheeled aircraft revealed large blue ice areas east of Mt. Cross, west of Mt. Whillans, and at Mt. Bruns in the Patuxent Range, and to the north and the west of Rosser Ridge in the Cordiner Peaks. Topographic surveys were made of the blue ice surfaces north of Rosser Ridge and at the base of Mt. Lechner, and the data are presented. Considerations of the effects of elevation, temperature, grade, and wind indicate that the Rosser Ridge site is more suitable as a runway. Power spectral density analysis of the two sites' ice surfaces showed them to be similar to field runways.

LEIGHTY, R. D. Use of Aerial Photographs and Field Reconnaissance for Ice Cap Route Location at Narssarssuaq, Greenland, Photogrammetric Engineering, March 1962, 28(1), MP 265.
(USACRREL, Hanover, New Hampshire)

Author Abstract - A report is given in the combined use of aerial photographic interpretation techniques and field and aerial reconnaissance to obtain information on terrain conditions in order to solve highway engineering problems in mountainous areas. The purpose of the study was to locate and evaluate an access area from the sea to the ice cap in Southern Greenland. The Narssarssuaq area was agreed upon after the summer of 1957 had been devoted to verification of predictions made in a preliminary study of small-scale aerial photographs, from which a tentative route had been selected, and to a field survey of the proposed route. The use of aerial photographs in the preliminary study and in the field yielded a maximum amount of information in a minimum amount of time for location of the road and preparation of an engineering report.

19b. TERRAIN ANALYSIS (GENERAL)

ANSON, A., Status of Aerial Color Photography in Government Agencies, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technology Brief TB-1, May 1968, NTIS AD 674 189. (USAETL, Fort Belvoir, Va.)

Author Abstract - The utility of aerial color photography for studies in the fields of geology, geography, archaeology, landforms, range management, target detection, highway planning, and hydrology has been recognized by those who are working in aerial photography; however, the usefulness of color has not been determined adequately for Military Geographic Intelligence. This report is a summation of research into the status of aerial color photography in several Government agencies, and its application to specific problems.

CURRIN, T. R. and J. W. Ingram, Jr., Terrain Data of Mount Hayes D-4 Quadrangle, Fort Greely, Alaska (Report No. 4 in the ETL Series of Remote Sensing), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-TR-74-7, August 1974, NTIS AD A002 627. (USAETL, Fort Belvoir, Va.)

Author Abstract - This report discusses a field investigation of Fort Greely, Alaska, conducted by the Geographic Sciences Laboratory (GSL) of the U. S. Army Engineer Topographic Laboratories (USAETL) as part of the Test and Analyze Experimental Color and Multiband Photography project. Field teams were deployed to collect terrain information in the areas of soils, vegetation, hydrology, and cultural features; various types of aerial imagery missions were flown coincident with the acquisition of ground data. A discussion of each of the areas of terrain data is presented.

DAVIS, B. R., E. B. Lipscomb, and S. J. Knight, Terrain Analysis by Electromagnetic Means, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES TR-3-693-1, October 1965, NTIS AD-472 873. (USAEWES, Vicksburg, MS)

Author Abstract - This report presents the results of tests conducted to determine the capabilities of active electromagnetic sensors operating in the 0.76- to 5.00-micron spectral region to measure terrain characteristics affecting trafficability of soils. Controlled tests were conducted under laboratory conditions in an attempt to correlate the effects of soil composition, moisture content, and density with the quantity of infrared energy reflected from a soil sample. Results of the tests indicate that the composition and moisture content of homogeneous soil specimens can be characterized by active infrared sensors under controlled laboratory conditions. However, since infrared

energy is reflected by infinitesimally thin surfaces of materials, information concerning density and subsurface parameters cannot be discerned. Techniques for prediction of soil parameters through the use of multiwavelength analysis are discussed.

EHLEN, Judy, Joint Analysis in Glen Canyon National Recreation Area, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-0073, October 1976, NTIS AD-A033 330.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This report attempts to determine what information can be derived from joint patterns developed from air photo analysis of flat-lying sedimentary rocks. The area selected is in the Glen Canyon National Recreation Area along the San Juan River in southeastern Utah. Two types of analysis were undertaken on joint patterns; (1) an analysis of joint orientation depicted on rosette diagrams to determine stress patterns within the various rock units and to determine whether or not they change through time, and (2) an analysis of joint density in which joints were analyzed with a grid and then contoured in order to determine whether or not individual rock units have characteristic joint densities. The results indicated that rock units do have characteristic joint densities and orientations and that they can be differentiated on these bases.

EHLEN, Judy, Photo Analysis of a Desert Area, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0068, April 1976, NTIS AD-A035 481.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Information derived from 1:9,600 scale stereoscopic aerial photography of a desert area near Yuma, Arizona, is presented. Physiography, geology, climate, landform, drainage, erosional aspects, vegetation, and cultural features are considered in the context of local and regional environmental, engineering, and military considerations. The second part of this report presents a field verification of the general geology, geomorphology, and vegetation in the study area with a list of selected references.

KOTHE, K. R., A Program for the Development of Advanced Capabilities for Collection, Analysis, Production and Dissemination of Military Geographic Intelligence, published in AGARD (Advisory Group for Aerospace Research and Development) Conference Proceedings No. 90.
(USAETL, Fort Belvoir, Va.)

Author Abstract - The U. S. Army Topographic Command Research and Development Program in support of Military Geographic Intelligence requirements is described in some detail on an unclassified basis. The R&D program is performed by the Engineer Topographic Laboratories, a command subelement at Fort Belvoir, Virginia. Military Geographic Intelligence is the information concerning the natural and man-made features of the environment required to support planning and operations. To provide Military Geographic Intelligence, operational units must collect the necessary data for a given geographic area and process the data into a suitable form for holding until a request is made for support. On this basis, the objectives of the R&D program are identified as Collection Systems, Data Reduction Systems and Information Systems. To improve data collection capabilities, work is described associated with Sidelooking Airborne Radar and Color Multiband Photographic systems. To improve the data reduction, research and development leading to automated image data extraction capability is reviewed. Then the development of a military geographic information system with an example output is outlined in relation to an overall concept. In conclusion, it appears the research and development objectives can be attained to implement the concept of operations in the 1985 time frame.

LINK, L. E., Jr., Ground Truth Requirements for Remote Sensor Data Acquisition and Analysis, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES Misc Paper M-72-8, November 1972, NTIS AD 752 420.
(USAEWES, Vicksburg, MS)

Author Abstract - Over the past few years airborne remote sensor devices have been developed for different regions of the electromagnetic spectrum that are capable of collecting data on the reflective and emissive properties of terrain. However, experience has shown that the capability to collect data of this type is not, in itself, sufficient to permit its fullest use. In almost every case, data collected with an airborne electromagnetic sensing system (remote sensor) must be augmented by data that define conditions existing in the environment at the time the remote sensor was used. The environmental factors that influence the electromagnetic energy received by remote sensing devices are defined for the following spectral regions: (a) gamma ray, (b) ultraviolet, (c) visible, (d) infrared and (e) microwave. In addition, the remote sensing devices used in each spectral region are

discussed and the environmental factors appraised for relative importance with respect to the final remote sensing product.

LINK, L. E., Jr., Procedures for the Systematic Evaluation of Remote Sensor Performance and Quantitative Mission Planning, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, WES-TR-M-76-8, August 1976, NTIS AD-A030 728. (USAEWES, Vicksburg, MS)

Author Abstract - Effective application of remote sensing techniques to civil engineering and environmental problems requires the selection of the sensor systems that will best provide the information desired. Because of the many phenomena involved and the lack of a simple means to consider them collectively, planning remote sensing missions has been done subjectively, quantitatively on a piecemeal basis, or solely on the experience of the investigator. None of these offers a systematic means to optimize the mission for acquisition of specific information types as a function of the many variables involved. The purpose of this study was to (a) quantitatively examine the natural phenomena that influence the information content of remote sensing imagery obtained in the visible and infrared (IR) portions of the electromagnetic spectrum, and (b) from the knowledge gained through these examinations, develop analytical tools for planning remote sensing missions and provide guidance for application of photographic and thermal IR sensor systems to civil engineering and environmental problems. This study consisted of (a) the development of analytical models that allow systematic control of the major variables that influence the character of imagery produced by photographic and thermal IR scanning sensor systems, and (b) formulation from the models of simple, but comprehensive tools for planning photographic and thermal IR remote sensing missions.

MIROSHNICHENKO, V. P., Use of Aerial Methods for Studying Zonal and Regional Landscape Patterns,(Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 106, September 1969, NTIS AD-695 724.

Author Abstract - Presents a number of specific examples showing the effectiveness of the use of aerial photography in landscape studies. Followed by a review of the author's proposals for coverage of the country by a system of geographic reference profiles running east to the west and north to south across the entire Soviet Union, which could serve as a basis for making more detailed landscape studies.

PETROV, M. P., Utilization of Aerial Photography for the Geographic Study of the Deserts of Central Asia, (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 118, September 1969, NTIS AD-693 147.

Author Abstract - Aerial photographic work in the deserts of East Central Asia, in comparison with the deserts in West Central Asia, does not differ basically. The methods of Soviet scientists using aerial photography in geographic studies on deserts of the Soviet Union could be used also in East Central Asia and elsewhere.

RINKER, J. N., J. Ehlen, A. E. Krusinger, T. R. Currin, A. O. Poulin, and P. B. McCracken, Capabilities of Remote Sensors to Determine Environmental Information for Combat, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Report ETL-0081, Nov. 1976, NTIS AD-A035 139. (USAETL, Fort Belvoir, Va.)

Author Abstract - U. S. Army Field and Technical Manuals were used to develop a list of 313 environmental information needs, or factors, required by the Army to accomplish its various tasks. Each factor was evaluated against a list of remote sensing systems to determine the extent to which each system could provide the needed information. Interpretation procedures were restricted to evaluation of imagery by conventional interpretation techniques and equipment. The systems evaluated are LANDSAT (ERTS), radar, thermal infrared, low-level oblique photography, standard photo index sheets, stereo 1:100,000 scale vertical aerial photography, and stereo 1:20,000 scale vertical aerial photography. Each image form is considered for each factor by a means of identification, i.e., by direct observation of the image, by measurements on the image, or by inferential procedures. For each category, one of our levels of capability is assigned. The levels are (1) a practical way of gaining information about a given factor, (2) a possible method, but with limitations, (3) the evidence is not available to make a judgment, but there is no reason that it cannot be done, and (4) the technique is not applicable to the specified factor. The factors were also evaluated in terms of the level of skill required to obtain the information. The evaluation includes comments and discussions about definitions of factors, difficulty in extracting needs from the manuals, limitations with reference to both the factors and the procedures, and possible use of other sensor systems. Four examples that demonstrate the application of the evaluations to specific problems are presented following the evaluation: Cover and Concealment, Cross-Country Movement, Lines of Communication, and River Crossing Operations.

VICTOROV, S. V., et al, Use of Aerial Methods in Landscape Studies, (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 177, October 1969, NTIS AD-698 170.

Author Abstract - The collection of articles covers a wide range of problems: The use of aerial methods in the tundra, taiga, steppes, and sandy deserts; the possibilities of aerial methods for the study of regional characteristics of landscapes; and the applications of aerial photography to large-scale mapping.

VINOGRADOV, B. V., Experience in Large-Scale Landscape Interpretation and Mapping of Key Sectors in the Arid and Sub-Arid Zones of Central Asia and Kazakhstan, (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 178, August 1968, NTIS AD-692 374.

Author Abstract - The paper is a presentation of some results in an experiment with large-scale landscape mapping based on the interpretation of aerial photographs taken during geological, soil and hydrogeological studies in western Turkmenia and in Northern and Western Kazakhstan in 1952-1958. The author deals with all the basic problems involved in landscape mapping such as scales and accuracy. In the text, a number of aerial photographs are accompanied by landscape maps compiled on the basis of these photographs. These landscape maps in turn are fully analyzed as examples of the application and problems of landscape mapping.

The author demonstrates the complexity in interpreting aerial photographs because of the spatial and functional correlations among the individual elements, such as geology, soils, vegetation and hydrology. The methods used in compiling such maps are described and the possible applications of such maps in the national economy are discussed.

VOGEL, T. C., Remote Sensor Image Capabilities for Acquisition of Terrain Information (Report No. 8 in the ETL Series on Remote Sensing), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0054, June 1976, NTIS AD-A026 592. (USAETL, Fort Belvoir, Va.)

Author Abstract - This report utilizes the 1,765 terrain data requirements presented in a USAETL experimental topographic data base system to determine subjectively the overall capability of remote sensor imagery to acquire terrain and environmental information. Remote sensor imagery (RSI) capabilities are evaluated by standard image-interpreter methods and are presented as five levels of capability and two levels of

required mensuration. The capability codes are as follows: A - data element can be obtained from RSI; B- data element can not presently be obtained from RSI; C - partial information obtainable; D - other collection methods required; E - data element not compatible with RSI methods; 1 - measurement in X and Y direction required; 2 - measurement in X, Y, and Z direction required.

The results of these evaluations indicate that 40 percent of the terrain requirements fall in code A, 5 percent in code B, 38 percent in code C, 17 percent in code D, 13 percent in mensuration category 1, and 10 percent in category 2.

VOGEL, T. C., M. J. Lynch, A. O. Lind, and R. W. Birnie, A Matrix Evaluation of Remote Sensing Capabilities for Military Geographic Information (MGI), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-TR-72-6, July 1972, NTIS AD 751 192.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This work is an initial attempt to evaluate 20 selected remote sensor types for their ability to obtain data on specific natural and cultural terrain components (81 selected MGI elements). The evaluations were made at three levels according to the complexity of the MGI element and the level of experience required from the interpreter. The MGI elements were categorized into four major divisions: (1) Drainage and Water, (2) Vegetation, (3) Land-forms and Surficial Materials, and (4) Cultural and Industrial-Economics.

WOLOSHIN, A. J., Evaluation and Comparison of Terrain Classification Methods (Type III), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., June 1968, NTIS AD 845 338L.
(Geonautics, Inc., Falls Church, Va.)

Author Abstract - This report presents the methodology for and conclusions from the detailed evaluation and comparison of the potential of eleven terrain description and classification methods for (1) providing military geographic information and (2) for inclusion in automatic data processing systems. The methodology employs semi-quantitative analyses to determine the relative merits of each terrain description and classification method for describing, classifying and assessing militarily significant terrain parameters. Factors considered, among others, are basic premises of the various methods, descriptive techniques, data input requirements, scales, formats and completeness of terrain descriptions. Results of the study indicate that none of the terrain description and classification methods effectively addresses more than 29% of military geographic information requirements. However, the basic premises and techniques of several methods, if expanded in scope, show promise of effectively meeting military requirements.

19c. TERRAIN ANALYSIS (GEOLOGY)

ANSON, A., Comparative Photointerpretation from Panchromatic, Color, and Ektachrome IR Photography, Report of Working Group I, Aerial Color Photography Committee, American Society of Photogrammetry.
(USAETL, Fort Belvoir, Va.)

Author Abstract - As the result of action by the Color Committee, ASP, several flights were made over the Bennettsville, S. C., Test Area in midsummer 1964. This report, prepared by Work Group I, presents the significant findings of a comparative study of panchromatic, color, and camouflage detection photography of the same area obtained under essentially identical conditions. The study involves the identification and interpretation of specific terrain and cultural features as well as the measurement of predetermined items. Field identification obtained independently is used as a control. Certain advantages are determined for color photography, other advantages are listed for camouflage detection film; both are weighed against the universality of black and white panchromatic film. Cooperating agencies in this effort include the U. S. Air Force, the Coast and Geodetic Survey, the Eastman Kodak Co., the Ansco Corporation, the Fairchild Camera and Instrument Corporation, the U. S. Army Map Service, the Itek Corporation, and the U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency.

ANSON, A., The Use of Color Aerial Photography in the Reconnaissance of Soils and Rocks, Materials Research and Standards, Vol. 8, No. 2.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Man's quest for more intimate knowledge of the structure of the earth, and the distribution of soils and rocks has been the subject of a continuing investigation as man has progressed from the Stone Age to the Nuclear Age. This paper describes the specialized area of the interpretation of soils and rocks which can be obtained from aerial photography in color. Several controlled tests are described, in the Eastern Coastal Plain, Bennettsville, South Carolina, and in the Western Desert, near Phoenix, Arizona. Other work in color photography is described, and some results are given. In using aerial color film, the three layer emulsion presents a more readily understood spectral relationship than can be obtained from black and white film; the reconnaissance of inaccessible areas with their rock structures can be more rapidly analyzed with the aid of the distant view of aerial photography than solely by ground exploration.

The Bennettsville, South Carolina, test demonstrated that geologists never having visited the ground site could make an analysis of soil conditions with the use of 1:20,000 scale aerial photography in color and in Infrared color, with sparse generalized ground information. A highly skilled soils engineer performing interpretation on the Phoenix, Arizona, test photography reached a valid conclusion as to the type of soils in the desert area when he was halfway through the study of the 1:40,000 scale aerial color photography along with infrared color photography. Technical questions regarding the fall-off in color density with the use of wide angle lenses are answered.

Aerial color photography is another tool which can be used to assist soils engineers in the reconnaissance of soils and rocks when employed to its full capability and within its limitations.

ANSON, A., Color Aerial Photos in the Reconnaissance of Soils and Rocks, Photogrammetric Engineering, Vol. 36, No. 4, April 1970.
(USAETL, Fort Belvoir, Va.)

Author Abstract - A specialized area of interpretation of soils and rocks can be obtained from aerial photography in color. Several controlled tests include the Eastern Coastal Plain Bennettsville, South Carolina, and the western desert near Phoenix, Arizona. In using aerial color film, the three-layer emulsion presents a more readily understood spectral relationship than can be obtained from black-and-white film; the reconnaissance of inaccessible areas with their rock structures can be more rapidly analyzed with the aid of the distant view of aerial photographs than solely by ground exploration. Geologists never having visited the ground site could analyze soil conditions using 1:20,000-scale aerial color photographs and infrared with sparse generalized ground information. A highly skilled soils engineer interpretating the Arizona test photographs reached a valid conclusion as to the type of soils in the desert area when he was halfway through the study of the 1:40,000-scale aerial color photographs along with infrared color photographs.

DORNBUSCH, W. K., J. R. May, and W. P. Covey, Distribution of Coarse-Grained Construction Materials and Potential Construction Sites in the Mekong Delta, South Vietnam. Volume II. U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-TR-5-69-7, Vol. 2, NTIS AD-862 584L.
(USAEWES, Vicksburg, MS)

Author Abstract - No abstract.

DORNBUSCH, W. K., Distribution of Coarse-Grained Construction Materials and Potential Construction Sites in the Mekong Delta, South Vietnam, Volume I, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-TR-S-69-7, Vol. I, June 1971, NTIS AD-855 547L.
(USAEWES, Vicksburg, MS)

Author Abstract - This volume presents the techniques developed for the location of natural construction materials and aggregate and potential construction sites in the Mekong Delta region of South Vietnam. Data utilized during the study (e.g., literature, maps, aerial photography) are described and evaluated. Application of these data to accomplish the project objectives is discussed. The physiography and geologic history of the region are presented to permit a more comprehensive appreciation of the physical setting of the delta and the impact of past and present factors in producing today's landscape. The study assumed that landforms and environments of deposition in deltaic regions throughout the world are similar in their evolution and therefore have similar characteristics. Thus, knowledge gained from studies in the Mississippi Delta region, which have resulted in considerable experience in the recognition of landforms and environments of deposition and knowledge of their associated engineering soils through the interpretation of aerial photography validated by a wealth of ground control data, could be applied. This rationale was applied to the Mekong Delta, and the resulting interpretations were effected through the analysis of all available photography and limited ground data.

Photo interpretation techniques were developed for the recognition of landforms and environments of deposition in the Mekong Delta. Elements of interpretation discussed are morphology, drainage, erosion, vegetation, land use, engineering soils, photographic characteristics (tone, contrast, or geometry), associated features, and distribution. Indirect or inferred criteria were also used in the development of the techniques because cultural influence has substantially changed the natural appearance of various landforms.

The techniques developed were applied to the interpretation of aerial photographs and other available data for the preparation of maps showing the distribution of landforms and engineering construction materials in the Mekong Delta. These maps are presented in Volume II and Supplement I to Volume II of this report. Methodologies utilized for the mapping of the quadrangles included in Volume II and Supplement I are discussed and description of the plates and figures presented in these folio reports are included in this volume. Also included is a selected bibliography consisting of approximately 250 references that contain geologic, geomorphic, hydrologic, pedologic, and climatic descriptions of the Mekong Delta and more generally Southeast Asia or that deal with the evolution of deltaic and coastal landforms generally or in other regions of the world.

DORNBUSCH, W. K, J. R. May and H. K. Woods, Distribution of Coarse-Grained Construction Materials and Potential Construction Sites in the Mekong Delta, South Vietnam, Volume II, Supplement, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-TR-S-69-7, Vol. 2, Suppl., June 1970, NTIS AD-875 321. (USAEWES, Vicksburg, MS)

Author Abstract - No abstract.

Forecasting Trafficability of Soils, Airphoto Approach, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, Technical Memo AEWES-TM-3-331-6, Vol 2, June 1963, NTIS AD-410 212. (USAEWES, Vicksburg, MS)

Author Abstract - Forecasting trafficability of soils from aerial photographs.

GELNETT, R. H., Airborne Remote Sensors Applied to Engineering Geology and Civil Works Design Investigations, National Aeronautics and Space Administration, Wash, DC, December 1975. (U. S. Army Corps of Engineers, San Francisco, CA)

Author Abstract* - This report determines the usefulness of various airborne remote sensing systems in the detection and identification of regional and geologic features such as dams, nuclear powerplants, tunnels, underground installations, highways, railroads, etc.

This report is an account of the findings derived from the interpretation of various kinds of imagery used in the study area, which is located in northern California. The interpretations are supported by considerable ground truth data in the project area. The report is not a concluding thesis on the regional geology, nor are the findings necessarily complete.

*Abstract provided by bibliography authors.

HARALICK, R. M. and J. Adams, Gamma-Ray Spectrometer Study, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0008, February 1975, NTIS AD A011 311. (University of Kansas, Lawrence, Kansas)

Author Abstract - Gamma ray spectrometer measurements have been applied to a large variety of problems in rock and soil mapping, terrain analysis, trafficability, snow water equivalent estimation, detection of environmental contamination by nuclear fission products, and direct and indirect mineral exploration. Fuller utilization of gamma spectrometric outputs is currently limited by the inadequacy of data reduction and presentation techniques. This report describes a data reduction technique designed to detect spatially contiguous ground regions which are homogeneous in thorium, uranium, and potassium content. The data reduction technique was applied to gamma-ray spectrometric data obtained at an altitude of 50 feet in the Garden City, Kansas, area. Results indicate that 83% of the homogeneous areas detected by the technique can be directly interpreted on the basis of information contained in simultaneously obtained imagery.

HEINSOHN, P. P., A. O. Poulin, Illustrated Summary of the Geology of the Yukon Flats Region, Alaska, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TR 154, September 1964, NTIS AD-451 722.
(USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

KAHN, M., Studying the Slide Pattern of Avalanches by Means of Photogrammetric Methods, Translation of McGill University, Axel Heiberg Expedition, TL 207, January 1972.

Author Abstract - No abstract.

LIVEROVSKII, IU.A., Methods for Compiling Large-Scale Soils Maps Using Aerial Photographs, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 93, 1969, NTIS AD-694 579.

Author Abstract - No abstract.

McKIM, H. L. and C. J. Merry, Use of Remote Sensing to Quantify Construction Material and to Define Geologic Lineations, Dickey-Lincoln School Lakes Project Maine, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 242, I and II, December 1975, NTIS AD-A023 276. (USACRREL, Hanover, New Hampshire)

Author Abstract - A potential site for construction of a series of earth dams and dikes with a maximum height of 335 ft., the Dickey-Lincoln School Lakes Project, is being evaluated by the New England Division, Corps of Engineers. The site is located on the St. John River in Aroostook County, Maine, approximately 30 miles west of the town of Ft. Kent. The project is primarily designed to generate hydroelectric power, but is also intended to provide flood control. During November 1974, a study was initiated to apply state-of-the-art remote sensing techniques to the delineation and quantification of surficial geology units to locate construction material within the headwaters of the St. John River Basin. A photo-mosaic was prepared from 1966 black and white photography(scale 1:33,600). Fourteen surficial geology units were delineated in an 1100-square-mile area: alluvial fan, alluvial terrace, esker, floodplain, glacial, moraine, kame, kame terrace, outwash, outwash terrace, bedrock, till, till over bedrock, wet outwash and wet till. These units were field checked and the depths estimated utilizing initial boring data, field measurements and seismometer values. The areal extent of each surficial geology unit within a four-mile radius of the three dike sites and a six-mile radius of the main dam site was quantified using a planimetric color densitometer. The volume of construction material was computed based upon these areal determinations and estimated depths. Considerable time was saved using remote sensing techniques compared with conventional ground surveys. The volume estimates obtained from this investigation were compared with the estimates of required construction material computed during the 1967 initial design phase. This comparison showed that the required construction material could be found with the prescribed area around the dam and dike sites. Because transportation distances determined from this study could result in considerable savings. In addition, the lineations observed on the LANDSAT imagery provided a sound base for analysis of possible tectonism in the Dickey-Lincoln area. It is believed that future movement along the east, northeast, north and N60^{o}W lineations will be negligible.

McKIM, H. L., R. L. Berg, R. W. McGaw, R. T. Atkins and J. Ingersoll, Development of a Remote-Reading Tensiometer/Transducer System for Use in Subfreezing Temperatures, in Proceedings of the Second Conference on Soil-Water Problems in Cold Regions, Edmonton, Alberta, Canada, 1-2 September 1976.

Author Abstract - No abstract.

McLERRAN, J. H., Infrared Sensing of Soils and Rocks, Materials Research and Standards, MP 286, February 1968, 8(2). (USACRREL, Hanover, New Hampshire)

Author Abstract - Infrared imagery does show terrain features. However, to interpret the imagery one must be aware of the environmental factors that affect the everchanging thermal pattern of a terrain. Infrared imagery is used to illustrate soil and rock features that have distinctive infrared signatures. Before infrared sensing becomes a useful technique, there must be considerably more study of the soil physical factors that influence the emissivity and thereby the radiation that is sensed.

MERSHIN, A. P., Manual for Using Aerial Photographs in Soil Mapping (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 103, May 1970, NTIS AD-708 787.

Author Abstract - Discusses the use of aerial photography in the mapping of soils. Much attention is given to the methods of interpreting soils by aerial photographs and to the study of interpreting soils by their distinctive characteristics in various zones and provinces. The authors also point out that the application of aeromethods in the practice of large-scale soil mapping in the Soviet Union and abroad indicates that the use of materials from aerial survey increases considerably the accuracy of soil mapping, reduces the volume of the field work, cuts down its cost and increases the practical value of soil maps.

MINTZER, O. W., A Comparative Study of Photography for Soils and Terrain Data, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report 38-TR, April 1968, NTIS AD 670 012. (USAETL, Fort Belvoir, Va.)

Author Abstract - A comparative study was made of ground-controlled aerial photography over the Phoenix, Arizona, test area for soils determination. Three separate emulsions were studied: Plus-X (panchromatic) film; Ektachrome-MS (color) film; and Ektachrome (color) Infrared film. The last two films provided more information at greater flying heights (20,000 and 30,000 feet) than did the Plus X film.

MOORMAN, F. R., F. J. Ident, L. Moncharoen, D. A. Libby, M. Cheutongdee, Soil Series Survey of Selected Study Areas in Thailand, Summary Report, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, CR-3-156-S, October 1966, NTIS AD-807 704.
(Land Development Dept., Bangkok (Thailand) Soil Survey Div.)

Author Abstract - The study reported herein presents a summary of the methods and techniques used in the survey and correlates the various soil series with great soil groups and subgroups and physiographic position. The corresponding taxa of the new USDA soil classification system were also indicated. A summary is given of the geomorphologic relations between the various soil series. For each of the selected study areas, detailed descriptive reports accompanied by soil maps on a scale of 1:50,000 were prepared and included.

NIKOLAEV, V. A., et al, Aerial Photography as a Method for the Complex Study of the Landscape of Semi-Deserts and Dry Steppes, (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 111, September 1969, NTIS AD-695 723.

Author Abstract - Identification of different components of the natural medium (soils, topography, ground waters, etc.) by means of aerial photographs is possible only if there is knowledge of the intra-landscape relationships of the components. The data used successfully in the Caspian area were not suitable in the Turgay area because the former has accumulative plains while the latter has denudation plains. The whole problem of the study of the structure of landscapes is related with advances in typology and cartography of landscapes.

ORR, D. G., Project Sand (Phase III): Analysis of Remote Sensor Imagery of Selected Areas in the Mississippi Delta, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-TR-71-3, September 1971, NTIS AD-892 579L.
(USAETL, Fort Belvoir, Va.)

Author Abstract - This report describes the approach and procedures for locating engineer construction materials in a deltaic environment using multispectral remote sensors and presents the results obtained during Phase III of Project Sand.

Flights were conducted over selected areas in the Missippi Delta to determine the sensor configuration, analysis techniques, and criteria for locating engineer construction materials under Project Sand. The sensors utilized included color, color infrared and panchromatic

photography, thermal infrared scanners, and sidelooking radar (brute force and coherent). The sensor imagery was analyzed by a team of experts in various earth science and engineering disciplines.

It was concluded that: (1) the most efficient use of remote sensors for location of construction materials involves a two-phased approach: a regional analysis followed by a detailed analysis; (2) small-scale photo index and sidelooking radar were preferred for the regional analysis; (3) color infrared photography was considered to be the best for detailed analysis in a deltaic environment; and (4) the highest potential for the occurrence of construction materials in the Mississippi River is within the cheniers, point bars, river bars, and active beach.

ORR, D. G. and J. R. Quick, Project Sand - Remote Sensing for Engineer Construction Materials, published in AGARD (Advisory Group for Aerospace Research and Development) Conference Proceedings No. 90. (USAETL, Fort Belvoir, Va.)

Author Abstract - Remote sensor flights have been conducted over areas in the Mississippi Delta to determine the sensor configuration, analysis techniques, and diagnostic criteria for locating engineer construction materials under Project Sand. The sensor utilized included photography (color, color infrared and panchromatic), thermal infrared and sidelooking radar (brute force and coherent). In addition to the aerial imagery acquisition, ground measurements were made in each of the areas under investigation. The sensor imagery and ground truth data were analyzed by a team of experts in various earth science disciplines. The airborne operation and field data collection are described and a summary of the analyses results with unclassified illustrations are presented. The remote sensing investigations conducted under Project Sand were a joint effort of the U. S. Army Waterways Experiment Station and the U. S. Army Engineer Topographic Laboratories.

POULIN, A. O., Measurement of Frost Formed Soil Patterns Using Airphoto Techniques, Photogrammetric Engineering, March 1962, 28(1), MP 367.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Airphoto patterns in cold regions are greatly influenced, if not dominated, by the effect of frost action or, more specifically, by the motion imparted to soil particles during freezing and thawing cycles. In order to determine the rate of pattern development this motion is being measured with an accuracy of 2-3 mm. from maps at a scale of 1 to 4 with a contour interval of 0.02 ft. These maps are compiled photogrammetrically from photos obtained from scaffolding at distances of 10-20 ft. above the ground. Areas selected for study are in N. Greenland and the Colorado Rockies. All maps were prepared on Mylar base material. The design of a stable control point in permafrost is also presented. The intent of this research is to introduce a quantitative aspect to the interpretation of frost patterns and the frost susceptibility of soils.

PROTAS'YEVA, I. V., Aeromethods in Geocryology, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TR 482, July 1975, NTIS AD-A014 143.

Author Abstract - The book presents the possibility of the application of aeromethods for studying the conditions in the development of permafrost soils (rocks) and permafrost phenomena connected with them. Theoretical and methodical conclusions have been drawn which can be utilized as a basis for a further broader adoption of aeromethods into the practice of regional and topical studies of the tendencies in the distribution, composition, structure and properties of permafrost soils. This is the first time that such a scientific-procedural handbook has been published for geocryological purposes. We have generalized fairly completely in it the experience gained in the problems of their future development are also reviewed. The book is meant for specialists conducting studies in the distribution of permafrost soil for the purpose of the economic development of its territory, i.e., the book is oriented toward geologists, engineer-geologists, prospectors, engineering-builders, mining engineers and also for the scientific workers concerned with a study of the features in the terrain structure under the developmental conditions of permafrost soils (rocks).

RINKER, J. N., An Application of Air Photo Analysis to a Cave Location Study, presented at the American Society of Photogrammetry Meeting at St. Louis, MO, on 10-15 March 1974.
(USAETL, Fort Belvoir, Va.)

Author Abstract - The sedimentary rocks are the most common group of rocks at the planet's surface. An important member of this group is limestone, a rock whose principal component is calcium carbonate. Massive beds of limestone are usually highly fractured and, in areas of

abundant rainfall, runoff seeps down through the cracks and slowly dissolves away the calcium carbonate, creating a vast and intricate underground three-dimensional drainage net composed of various sized channels and caverns. Such a condition offers problems, and surprises, to the construction engineer, for foundations and deep footings can penetrate into an unsuspected cavern, or the weight of a structure can collapse a cave roof. Such a condition can also make it difficult for a reservoir to maintain the desired water level. Furthermore, a subsurface water system can be easily contaminated by improper waste disposal methods. Any means of gaining information about subsurface conditions in a limestone area would be a help to engineers and planners, as well as to those engaged in preparing statements about the potential environmental impact of any given action. This study used stereo aerial photography for a lineament and sinkhole pattern analysis which served as a basis for predicting probable locations of underground channels of a subsurface river. Predicted locations were in good agreement with later mapped locations.

ROOKE, A. D., Jr., T. D. Chew, L. K. Davis and J. N. Strange, Operation Snow Ball Project 3.1, Crater Measurements and Earth Media Determinations; The Apparent and True Craters, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-Misc-Paper 1-987, April 1968, NTIS AD-832 913L.
(USAEWES, Vicksburg, MS)

Author Abstract - A 500-ton, hemispherical TNT charge resting on the ground surface was detonated on 17 July 1946 at the Defence Research Establishment, Suffield (DRES), Ralston, Alberta, Canada. Project 3.1, Crater Measurements and Earth Media Determinations, was included in the program of U. S.-sponsored projects pertaining to the event. Briefly, the objectives of Project 3.1 were the measurement of the apparent and the true craters, the measurement of the permanent deformation of the medium, and the correlation and explanation of the results. Measurements of the apparent crater were made by means of aerial stereophotography and by ground survey, with surface deformation measured by means of displacement stakes. Soil samples were collected before and after the detonation to permit an evaluation of changes in the physical properties of the medium that were attributable to the explosion. The true crater and subsurface zones of deformation were measured by excavation and mapping of colored sand columns emplaced prior to the shot. The earth medium at the test site was a glacially deposited silt, with underlying beds of clay, sand, and gravel. The water table was encountered at 76 meters. Sand and water from these underlying stratia were forced to the surface by the explosion-produced pressures. The apparent crater as it existed immediately after the shot was 4.2 meters deep at ground zero, with a radius of 42.6 meters. Long-term subsidence enlarged these dimensions.

SELLMAN, P. V., P. Hoekstra and Delaney, Airborne Resistivity Survey Near Fairbanks, Alaska, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 202, March 1974, NTIS AD-777 792.
(USACRREL, Hanover, New Hampshire)

Author Abstract - An airborne electrical resistivity survey was flown near Fairbanks, Alaska. One of the objectives of the survey was to evaluate the potential of airborne VLF resistivity mapping to distinguish between rock types. The impetus for the study was the requirement by the U. S. Army Engineer District, Alaska, for a rock quarry in connection with the Chena River Lakes Project. The general area is near the southern limit of the rolling Yukon-Tanana Uplands. The bed rock consists of both the common Birch Creek schist and local intrusive igneous rocks. The schists are commonly deeply decomposed and fractured, while the intrusives are less decomposed but usually jointed. Electrical resistivity measurements on the ground at bare rock sites showed about a factor of two difference in resistivity between the schists and the intrusives. On the schists, values ranging from 150 to 1100 ohm-m were found, while on the intrusives values ranged from 2000 to 5000 ohm-m. Of the three frequencies used during the airborne survey (VLF, LF and BCB) VLF at 18.6 kHz was the best local topography and it has the potential to provide information to considerable depth. Resistivities in a 50-square-mile area flown in connection with the Chena River Lakes Project near Eielson AFB varied from 100 to 6000 ohm-m. High values of resistivity were in general associated with the valley bottoms, and reflect thick, perennially frozen valley bottom sediments. To separate the resistivity variation caused by the depth and the frozen or thawed state of the overburden silt, a ridge top overlay was made in this area. Because the silt cover is thin on ridge tops, the resistivity variations there are most likely to reflect rock types. The sites of high resistivity on ridge tops(>1500 ohm-m) were in agreement with the limited amount of ground control available in the area. The other area was a mapped intrusive body in the northern area of the Fairbanks D-1 Quadrangle (Williams et al, 1959). The boundaries of the intrusive body of the geological map corresponds fairly well with the 1500 ohm-m resistivity contour.

SHOCKLEY, W. G., S. J. Knight and E. B. Lipscomb, Identifying Soil Parameters with an Infrared Spectrophotometer, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES Misc Paper 4-547, January 1963, NTIS AD 744 220.

Author Abstract - The terrain analyzer project describes laboratory studies using infrared sensors in order to fingerprint soil parameters with applications to remote sensing of the trafficability of terrain.

TOLCHEL'NIKOV, IU.S., Role of Soils in the Interpretation of Arid-Zone Landscapes from Aerial Photographs (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 157, 1969, NTIS AD-692 656.

Author Abstract - The characteristics of soil cover are closely related with all components of the landscape, reflecting the specifics of the geologic and geomorphologic structure of the territory, hydrological conditions, migration of chemical compounds, composition of vegetative cover, etc. Examples of interpretation of aerial photographs are given.

TREIBER, M. and A. E. Krusinger, Inferential Techniques for Soil Depth Determinations, Part I: Coleogyne Ramosissima Torr. (Blackbrush), U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research Note ETL-0036, November 1975, NTIS AD-A024 355. (USAETL, Fort Belvoir, Va.)

Author Abstract - Inferential techniques for soil depth determinations in a high desert environment, Lake Powell, Arizona/Utah, have been investigated for 16 months. The use of vegetation as "indicator species" to facilitate determinations of soil depth and soil type were examined. Coleogyne ramosissima Torr., commonly called black-brush, has been established as a reliable indicator of the depth of soil to bedrock. Over 375 soil-depth-to-bedrock measurements were performed. The soil depths to bedrock within Coleogyne ramosissima communities have a mean of 21 cm with a maximum of 100 cm; the mean of soil depths to bedrock outside Coleogyne Ramosissima communities was 120 cm, with a maximum measured depth of 180 cm.

Use of Aerial Photography in Geocryological Surveys, (Translation of an unidentified Russian article), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 127, 1970, NTIS AD-711 926.

Author Abstract - Advantages of the use of aerial photographic methods in geocryological research are given.

19d. TERRAIN ANALYSIS (HYDROLOGY)

GATTO, L. W., Circulation and Sediment Distribution in Cook Inlet, Alaska, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The purpose of this investigation was to analyze surface circulation, suspended sediment distribution, water-type migration, and tidal flushing mechanisms, utilizing medium and high altitude aircraft and repetitive synoptic satellite imagery with corroborative ground truth data. This approach provides a means of acquiring synoptic information for analyzing the dynamic processes of Cook Inlet in a fashion not previously possible. LANDSAT-1 and -2 and NOAA-2 and -3 imagery provided observations of surface currents, water type migrations and sediment and sea ice distributions during different seasons and tides. NASA NP-3A and U-2 aircraft multispectral imagery was used to analyze coastal processes, i.e., current and sediment dispersion in selected areas. Ground truth data were utilized in the interpretation of the aircraft and satellite imagery and verified many of the regional circulation patterns inferred from the suspended sediment patterns apparent on the imagery. Several local circulation patterns not previously reported were identified.

HAUGEN, R. K., H. L. McKim, and T. L. Marlar, Remote Sensing of Land Use and Water Quality Relationships - Wisconsin Shore, Lake Michigan, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, 1976, CRREL Report 76-30.

Author Abstract - The focus of this investigation was to assess the utility of remote sensing techniques in the study of land use-water quality relationships in an east central Wisconsin test area. The following types of aerial imagery were evaluated for this purpose: high altitude (60,000 ft.) color, color infrared, multispectral black and white, and thermal; low altitude (less than 5000 ft.) color infrared, multispectral black and white, thermal, and passive microwave. A non-imaging hand-held four-band radiometer was evaluated for utility in providing data on suspended sediment concentrations. Land use analysis includes the development of mapping and quantification methods to obtain baseline data for comparison to water quality variables. Suspended sediment loads in streams, determined from water samples, were related to land use differences and soil types in three major watersheds. A multiple correlation coefficient R of 0.85 was obtained for the relationship between the 0.6-0.7 μm incident and reflected radiation data from the hand-held radiometer and concurrent ground measurements of suspended solids in streams. Application of the methods and baseline

data developed in this investigation include mapping and quantification of land use, input to watershed runoff models, estimation of effects of land use changes on stream sedimentation, and remote sensing of suspended sediment content of streams. High altitude color infrared imagery was found to be the most acceptable remote sensing technique for the mapping and measurement of land use types.

KUZNETSOV, V. V., V. K. Markovskii, T. A. Popova, Interpretation of Ground Water of Typical Landscapes in the Caspian Lowland on Aerial Photographs, (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 180, September 1969, NTIS AD-693 148.

Author Abstract - No abstract.

KUZNETSOV, V. V., Use of the Properties of the Soil Cover in the Interpretation of Ground Water on Aerial Photographs, (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 90, 1969, NTIS AD-692 627.

Author Abstract - A study was made of the relationships between the soil cover and ground water using aerial photographs taken in different landscape areas in the Northern Caspian Lowland and Turkmenia. The work was done in key areas together with geobotanical, geomorphological, and hydrological studies. It was found that a study of the soil cover (thickness of genetic horizons, color, moisture content, humus content, content of salts, etc., as well as the characteristics of the structure and mechanical composition of the soils) gives information on the character and depth of ground water. Soils beneath which fresh ground water is situated close to the surface appear on aerial photographs in dark tones.

LICHY, D. E., Remote Sensing Demonstration Project Verona Lake, Va., Baltimore District, Corps of Engineers, December 1976.

Author Abstract - A variety of remote sensing data was analyzed to develop information for the Phase I Advanced Engineering and Design Memorandum of Verona Lake, Va., dam project. LANDSAT, SKYLAB SLAR, NASA U-2 color infrared, thermal infrared and conventional low-level black and white photography was analyzed and compared. This report consists of examples of each type of remote sensing and analysis overlays. The cost, man hours, acquisition and usefulness of the data was summarized. This report provides a summary of the usefulness of remote sensing for site-selection and examples and inter-relationship of the imagery, analysis, cost and project needs.

MEIER, G.IA., Aerial Photographic Method for Studying Ground Water, (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 281, 1969, NTIS AD-690 613.

Author Abstract - This paper presents a general review of the use of the aerial photographic method in the search for ground water in various parts of the Soviet Union. The individual indicators of the presence of ground water shown on aerial photographs are discussed; these include such features as vegetation, relief, culture features, and many others. The article discusses the most useful scales of photography, cameras, light filters, aircraft, proper season for conducting the work, most suitable weather and best time of day. The various criteria used in different regions of the USSR are listed. The significant role of the geobotanical method is discussed, followed by some comments on the preparation of interpretation keys and photomosaics and the role played by black and white and color prints.

MEIER, G.IA., et al, Decoding Aerial Photographs of Glacial Landscapes--Indicators of Ground Waters, (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 104, October 1969, NTIS AD-696 181.

Author Abstract - Characteristics of landscape indicators of ground water are described for the following: four glacial types of landscape, including hilly-moraine, drumlin, morainic plain and terminal-moraine; three water-glacial types of landscape, including kame (and os), lake-glacial plain and outwash plain; the karst erosion type of landscape; and seashores. The decoding of these types of terrain on aerial photographs is discussed.

MEIER, G.IA., K. E. Nefedov, Interpretation of Ground Water of Typical Landscapes in Turkmenia on Aerial Photography, (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 100, June 1969, NTIS AD-691 566.

Author Abstract - The report gives a geographical description of the natural landscapes existing in Turkmenia and the individual landscape elements in that Soviet Republic: topography, climate, hydrography, soils and culture features. The article gives the results of aerial surveys made in the principal landscape types of Turkmenia; particular attention in this article is given to the relationship between ground water and relief, vegetation and soils, and a description of what features serve as indicators of ground water and how these indicators appear on aerial photographs.

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MERRY, C. J., The Correlation and Quantification of Airborne Spectroradiometer Data to Ground Turbidity Measurements at Lake Powell, Utah. Master's thesis, CRREL Special Report (in press).

Author Abstract - During the past three years there has been a renewed interest in the methodology and procedures used to monitor water quality in fresh and salt water regimes. However, there still exists a need to calculate quantitatively the amount of surface turbidity by remote sensing methods to provide rapid and synoptic water quality surveys. Recently, a 500-channel airborne spectroradiometer, which may provide a quantitative means of comparing high resolution multispectral data to water quality parameters, has been designed at the NASA Goddard Institute for Space Studies (GISS). The objective of this thesis is to correlate and quantify the airborne spectroradiometer multispectral data to ground truth water quality measurements obtained in Lake Powell, Utah, during June 1975.

A ground truth water sampling program was accomplished during 9-16 June 1975 for correlation to an aircraft spectroradiometer flight. Field measurements were taken of percent transmittance, surface temperature, pH and secchi disk depth. Also, percent transmittance was measured in the laboratory for the water samples. In addition, electron micrographs and suspended sediment concentration data were obtained of selected water samples located at Hite Bridge (Mile 171), Mile 168, Mile 150 and Bullfrog Bay (Mile 122). Airborne spectroradiometer spectra were selected which correlated to the Hite Bridge (Mile 171), Mile 168, Mile 150 and Bullfrog Bay (Mile 122) test sites.

Analysis of the test data leads to the following conclusions: (a) as the secchi disk depth measurement of light extinction decreased, the reflected radiance measured by the airborne spectroradiometer increased; (b) as the percent transmittance of the water samples decreased, the reflected radiance increased; (c) as the insoluble particulate concentration (mg/l) increased, the reflected radiance increased, at least in the 1-80 mg/l range; (d) the reflected radiance in the near infrared region (0.76-0.91μ) always increased as the insoluble particulate matter concentration (mg/l) increased, and (e) when a spectral peak occurred at a wavelength of 0.58 μ, the peak reflected radiance varied with the insoluble particular matter concentration as follows:

Peak reflected radiance ($mw/cm^2/sr$)	Concentration (mg/l)
0.0001 - 0.0027	1 - 5
0.0027 - 0.0047	5 - 44
0.0047 - 0.0060	44 - 77

An interpretation of the Hite Bridge (Mile 171), Mile 168 and Mile 150 aircraft spectral indicated a similar mineralogic source due to the occurrence of a 0.58μ spectral peak and 0.64μ shoulder. The decrease of reflected radiance throughout the visible and near infrared regions for the three sites corresponds to a quantitative decrease of suspended sediment concentration from 77.2 mg/l to 41.1 mg/l to 5.9 mg/l, respectively.

Analysis of the aircraft spectra shows that quantification of turbidity in water bodies is feasible. The technique is especially effective when the turbidity in the water is derived from the same source as was the case in the Hite Bridge (Mile 171), Mile 168 and Mile 150 sites which are all located along the main Colorado River channel.

The quantification consists in plotting the measured spectral reflected radiance, at the key wavelengths of 0.58μ, 0.64μ, and 0.79μ, with the measured concentration of particles in the water. The resulting graphs can be used as a quantitative measure of particle content throughout this reach of the Colorado River channel, as long as the spectral peak at 0.58μ and shoulder at 0.64μ are present indicating a similar mineralogic source.

The relationship should be tested for uniqueness and reproducibility to complete the study of the quantitative usefulness of reflected radiances in monitoring water quality. A combination of theoretical work and laboratory or controlled field experiments would provide a solid foundation for further development of remote sensing as a practical tool in the monitoring of water quality.

MERRY, C. J. and H. L. McKim, Application of Remote Sensing to the Boston Urban Studies Program, Proceedings of the Social Scientists Conference, Memphis, Tennessee, 20-24 September 1976, CRREL Report 33 (in press).

Author Abstract - The primary objective of this study was to compare the cost effectiveness of photo-interpretation techniques with that of conventional techniques used by the New England Division, Corps of Engineers (NEDCE) in the Boston Harbor - Eastern Massachusetts Metropolitan Area (EMMA) Study. Quantification of the following parameters was accomplished for use in the STORM (storage, treatment, overflow runoff model) model: (1) area of a watershed; (2) land use type in a watershed; (3) impervious surface area for a land use type; and (4) curb length for a land use type. The secondary objective was to assess the utility of remote sensing in the delineation of water bodies, drainage patterns, and watershed boundaries.

A total of six level I, 17 level II and 18 level III land use categories were mapped for six selected 7-1/2 minute quadrangles located in the Boston, Massachusetts, area. These units were delineated from black and white photomosaics prepared from NASA RB-57/ RC-8 high altitude aircraft photography enlarged to a scale of 1:24,000.

The photography provided adequate detail for land use mapping of categories used in the STORM model. The total cost associated with the land use mapping using photo-interpretation techniques was $0.014/acre or a total of $2890 for the six quadrangles. This compared to associated costs of $0.003/acre or a total of $600 using conventional techniques. However, the conventional procedure did not include the cost of photographic data products, enlargement of photography or the assembling of photomosaics.

Watershed boundaries could not be mapped from NASA high altitude aircraft photography. This information would have to be obtained by interpretation of contour elevations from existing USGS topographic maps. However, hydrologic features such as lakes and streams could be delineated on a cost effective basis.

Impervious surfaces were mapped from low altitude aircraft photography taken with a Zeiss RMK 15/23 camera system (measured scale 1:3,500) for two selected test sites located in the Boston South and Newton quadrangles. The percentage of impervious surface determined using photo-interpretation techniques compared favorably to the values calculated by conventional techniques. The cost of using photo-interpretation techniques to measure impervious surface percentages was $1.547/acre; however, there was not sufficient information available to compare these costs to the conventional procedures used by NEDCE. The estimated cost using conventional techniques for the determination of impervious surface percentages was $100. Since all rooftops and buildings, parking lots, roads, etc., were easily delineated using photo-interpretation techniques, the results from the remote sensing method would be much more accurate than the method employed by NEDCE.

An evaluation of the accuracy associated with the measurement of curb length could not be made using conventional techniques because ground truth data were not obtained. More than 64% of all curbs located in the Newton test site were identified from the low-altitude aircraft photography. A random-dot statistical method was employed to obtain a total ft/acre curb length measurement for the various land use units. The curb density for each land use found by conventional techniques varied with the degree of urbanization when using residential density as an index of urbanization. The cost of curb density mapping was $0.899/acre using photo-interpretation techniques and compared to a cost of $1.200/acre using conventional techniques.

The photo-interpretation procedures used in this study provided much greater detail than the methodology used to obtain the same information using conventional procedures. The increased accuracy provides for more confidence in the predictive capability of the STORM model. The photo-interpretation procedures were not always cost effective when compared to the conventional procedures, but they were always more accurate when compared to ground truth data. Therefore,

the use of photo-interpretation techniques should be employed and appropriate photographic resolution and scale factors taken into consideration when mapping these parameters, specifically land use, curb density, and impervious surface for use in the STORM model.

SELLMAN, P. V., J. Brown, R. I. Lewellen, H. McKim and C. Merry, The Classification and Geomorphic Implications of Thaw Lakes on the Arctic Coastal Plain, Alaska, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 344, December 1975, NTIS AD-A021 226.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The lakes of the Arctic Coastal Plain of Northern Alaska were classified, based on size, shape, orientation and distribution, into six lake units and three nonlake units. Regional slope and relief were demonstrated to control lake size, the largest lakes occuring on the flattest, northern-most segment of the Coastal Plain. Using ERTS-1 sequential imagery and existing photography and data, lakes were grouped according to three depth ranges, m, 1-2 m and 2 m. Deepest lakes have the longest period of summer ice cover. Ice on shallow lakes melts the earliest. Maximum depths of lakes were computed based on ice volume content of the perennially frozen ground (permafrost) and these agreed with observed values and ranges. The lake classification and regional ERTS-1 coverage also appear to provide additional information on the limites of the late-Pleistocene transgressions on the Coastal Plain.

19e. TERRAIN ANALYSIS (TRAFFICABILITY)

KNIGHT, S. J., Aerial Cone Penetrometers for Measuring the Trafficability of Soils, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES Misc Paper 4-900, May 1967, NTIS AD 746 402. (USAEWES, Vicksburg, MS)

Author Abstract - The aerial cone penetrometer is a simple device for the determination of soil trafficability for a remote source. It has a number of possible military applications and would require only a modest amount of additional development to make it a practical Army tool. The credibility of the aerial cone penetrometer is best exemplified by the smooth and reproducible relations that exist between soil strength (as measured in terms of cone index) and depth of penetration of the aerial penetrometer at a constant contact velocity.

LEIGHTY, R. D., Proposed Relocation of Camp Tuto and Access Road - An Airphoto Survey, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TR 52, April 1958, NTIS AD-202 623. (USACRREL, Hanover, NH)

Author Abstract - A new location for Camp Tuto and an access road to the ice cap was selected by use of aerial photography and field checking. For this study, a simplified soil classification system was designed, considering: broad grain size classification, the recognition of natural deposits in the field, the use of soil as borrow material and natural subgrade, and the general engineering problems concerned with frost action, permafrost, and moisture.

LEIGHTY, R. D., Terrain Mapping from Aerial Photography for Purposes of Vehicle Mobility, Journal of Terramechanics, 1965 2(3), MP 266. (USACRREL, Hanover, NH)

Author Abstract - No abstract.

FROST, R. E., P. L. Johnson, R. D. Leighty, V. H. Anderson, A. O. Poulin, and J. N. Rinker, Mobility Environmental Research Study, A Quantitative Method for Describing Terrain for Ground Mobility, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, Technical Report 3-726, MP 556, May 1966.
(USACRREL, Hanover, New Hampshire)

Author Abstract - This volume contains a catalog of photographs of Thailand terrain features described in such a way that the information can be used in making estimations of their effects on the performance of ground vehicles. Results of a limited study to determine the effects of the film emulsion and photo scale on the acquisition of terrain information from aerial photographs are also presented.

FROST, R. E., P. L. Johnson, R. D. Leighty, V. H. Anderson and A. O. Poulin, Mobility Environmental Research Study, A Quantitative Method for Describing Terrain for Ground Mobility, Volume VI, Selected Air-Photo Patterns of Terrain Features, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-TR-3-726, Vol 6, May 1966, NTIS AD-484 656.
(USAEWES, Vicksburg, MS)

Author Abstract - A catalog of photographs of Thailand terrain features is described in such a way that the information can be used in making estimations of their effects on the performance of ground vehicles. Results of a limited study of the effects of ILM emulsion on the acquisition of terrain information from aerial photographs are also presented.

FROST, R. E., A Reconnaissance for a Southern Greenland Ice-Cap Access for Military Purposes, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TR 46, April 1957, NTIS AD-138 264.
(USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

McLERRAN, J. H., Photographic Interpretation, Its Significance in the Highway Program, Photogrammetric Engineering, September 1957, 23(4), MP 291.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The impact of the new highway program will require development and utilization of time-saving methods to obtain information required for planning, location, design, and construction. The use of airphoto interpretation to evaluate soil and materials is a proven method that will save much time. Illustrations show the application of the technique to specific engineering uses, such as soil surveys and material prospecting. The use of airphoto interpretation and carefully planned field work should go hand in hand.

McLERRAN, J. H., Airphoto Interpretation for Airfield Site Location, Journal of the Air Transport Division Proceedings of the American Society of Civil Engineers, No. 86, MP 729, May 1960.
(USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

RANDOLPH, D. D. and C. A. Blackman, Terrain Analysis for the Armored Reconnaissance Scout Vehicle Test Program, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, March 1974, NTIS AD 776 387.
(USAWES, Vicksburg, MS)

Author Abstract - Two study areas totaling approximately 11 square miles, were selected at Fort Knox, Kentucky, for comparison with a previously mapped 60-sq-mi sample of terrain in West Germany and as potential areas for field tests with the prototype armored reconnaissance scout vehicles and comparison vehicles, areal and linear terrain data from 119 sites, aerial photographs, and other pertinent information were used to prepare the Fort Knox terrain factor complex maps. These aerial maps describe the terrain characteristics that affect vehicle performance, i.e. soil type, soil strength, topographic slope, obstacles, vegetation, surface roughness, and visibility. The linear terrain factor complex maps describe the terrain characteristics that determine 'Go or No Go' vehicle performance, i.e. linear feature geometry, water depth, and water velocity.

Report of Meeting of ARPA Advisory Committee on Mobility Environmental Research Study (2nd) (24-26 February 1964, Vicksburg, MS), U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-Misc Paper 4-670, August 1964, NTIS AD-478 994. (USAEWES, Vicksburg, MS)

Author Abstract - Contents: WES MEGA studies; WES trafficability, terrain analyzer, and mobility studies; review of background and history of Project MERS; review of first advisory committee meetings recommendations; general status report on Project MERS activities; Marsh Screw Amphibian; conceptual approach to the development of terrain-vehicle relations; compilation of existing trafficability data; one-pass soil trafficability study; mobility in rice fields; environmental data-collection manual; review of published environmental data of Southeast Asia; prediction of terrain characteristics in Thailand by airphoto interpretation; radar studies for detection of surface and groundwater; design and acquisition of instruments and test vehicles; classification of terrain types of Southeast Asia; state-of-the-art of off-road vehicle design; plans for the next 12 months.

RULA, A. A., W. E. Grabau and R. D. Miles, Forecasting Trafficability of Soils, Airphoto Approach, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-TM-3-331-6, Vol I, June 1963, NTIS AD-409 916. (USAEWES, Vicksburg, MS)

Author Abstract - The study reported herein is part of a comprehensive effort, begun in 1949, to develop techniques for estimating the trafficability of soil by remote means. It is devoted specifically to development of techniques for analyzing and interpreting vertical aerial photographs for soil trafficability purposes. To provide a basis for this study, airphoto and soil trafficability data were collected over a period of several years from 33 humid-climate states and 2 arid-climate states in the United States. This report describes the principles and procedures of airphoto interpretation required to estimate the trafficability of soils, and summarizes data reported previously in supplemental reports in a form suitable for use by personnel engaged in airphoto-trafficability analyses. Soil factors, slope factors, and obstacle factors, all pertinent to terrain trafficability, are discussed. Terrain is classified into various representative landscapes which are fully described in regard to regional drainage, topography, local erosion, natural vegetation, cultural practices, parent material, soil profile, and trafficability and cross-country movement characteristics. Procedures for airphoto analysis of trafficability are rigidly defined, and an example of photo interpretation is given.

SHAMBURGER, J. H., C. R. Kolb, and H. K. Woods, Terrain Evaluation of a Portion of the Fort Greely Automotive Test Course, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES Misc Paper 3-861, December 1966, NTIS AD 806 538. (USAEWES, Vicksburg, MS)

Author Abstract - A method for classifying and mapping terrain features pertinent to off-road mobility in selected temperate, tropical, and desert areas was applied to subarctic terrain in this study. The area involved borders the automative test course of the U. S. Army Arctic Test Center at Fort Greely, Alaska, and is roughly 2000 ft. wide and 15 miles long. Conditions mapped were those prevalent during the late summer. The classification and mapping method proved satisfactory with only minor modifications. Terrain factors unique to cold regions which require additional research before they can be properly classified and mapped for mobility test purposes include depth of thaw, snow depth, snow type, ice thickness and stream turbidity.

WILLIAMSON, A. N., Laboratory Investigations of the Gamma-Ray Spectral Region for Remote Determination of Soil Trafficability Conditions, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-Misc-Paper-4-823, May 1966, NTIS AD-747 097. (USAEWES, Vicksburg, MS)

Author Abstract - Gamma radiation from soil samples was measured, and the results were analyzed to evaluate the use of gamma rays in remotely determining soil parameters useful in estimating trafficability. Gamma-ray spectral were obtained from representative samples of sand, silt, and clay placed in a low-background inclosure. Photopeak counting rates and Photopeak ratios of thorium, uranium, and potassium were considered in the analysis. Results indicated that Photopeak counts of the radioisotopes of primary interest were proportional to moisture content of the soil samples, but ratios of the Photopeaks were nearly independent of moisture content, although different for each soil tested. Gamma-ray measurements were also made on soil samples obtained from all 50 states in an attempt to correlate the ratios of their Photopeaks of thorium, uranium, and potassium with soil type and other morphological, genetic and physical-chemical characteristics of the soils.

19f. TERRAIN ANALYSIS (VEGETATION)

ALLEN, H. H. and J. G. Collins, Characterizing Vegetation from Existing Source Material for Predicting Munition Height of Burst in Inaccessible Areas, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, AEWES-Misc-Paper-M-73-8, June 1973, NTIS AD-763 179.
(USAEWES, Vicksburg, MS)

Author Abstract - In the report a procedure for characterizing vegetation of inaccessible areas for input to munition height-of-burst models was developed. The procedure entails three steps: Statistical stratification, vegetation sampling, and vegetation data transformation. An area is stratified on the basis of average height, crown diameter, and spacing of plants in the upper two layers using the WES factor mapping process. For each unique combination of factors mapped, a 20-plant minimum sample is taken for each height layer. Sample data include average spacings of plants and the height and crown diameter of each plant. Data are obtained photogrammetrically when feasible: otherwise, available ground truth data are substituted. Plants with known stem and branch geometries are then substituted for the sample plants.

BOCHAROV, M. K., et al, Mathematical Fundamentals of Aerial Photo-interpretation of Forests (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 20, June 1969, NTIS AD-691 916.

Author Abstract - Present status of photointerpretation of forests is discussed along with results of theoretical and experimental studies on use of mathematical modeling in investigating tree stands. The use of computers in forest management is feasible and requires starting information and the preparation of special maps bearing information essential for electronic computer operation. Mathematical modeling expands the theory of timber stand study and leads to new methods of measurement and determination of appraisal indexes concerning timber stands.

DANSEREAU, P. and P. F. Buell, Studies on the Vegetation of Puerto Rico, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, November 1966, NTIS AD 813 748.
(New York Botanical Garden, Bronx, NY)

Author Abstract - Existing vegetation structures, including cultivated types, were examined in the field, in terms of ecological, botanical, and physiognomic characteristics. Sampling ranged from subjective examination to detailed quantitative description, as practiced by the U. S. Army Engineer Waterways Experiment Station. Eight zones, each comprising distinctive aggregations of plant-communities, were identified: Lilloral, lowland rainforest, seasonal evergreen forest, hill scrub, semi-deciduous forest, lower montane rainforest, montane forest, and montane scrub. Each plant-community in each zone was described in terms of formation type, dominant habit-form, heights of strata, floristic composition and abundance, and site features. A 'type physiognomy' was determined for each plant species identified, and recorded in terms of Dansereau descriptors (life-form, leaf size, habit-form, leaf shape, leaf texture, seasonality, dispersal type, and floristic element. Photographs and diagrams illustrate releves and plant-communities. A detailed map of vegetation physiognomies was constructed for the Roosevelt Roads areas by photointerpretation controlled by intensive ground sampling. Almost all basic variations in physiognomy could be detected by photointerpretation.

JOHNSON, P. L., Investigation of Sugar Cane Vigor with Aerial Photography in Puerto Rico, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 93, June 1965, NTIS AD-624 625.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Aerial photointerpretation was attempted to identify reasons for the reduction of sugar cane yield in Puerto Rico. Although lack of vigor in the crop was evident on the film, the cause was difficult to identify. Areas of low vigor can be located on aerial photography, the causal agent confirmed, and control measures applied with considerable economic advantages over ground surveys alone.

JOHNSON, P. L. and D. M. Atwood, Aerial Sensing and Photographic Study of the El Verde Rain Forest, Puerto Rico, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 250, December 1969, NTIS AD-703 123. (USACRREL, Hanover, New Hampshire)

Author Abstract - Aerial and ground photographs were taken over a 2-year period of sites in the El Verde rain forest to record the consistency of the vegetational patterns in untreated sites and the changes that occurred following gamma irradiation. Four emulsions were used. Panchromatic, infrared, false color transparency and color transparency. Densitometry was used to evaluate color film and the vegetation response to 3 months of radiation. The color emulsions provided the sharpest indication of damage to vegetation and the succession following treatment. Hemispherical photography of the canopy was evaluated in terms of a canopy cover index defined as percent of light passing through the negative in a 90-degree cone area. Control stations were remarkably constant in all photography, establishing the stability and slow natural changes in rain forest structure. Spectral light measurements within the forst confirmed the predominance of far red shade light. Compared to similar studies on the chronic irradiated forest at Brookhaven National Laboratory the El Verde results were less distinct.

JOHNSON, P. L., T. C. Vogel, Vegetation of the Yukon Flats Region, Alaska, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 209, November 1966, NTIS AD-647 237. (USACRREL, Hanover, New Hampshire)

Author Abstract - This paper describes the characteristic vegetation types and their ecology in the Yukon Flats Region, Alaska, and associates aerial photographic patterns with these types. The discussion includes the physiographic setting, vegetation patterns, forest fires, bog succession, the selection of sample sites, vegetation sampling, photographic interpretation, composition and structure of vegetation, and radar and thermal imagery. Appendix A lists the scientific and common names of plants, while Appendix B tabulates selected soil samples from vegetation stands. Ground and air reconnaissance were used to select 43 stands representative of the common plant communities. Ten individual trees were harvested by meter increments, and stem, branch and leaf components were weighed. Three kinds of vegetation type maps were constructed from an examination of aerial phogography by application of the ground data to photo interpretation.

MOTOVILOV, G. P., Aerial Photography and Mapping of the Siberian Forest, (Translation of Aerofotos" emka i kartografirovanie lesov Sibiri, Moscow, 1966), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshhire, TL 109, July 1969, NTIS AD-693 226.

Author Abstract - A number of theoretical and methodical problems of aerial survey and cartography are discussed in this book and a new method of determining the seasonal conditions of aerial surveys by phenological maps is described.

PRENTICE, V. L., Background Study of Puerto Rico, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 71, February 1965, NTIS AD-458 509. (USACRREL, Hanover, New Hampshire)

Author Abstract - Information contained in this report provided the basis for briefing field personnel about natural and cultural aspects of Puerto Rico priot to field work. The material was obtained through an extensive literature search and review. Primary emphasis was placed on soils, rocks, vegetation, physical makeup, and land use. Secondary emphasis was given to historical and sociological aspects.

SAMOILOVICH, G. G., Use of Aerial Photography in Studying Forest Types, (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 137, 1969, NTIS AD-692 360.

Author Abstract - No abstract.

VINOGRADOW, B. V., Aerial Analysis of Vegetation in Arid Zones, (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TL 181, November 1969, NTIS AD-698 850.

Author Abstract - The report is a complete survey of the application of aerial hhotography to the analysis of vegetation in arid zones. Techniques for photographing, identifying, analyzing and interpreting vegetation at all photographic scales from 1:3,00 and larger to 1:50,000 and smaller are discussed. The technique which receives primary emphasis for the photographic interpretation of vegetation over wide areas is the selection of key sites, the preparation of aerial photographic interpretation standards and the extrapolation of these standards from the key sites over the entire area. Almost 400 different plants are mentioned by name, and there is an extensive bibliography. Areas discussed are primarily within the bounds of the Soviet Union, with some references to Africa and the Near East.

SECTION	REPORT TITLE
1	Lukes, G. E., Interpretation of Optical Power Spectrum Analysis and Projective Sampling for Land Use Change Assessment.
1	Murphy, L. P., and W. W. Abbe, An Automated Technique for Measuring Built-Up Urban Areas from Map Graphics Through Analog Image Processing.
1	Murphy, L. P., and E. G. Trelinskie, Jr., Analog Graphic Processing for 3-D Terrain Displays, Profiles, and Elevation Layer Tints.
3	Lind, A. O., Photo-Geomorphology of Coastal Landforms, Cat Island, Bahamas (Vol. II).
3	Stafford, D. B., R. O. Bruno, and H. M. Goldstein, An Annotated Bibliography of Aerial Remote Sensing in Coastal Engineering.
5	Andreev, V. N., Use of Aerial Methods for the Study of Tundra Landscapes and for their Agricultural Utilization.
5	Frost, R. E., Aerial Photography in Arctic and Subarctic Engineering.
5	Frost, R. E., J. H. McLerrain, R. O. Leighty, Photo-interpretation in the Arctic and Sub-Arctic.
5	Hibler, W. D., Characterization of Cold-Regions Terrain Using Airborne Laser Profilometry.
5	Poulin, A. O., V. H. Anderson, J. M. McAnerney, Aerial Reconnaissance of Sea Ice and Snow Covered Terrain.
11	Dingman, S. L., H. R. Samide, D. L. Saboe, M. J. Lynch, and C. W. Slaughter, Hydrologic Reconnaissance of the Delta River and Its Drainage Basin, Alaska.
11	McKim, H. L., L. W. Gatto, C. J. Merry, D. M. Anderson, and T. L. Marlar, Land Use/Vegetation Mapping in Reservoir Management Merrimack River Basin.
14	Leighty, R. D., A Logical Approach Toward Automated Terrain Pattern Recognition for Engineering Purposes.

SECTION	REPORT TITLE
17	Davis, B. R., J. R. Lundien, A. N. Williamson, Jr., Feasibility Study of the Use of Radar to Detect Surface and Ground Water.
17	Dellwig, L. F., B. C. Hanson, N. E. Hardy, et al, Use of Radar Images in Terrain Analysis: An Annotated Bibliography.
17	Dellwig, L. F., B. C. Hanson, et al, A Demonstration and Evaluation of the Utilization of Side Looking Airborne Radar for Military Terrain Analysis.
17	MacDonald, H. C., Geologic Evaluation of Radar Imagery from Darien Province, Panama.
18	Anderson, D. M., et al, The Use of ERTS-1 Imagery in Regional Interpretation of Geology, Vegetation, Permafrost Distribution and Estuarine Processes In Alaska.
18	Vogel, T. C., An Analysis of LANDSAT Systems for Cartographic and Terrain Information.
20	Anderson, D. M., General Report on Thermal Characteristics of Soils, Thermodynamics of Soil Systems, Fluid Flows, and Frost Action.

20. THERMAL INFRARED SYSTEMS

ANDERSON, D. M., General Report on Thermal Characteristics of Soils, Thermodynamics of Soil Systems, Fluid Flows, and Frost Action, National Research Council, Highway Research Board, Special Report, 1969, No. 103.
(USACRREL, Hanover, New Hampshire)

Author Abstract - No abstract.

CARNEY, J. R., T. C. Vogel, E. R. Love and G. E. Howard, Interagency Energy and Environmental Survey, U. S. Army Security Agency, Arlington, Va., February 1977.
(U. S. Army Security Agency, Arlington, Va.)

Author Abstract - The results of this survey demonstrate the feasibility of using multispectral remote sensing techniques, whereby an U. S. Army Facility Engineer can reduce the number of man-hours currently required for energy and environmental assessments. These include detecting building heat losses and deteriorated insulation invisible to the human eye, performing electrical inspections under full operating loads, and monitoring environmental conditions on a successive annual basis. This survey method, developed during the winter and summer of 1976, employs a handheld infrared imaging device, color and color infrared aerial photography, and thermal infrared imagery.

The thermal infrared imagery is used in conjunction with color aerial photography to detect energy losses and defective roof insulation. This imagery should be obtained during the winter season on a 2-year cycle, 2 to 3 hours after sundown at a scale of 1:4,000.

The color and color infrared photography aids the Facility Engineer in the analysis of the thermal infrared imagery, provides a source of information for establishing a baseline of environmental conditions for future comparison, and monitors potential environmental problem areas. This photography should be obtained simultaneously on a 4-year cycle, between the hours of 1000 and 1500, at scales of 1:10,000 and 1:20,000. During the first cycle, the photography should be obtained in conjunction with the winter thermal infrared flights and repeated during the winter season. The photography and infrared imagery should always be acquired under clear, unobstructed skies.

The handheld infrared device is employed to determine the exact locations of energy losses and roof areas underlain with wet insulation after they have been detected on the aerial infrared imagery. The device can also be used to survey electrical distribution systems, detect heat losses through building walls, and monitor steam lines.

DEMBSEY, D. A. and G. England, Processing Magnetically Taped Infrared Data Acquired in the Arctic, and Associated Studies, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 205, March 1966, NTIS AD-370 918. (USACRREL, Hanover, New Hampshire)

Author Abstract - Under the sponsorship of the United States Army Cold Regions Research and Engineering Laboratory, personnel of the Infrared Physics Laboratory at Willow Run Laboratories engaged in studies aimed at improving the utility and interpretability of infrared data acquired in arctic regions. The first area of inquiry was the processing of infrared scanner signals recorded on magnetic tape so as to produce enhanced imagery, and found this technique yields imagery of greater utility. Two other studies were concerned with the thermodynamics of ice and snow; in one, the infrared sensitivity of snow was measured, while the other derived a steady-state model for surface temperatures in a sheet of snow and ice.

DIAMOND, M. and R. W. Gerdel, Radiation Measurements on the Greenland Ice Cap, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 19, October 1956, NTIS AD-121 350. (USACRREL, Hanover, New Hampshire)

Author Abstract - During the period July 6 - August 7, 1955, global & net radiation measurements were made at a permanent station located approximately 200 mi. E. of Thule and near 6800 ft. elevation. Total incident global radiation amounted to 20,628 ly., of which about 15 percent was absorbed by the snow cover. Most of the absorbed radiation was re-emitted as long-wave radiation. Diffuse sky radiation amounted to about 19 percent of the total incoming radiation. The long-wave radiation balance remained negative. Slightly higher radiation values were measured in blowing snow at a level 1.25 m. above the snow as compared to levels higher up; this increase may be due to multiple reflection. The heat balance of the snow cover at this site was computed at 7.6 ly./day. All data are tabulated and graphed, including hourly values of the incident and reflected solar radiation.

DiCARLO, C. and J. Quick, Infrared Mapping of Liberia,
NTIS AD 721 911.
(Defense Mapping Agency, Washington, DC)

Author Abstract - U. S. efforts to map Liberia date back to 1951, at which time the two Governments negotiated an agreement for the Liberia Survey. In 1963, a project agreement was signed by U. S. personnel of the Agency for International Development (AID) and the Liberian Bureau of Natural Resources and Survey. As a result, the 72nd Engineer Detachment, under the direction of the Army Map Service, set up field Headquarters at Camp Ramrod, about 11 miles east of the capital of Monrovia. (See Figure 1). Its mission was to:

(1) Establish vertical control for mapping.

(2) Establish astronomic positions at HIRAN stations; and to

(3) Observe astronomic azimuths at HIRAN stations and along the traverse.

(4) Provide on-the-job training for members of the Liberian Cartographic Service.

Planning for the most recent mapping effort began in 1966. Early in 1967, the USAF Military Airlift Command (MAC) assigned the job to the 1370th Photo Mapping Wing, whose worldwide field operations, both airborne and ground, are performed by Aerial Survey Teams (AST's).

Project AF 67-4 was thereby generated, and Aerial Survey Team No. 2, under the command of Major William H. Kinghorn, was organized. Its mission: to obtain visual and HIRAN controlled photography of the entire country of Liberia during one photographic season.

DUNKLE, R. V. and J. T. Gier, Radiation in a Diffusing Medium with Application to Snow, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TR 16/2, November 1953, NTIS AD-023 217.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The transmission through an idealized snow cover has been shown to be directly related to the albedo and to be an exponentially decreasing function. Two parameters have been proposed as possible correlating factors for transmission and albedo measurements. The first factor is a characteristic of the surface condition of the cover and the second is a characteristic of the snow beneath the surface.

GERDEL, R. W., M. Diamond and K. J. Walsh, Nomographs for Computation of Radiation Heat Supply, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 8, February 1954, NTIS AD-031 051.
(USACRREL, Hanover, New Hampshire)

Author Abstract - A nomogram is given for computing the total daily amount of solar and sky radiation for 40-90 N lat. Correction values for elevation and cloud cover are tabulated. A second nomogram is presented which permits conversion of the values of radiation received to the net radiational heat balance of a snow cover, including the volume of meltwater produced when the snow temperature is at 0 C. A third nomogram is given which may be used to determine the radiation through a snow cover for snow densities from 0.2 - 0.6. An example of the use of the nomograms is illustrated.

KONDRAT'EVA, A. S. Thermal Conductivity of the Snow Cover and Physical Processes Caused by the Temperature Gradient (Translation), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hamshire, SIPRE TL 22, NTIS AD-035 124.

Author Abstract - Laboratory tests were conducted to determine the relationship between the density and thermal conductivity of snow. Snow of known densities was placed in 30 x 50 cm. open-top wooden boxes with metal bases immersed in a NaCl solution at -1C. The air temperature surrounding the box was kept constant at -12C. Thermocouples were placed at various depths, approximately 10 cm. apart. The initial temperature of the snow was recorded and new recordings were plotted every 30 min. The results indicated that the ratio of the coefficient of thermal conductivity to the square of the density was 0.00068 for smaller densities and 0.0085 for larger densities.

LEIGHTY, R. D., Operation Hot Deck (Preliminary Report), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 48, July 1962, NTIS AD-331 711.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Operation Hot Deck was initiated in April 1961 and continued into June 1961 with a series of aerial missions over selected "hot" surfaces which included desert surfaces heated by oxidation of ore bodies, areas of intense hydrothermal activity, and areas of burning lignite beds. This report covers the preliminary study of the imagery from these natural high temperature terrain features. Illustrations show the variations in thermal contrasts and tones throughout the day and the appearance of the thermal features with respect to the infrared pattern of the background.

LEIGHTY, R. D. and T. C. Vogel, Infrared Detection of Military Vehicles of Snow-Covered Background, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, TR 155, July 1965, NTIS AD-369 624.
(USACRREL, Hanover, New Hampshire)

Author Abstract - This report presents a detailed analysis of the infrared imagery with particular attention to detectability with respect to the natural and physical parameters which permitted or limited detection. From the imagery, indications of vehicle activity or presence on a snow-covered background were found to fit one of five detection classes. This classification of detection indicators was then used to classify each signal from each vehicle site on each of the aircraft overflights of the targets. Two approaches were used in the analysis of the data: grouping detection classes with regard to site, and investigating each vehicle site with respect to its detection situation.

LINK, L. E., Jr., Aerial Infrared Survey of the Walter F. George Lock and Dam, Chattahoochee River, Alabama-Georgia, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, WES-MP-M-70-3, May 1970, NTIS AD A032 902.
(USAEWES, Vicksburg, MS)

Author Abstract - A study was made to delineate subsurface seepage channels by infrared scanner imagery at the Walter F. George Lock and Dam, Chattahoochee River, Alabama-Georgia. Ground measurements of the conditions at the site were made to determine the optimum flight time for obtaining the infrared imagery and to aid in interpretation of the imagery. The infrared imagery was collected between 0300 and 0500 hr on 22 November 1969. The imagery was analyzed to determine if any trends existed which might suggest subsurface seepage channels at the site. The ground truth data were used in the imagery interpretation. Interpretation of the infrared imagery did not delineate any trends which indicated paths of flow of the groundwater and reservoir leakage. A study was then made to determine what features affected the tones on the infrared imagery. It was determined that surface features such as grass cover and soil moisture content produced most of the variations in the tone on the infrared imagery. Additional research is recommended in areas where seepage occurs closer to the terrain surface.

LINK, L. E., Jr., Demonstration of a New Technique for Rapidly Surveying Roof Moisture, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, WES-MP-M-76-14, June 1976, NTIS AD-A026 722.
(USAEWES, Vicksburg, MS)

Author Abstract - The results of this study demonstrate the potential of the combined thermal IR-nuclear moisture meter roof survey technique described herein. Application of the technique at Dyess AFB, Texas, resulted in the detection of roof areas with entrapped moisture on 5 of the 128 buildings surveyed. Airborne thermal IR imagery proved to be a very effective means of identifying roof areas with potential entrapped moisture. Some false alarms were created by air vents on smaller buildings; however, prior knowledge of the position of the vents (i.e., during the examination of the imagery) would probably reduce this problem considerably. Not all the questions were answered. Information is needed to define the usefulness of the technique as a function of climatic condtiions and roof types. In addition, more data are needed to help define the optimum time for acquiring thermal IR imagery for roof moisture surveys.

LINK, L. E., Jr., Roof Moisture Survey at Pease AFB, New Hampshire, and Offutt AFB, Nebraska, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, WES-MP-77-2, January 1977, NTIS AD-A036 090.
(USAEWES, Vicksburg, MS)

Author Abstract - A new technique for surveying roof moisture was applied at Pease AFB, New Hampshire, and Offutt AFB, Nebraska. The technique consists of using airborne thermal infrared (IR) imagery to rapidly examine all built-up roofs on an installation, and a nuclear moisture meter to examine in detail (on the roof) roof areas identified on the IR imagery to have possible entrapped moisture. The results of the surveys at these two Air Force bases show that the survey technique is a very efficient means of detecting roof areas with entrapped moisture. Twenty-three of the 238 buildings examined with thermal IR imagery were suspected to have areas with entrapped moisture. Detailed surveys with the nuclear meter showed that 14 of the 23 buildings had entrapped-moisture problems. The presence of elevated roof structures, vents, and standing water caused anomalies initially suspected to be due to entrapped moisture on several buildings. Prior knowledge of the existence of these features would have significantly reduced the number of misinterpretations. It is recommended that an initial draft of a manual for operational application of the thermal IR-nuclear meter roof survey technique be prepared.

McLERRAN, J. H., Infrared Sea Ice Reconnaissance, Proceedings of 3rd Symposium on Remote Sensing of Environment, October 14-16, 1964, University of Michigan, Ann Arbor, Michigan, MP 288.
(USACRREL, Hanover, New Hampshire)

Author Abstract - Infrared sensing of sea ice has been studied over a four year period and has shown great promise. Infrared sensing has shown more advantages over other imaging systems. It has nighttime capability and there is some relationship between thermal radiation and ice thickness. This paper presents a few illustrations of infrared imagery of sea ice with a discussion of the interpretation of each illustration. Applications and limitations are discussed briefly.

McLERRAN, J. H., J. O. Morgan, Thermal Mapping of Yellowstone National Park, Proceedings of 3rd Symposium on Remote Sensing of Environment, University of Michigan, Ann Arbor, Michigan, 14-16 October 1964, MP 292.
(USACRREL, Hanover, New Hampshire)

Author Abstract - In April 1961, infrared imagery was obtained over Yellowstone National Park. The purpose was to conduct a preliminary study of the usefulness of infrared imagery over terrain with natural high-temperature contrasts, and to determine if subsurface thermal anomalies could be imaged if they are not evident by surface hydrothermal features. This paper presents imagery from several areas of the Park and demonstrates that infrared sensing is useful for mapping hydrothermal features. The results from this study indicate that new studies should be conducted using new state-of-the-art infrared scanners and detectors.

McLERRAN, J. H., Infrared Thermal Sensing, Photogrammetric Engineering, May 1967, 33(5), MP 289.
(USACRREL, Hanover, New Hampshire)

Author Abstract - In the past several years, much progress has been made in developing infrared thermal sensing and its application in terrain analysis. Infrared imagery does portray terrain features; however, to interpret the imagery properly it is necessary to know the time of day and conditions under which it is obtained. Diurnal changes can create thermal pattern reversals. Infrared imagery is useful in inventory of hot springs and water resources. Sea-ice reconnaissance can be conducted by use of infrared sensors during periods when visual observations and photography cannot be obtained.

MUNIS, R. H., R. H. Berger, S. J. Marshall, and M. A. Bush,
Detecting Structural Heat Losses with Mobile Infrared Thermography, Part I - Description of the Technique, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 326, October 1974, NTIS AD 001 549.
(USACRREL, Hanover, New Hampshire)

Author Abstract - A method to assess quickly the insulation effectiveness of buildings using mobile infrared thermography has been developed at USACRREL. In contrast to the infrared thermography done in Sweden, this method concentrates on obtaining useful data by measuring the outside surface temperature of structures. This report outlines the basic principles involved in these measurements, and discusses field measurements and the inherent advantages of infrared thermography. Typical thermograms are presented in the appendixes.

MUNIS, R. H., R. H. Berger, S. J. Marshall, and M. A. Bush,
Detecting Structural Heat Losses with Mobile Infrared Thermography, Part III - Survey of USACRREL, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 348, December 1975, NTIS AD-A020 375.
(USACRREL, Hanover, New Hampshire)

Author Abstract - During the winter of 1973-74, a mobile infrared thermography system was used to survey the USACRREL building at Hanover, New Hampshire. This report provides a description of excessive heat losses at several locations around the building. This report also discusses the need to carefully monitor meteorological conditions before starting a survey of a building exterior to determine if solar radiation decay from the building surface might interfere with thermographic analysis by masking the heat emanating from within the building.

NAKANO, Y., J. Brown, Mathematical Modeling and Validation of the Thermal Regimes in Tundra Soils, Barrow, Alaska, Arctic and Alpine Research, Winter 1972 4(1), MP 348.

Author Abstract - Efforts were made to develop a mathematical model of the thermal regimes in tundra soils. The results of field investigations during summer and fall of 1970 in the vicinity of Barrow, Alaska, were used for validation of the model. Accuracy in simulating the field observations by the model is found satisfactory. Effects of important factors affecting the thermal regime are also discussed.

Operation Cold Deck: A Cold Regions Aerial Infrared Sensing Program, University of Michigan Institute of Science and Technology, Project Michigan Report No. 2900-319-T, RR 104, July 1962. (USACRREL, Hanover, New Hampshire)

Author Abstract - A coordinate program of simultaneous airborne and ground measurements in the thermal region of the spectrum was conducted in the subarctic environment of the Keweenaw Peninsula in northern Michigan. The research program was primarily intended to determine the usefulness of airborne infrared sensors in analyzing cold terrain, detecting undersnow structures, calculating the effects of environmental parameters, and detecting vehicles in various states of activity. Results show that under certain conditions the sensors are extremely useful for all these purposes. The report provices extensive data on the effects of man-made and natural structures, and the appearance of these structures against a low temperature background.

POULIN, A. O., Infrared Aerial Reconnaissance in the Arctic (Spring Condition), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RN 194, October 1965, NTIS AD-374 853.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Infrared thermal imagery and concurrent conventional photography is analyzed. Imagery was obtained with a mercury-doped germanium detector in a modified AN/AAD-2 scanner, and conventional aerial photography with Plus-X Panchromatic and infrared films was obtained with a 6-in., focal length camera. Included is sea ice of all ages; icebergs; ice islands; snow-covered terrain of various types; ice-bound and snow-covered land masses whose boundaries were visually indistinguishable; ice caps, glaciers and associated features, including crevasses and marginal lakes; and installations varying from 2-man, temporary stations to a major airbase. It was found that the thermal and visual images supplement each other to provide an effective system for aerial reconnaissance during the early Arctic spring. Infrared thermal imagery often permitted identifications of land and ice features where snow hindered visual recognition.

POULIN, A. O. and T. A. Harwood, Infrared Mapping of Thermal Anomalies in Glaciers, Canadian Journal of Earth Sciences, Volume 3, Number 6, Paper No. 16, 1966.
(USACRREL, Hanover, NH, and Defence Research Board, Ottawa, Canada)

Author Abstract - All-season aerial reconnaissance of the Arctic has been advanced with the development of airborne, infrared scanners. The utility of such equipment for detecting and studying the progression of thermal anomalies of glaciological interest is discussed with reference to specific examples of imagery obtained during three seasons on Project "Bold Survey" under conditions of both daylight and darkness. Where possible, comparisons are made between infrared thermal imagery and conventional aerial photography.

POULIN, A. O., On the Thermal Nature and Sensing of Snow-Covered Arctic Terrain, U. S. Army Engineer Topgraphic Laboratories, Fort Belvoir, Va., Research Note ETL-RN-73-4, May 1973, NTIS AD 764 239.
(USAETL, Fort Belvoir, Virginia)

Author Abstract - Thermal infrared imagery (8 to 14 micrometers) of selected areas of the North American Arctic above the 75th parallel was obtained at three different periods: early winter, midwinter and early spring. Data runs totaling approximately 2500 nautical miles in length were made at altitudes ranging from 1000 to 20,000 feet. Environmental conditions included: (1) daytime with solar altitudes from 2 to 27 degrees and the atmosphere ranging from very clear to very hazy and (2) very clear to very hazy conditions during the dark season. Subjects covered included sea ice, coastal areas, inland areas, lakes, streams, glaciers, the Greenland Ice Cap, and the Ward-Hunt Ice Shelf. Questions arising from analysis of the imagery led to a winter experiment in which study was concentrated on the temperature differences that develop at shorelines, but a number of secondary studies were also conducted. Aerial radiometric data and photographs were correlated with ground data which included subsurface temperatures in the soil, ice and snow on both sides of a shoreline.

A classification system for thermal features exhibited by Arctic terrain and preliminary criteria for seasonal maps was developed. It was found that: (1) a thermal condition, named the "cold fringe effect," that allows the identification of areas where sea and lake ice is frozen to the bottom develops late in winter, (2) it may be possible to map snow depths from surface temperature on undisturbed ice, and (3) useful infrared data can be obtained under very hazy and moderately windy conditions. Secondary studies included solar heating effects and infrared transmission through haze. Numerous examples of thermal imagery are included. Six appendices present basic principles; thermal and radiation properties of snow, ice and soil; data; and description of equipment.

POULIN, A. E., Hydrologic Characteristics of Snow-Covered Terrain from Thermal Infrared Imagery, presented at the Interdisciplinary Symposium on Advanced Techniques in the Study of Snow and Ice Resources, Monterey, California, December 2-6, 1973. (USAETL, Fort Belvoir, Va.)

Author Abstract - Snow cover, in addition to its own contribution to the hydrological state of the terrain, often conceals other hydrologic features or changes in their conditions. The differing subsurface thermal regimes of features such as streams, frozen lakes, and areas of deeper snow often produce surface temperature differences that are sufficient for the production of thermal images of those features. Measurements at a frozen arctic shoreline indicate that the part of these temperature differences resulting from systematic variations of the energy balance components is sufficiently large that it can be distinguished from the part due to random variations. This suggests that there is a degree of predictability to the information available in thermal infrared imagery of snow-cpvered terrain. However, it is often necessary to consider topographic relationships and short term environmental phenomena in order to understand some of the transient, but useful, image features. A phenomenon, which was given the name "cold fringe effect," was discovered that should allow the identification of areas in which the ice formed on bodies of water is frozen to the bottom. A qualitative model was developed for the diurnal variation of a shoreline temperature differential throughout the winter season, and studies are in progress to evaluate it using measurements from both aircraft and spacecraft.

POULIN, A. O., Significance of Surface Temperature in the Thermal Infrared Sensing of Sea and Lake Ice, Journal of Glaciology, Vol. 15, No. 73, 1975. (USAETL, Fort Belvoir, Va.)

Author Abstract - Thermal infrared sensing can provide much information about sea ice, and some of the physical conditions associated with sea ice suggest that surface temperature may be a good indicator of ice thickness. However, steady-state heat-flow calculations suggest that the variable thickness of the snow cover and its low, variable thermal conductivity would preclude the use of surface temperature alone as a suitable indicator of ice thickness. Measurements of surface temperature, snow depth, and ice thickness suggest that, in an area of relatively uniform ice thickness, surface temperature might be useful as an indicator of snow depth if some surface data can be obtained.

POULIN, A. O., The Potential of Thermal Infrared Imagery for Supplemental Map Information in Snow-Covered Areas, U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Technical Report ETL-0059, January 1976, NTIS AD-A028 384. (USAETL, Fort Belvoir, Va.)

Author Abstract - An experimental map showing winder conditions in an arctic area was developed by modifying an existing orthopictomap. Modifications included the addition of vegetation and hydrologic information, which are considered feasible to be derived from thermal infrared imagery obtained in winter. As suitable infrared imagery of the study area was not available, the information was derived from summer aerial photography. Interpretation of the photography was based on results obtained from thermal infrared research in other arctic areas. The mapped area covers a 7½ minute quadrangle at a scale of 1:25,000 in the Fort Greely, Alaska, area.

The processes that cause changing surface temperatures are discussed. Examples of thermal infrared imagery (8-14 micrometers) are presented that illustrate some of these energy transfer processes, as well as some of the types of features included on the experimental map. Recommendations for a production map format include a climate summary suitable for preliminary flight planning for the acquisition of thermal imagery; this is printed on the back of the map.

Uses suggested for this type of map are:

1. Land navigation assistance on the basis of vegetation characteristics and boundaries.

2. Camouflage and concealment characteristics of vegetated areas.

3. Cross-country movement planning on the basis of an initial assessment of the probable condition of lakes and streams that may have to be crossed or avoided.

4. Location of water supplies.

5. Guidance in planning for and utilizing new thermal infrared imagery.

RINKER, J. N., Infrared Thermal Detection of Caves, presented at the American Society of Photogrammetry Fall Convention on 10-13 September 1974.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Airborne infrared thermal scanners can be used to detect cave openings under certain conditions. First, the temperature inside the cave must be enough different than external conditions; and second, the breathing cycle of the cave, as a function of atmospheric pressure, must be determined. From these data, a flight time can be picked that will provide the most favorable circumstances. Even though the cave is detected, there is the problem of identifying its signal from similar-looking signals throughout the image. Results are presented for the Camuy cavern system in Puerto Rico.

RINKER, J. N., Airborne Infrared Thermal Detection of Caves and Crevasses, published in Photogrammetric Engineering and Remote Sensing, Vol. 41, No. 11, November 1975.
(USAETL, Fort Belvoir, Va.)

Author Abstract - Airborne infrared thermal scanners can be used to detect crevasses and cave openings, but only under certain conditions. First, the temperature inside the void must be significantly different from external conditions; and second, some mechanism must exist to bring this thermal difference to the surface where it can be detected by a scanner. Furthermore, it must be determined if other events influence this mechanism. In the case of crevasses, conduction and convection both play a role in altering the surface temperature of the snow bridge over a crevasse. For caves, convection is the mechanism that brings about the temperature alteration. Convection is linked to the breathing cycle which, in turn, is caused by changes in atmospheric pressure. From ground measurements of internal temperature, external temperature, and atmospheric pressure a flight time can be picked that will provide the most favorable circumstances. The cave signal is more of a problem because it is frequently surrounded by similar looking signals caused by other events. Results are given for a crevasse field in Greenland and for a cave system in Puerto Rico.

WECHSLER, A. E., et al, Methods of Laboratory and Field Measurements of Thermal Conductivity of Soils, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SR 82, September 1965, NTIS AD-475 793.
(USACRREL, Hanover, New Hampshire)

Author Abstract - This study evaluates experimental methods of measurement of thermal conductivity and diffusivity of soils and building construction and insulation materials under laboratory and field conditions. The applicability, cost, accuracy, and limitations of these techniques are assessed. Following a brief, review of the steady-state and transient methods of measuring thermal conductivity and diffusivity, the probe method is discussed in greater detail. Factors such as moisture migration, instrumentation requirements, methods of probe emplacement, and experimental technique used in probe measurements are considered. The probe method is the most applicable technique for rapid measurement in the laboratory and in the field, and it is suitable for measurements of dry and moist materials. This method can be used for basic studies of heat and mass tranfer in soils as well as specific measurements of a practical nature. The emplacement of probes in situ indicates changes in moisture content of materials.

YEN, Y.-C., Heat Transfer Characteristics of Naturally Compacted Snow, U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, RR 166, June 1965, NTIS AD-619 344.
(USACRREL, Hanover, New Hampshire)

Author Abstract - The heat transfer characteristics of naturally compacted snow have been determined experimentally. The results are interpreted as effective thermal conductivity k sub e and water vapor diffusivity D sub e and equations are derived for these characteristics. In contrast with the results obtained from previous investigations on unconsolidated snow, in the case of naturally compacted snow, values of k sub e and D sub e are found to be not only a function of air flow rate but also of snow density. From present as well as previous studies, it can be concluded that air flow has considerable effect on the thermal conductivity and water vapor diffusivity of unconsolidated and naturally compacted snow. It is reasonable to state that the essential factor influencing the formation of depth hoar and avalanches is a prolonged process of simultaneous heat and mass transfer due to steep temperature gradients.

YOSIDA, Z., et al, Measurement of the Thermal Conductivity of Snow Cover (Translation from Seppyo, Vol. 8;48-53, 1946), U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, SIPRE TL 30, November 1954, NTIS AD-070 465.

Author Abstract - A new method of measuring the thermal conductivity of a small sample of snow is described. A snow sample of cylindrical form, 10 cm in diameter and 5 cm in height, was packed in an airtight vessel. The sides were insulated to permit heat flow only in the vertical direction. The temperature of the terminal surfaces of the cylinder was -1C at the beginning of the test run. Both surfaces were rapidly cooled to -6C until the temperature of the entire sample was -6C. The rate of decrease of pressure in the vessel was measured. A mathematical analysis resulted in an equation from which the value of thermal conductivity can be determined from the rate of decrease in pressure. Data obtained by this method are given. A total of 13 measurements of thermal conductivity of snow determined by the older, established method are included in the appendix by Shigeji uOgiya.

SECTION	REPORT TITLE
5	Kumai, M., and J. D. Russel, Attenuation and Backscattering of Infrared Radiation by Ice Fog and Water Fog.
5	McLerran, J. H., Airborne Crevasse Detection.
5	McLerran, J. H., Remote Sensing and Interpretation of Sea-Ice Features.
5	Poulin, A. O., T. A. Harwood, Infrared Imagery in the Arctic Under Daylight Conditions.
17	Advanced Radar Topographic Application.
19c	McLerran, J. H., Infrared Sensing of Soils and Rocks.

Appendix. Corps of Engineers Divisions, Districts, and Laboratories

U.S. Army Engineer North Central Division
536 South Clark Street
Chicago, IL 60605

U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

U.S. Army Engineer District, Chicago
219 South Dearborn Street
Chicago, IL 60604

U.S. Army Engineer District, Detroit
P.O. Box 1027
Detroit, MI 48231

U.S. Army Engineer District, Rock Island
Clock Tower Bldg
Rock Island, IL 61201

U.S. Army Engineer District, St. Paul
USPO and Customhouse
St. Paul, MN 55101

U.S. Army Engineer North Atlantic Division
90 Church Street
New York, NY 10007

U.S. Army Engineer District, Baltimore
P.O. Box 1715
Baltimore, MD 21203

U.S. Army Engineer District, New York
26 Federal Plaza
New York, NY 10007

U.S. Army Engineer District, Norfolk
803 Front Street
Norfolk, VA 23510

U.S. Army Engineer District, Philadelphia
U.S. Custom House
2nd and Chestnut Street
Philadelphia, PA 19106

U.S. Army Engineer Lower Mississippi Valley Division
P.O. Box 80
Vicksburg, MS 39180

U.S. Army Engineer District, Memphis
668 Clifford Davis Federal Bldg
Memphis, TN 38103

U.S. Army Engineer District, New Orleans
P.O. Box 60267
New Orleans, LA 70160

U.S. Army Engineer District, St. Louis
210 North 12th Street
St. Louis, MO 63101

U.S. Army Engineer District, Vicksburg
P.O. Box 60
Vicksburg, MS 39180

U.S. Army Engineer Southwestern Division
Main Tower Bldg
1200 Main Street
Dallas, TX 75202

U.S. Army Engineer District, Albuquerque
P.O. Box 1580
Albuquerque, NM 87103

U.S. Army Engineer District, Fort Worth
P.O. Box 17300
Fort Worth, TX 76102

U.S. Army Engineer District, Galveston
P.O. Box 1229
Galveston, TX 77550

U.S. Army Engineer District, Little Rock
P.O. Box 867
Little Rock,AR 72203

U.S. Army Engineer District, Tulsa
P.O. Box 61
Tulsa, OK 74102

U.S. Army Engineer South Atlantic Division
510 Title Bldg
30 Pryor Street, SW
Atlanta, GA 30303

U.S. Army Engineer District, Charleston
P.O. Box 919
Charleston, SC 29402

U.S. Army Eningeer District, Jacksonville
P.O. Box 4970
Jacksonville, FL 32201

U.S. Army Engineer District, Mobile
P.O. Box 2288
Mobile, AL 36628

U.S. Army Engineer District, Savannah
P.O. Box 889
Savannah, GA 31402

U.S. Army Engineer District, Wilmington
P.O. Box 1890
Wilmington, NC 28401

U.S. Army Engineer Ohio River Division
P.O. Box 1159
Cincinnati, OH 45201

U.S. Army Engineer District, Huntington
P.O. Box 2127
Huntington, WV 25721

U.S. Army Engineer District, Louisville
P.O. Box 59
Louisville, KY 40201

U.S. Army Engineer District, Nashville
P.O. Box 1070
Nashville, TN 37202

U.S. Army Engineer District, Pittsburgh
Federal Bldg
1000 Liberty Avenue
Pittsburgh, PA 15222

U.S. Army Engineer North Pacific Division
P.O. Box 2870
Portland, OR 97208

U.S. Army Engineer District, Alaska
P.O. Box 7002
Anchorage, AK 99510

U.S. Army Engineer District, Portland
P.O. Box 2946
Portland, OR 97208

U.S. Army Engineer District, Seattle
P.O. Box C-3755
Seattle, WA 98124

U.S. Army Engineer District, Walla Walla
Bldg 602, City-County Airport
Walla Walla, WA 99362

U.S. Army Engineer South Pacific Division
630 Sansome Street, Rm 1216
San Francisco, CA 94111

U.S. Army Engineer District, Los Angeles
P.O. Box 2711
Los Angeles, CA 90053

U.S. Army Engineer District, Sacramento
650 Capital Mall
Sacramento, CA 95814

U.S. Army Engineer District, San Francisco
100 McAllister Street
San Francisco, CA 94102

U.S. Army Engineer Missour River Division
P.O. Box 103, Downtown Station
Omaha, NE 68101

U.S. Army Engineer District, Kansas City
700 Federal Bldg
Kansas City, MO 64106

U.S. Army Engineer District, Omaha
6014 USPO and Courthouse
215 North 17th Street
Omaha, NE 68102

U.S. Army Engineer Middle East Division
APO, NY 09038

U.S. Army Liaison Detachment
26 Federal Plaza
New York, NY 10007

U.S. Army Engineer Pacific Ocean Division
BLDG 230, Fort Shafter
Honolulu, HI
APO San Francisco 96558

U.S. Army Engineer District, Japan
APO San Francisco 96343

U.S. Army Engineer District, Far East
APO San Francisco 96301

U.S. Army Engineer Huntsville Division
P.O. Box 1600, West Station
Huntsville, AL 35807

U.S. Army Engineer New England Division
424 Trapelo Road
Waltham, MA 02154

U.S. Army Engineer European Division
APO New York 09757

U.S. Army Coastal Engineering Research Center
Fort Belvoir, VA 22060

U.S. Army Engineer Topographic Laboratories
Fort Belvoir, VA 22060

U.S. Army Waterways Experiment Station
Vicksburg, MS 39180

U.S. Army Cold Regions Research and Engineering Laboratory
Hanover, NH 03755