Bibliography of In-House and Contract Reports, Supplement 17

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September 1991

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U.S. Army Corps of Engineers
Engineer Topographic Laboratories
Fort Belvoir, Virginia  22060-5546
This is Supplement 17 to the ETL Bibliography of In-House and Contract Reports. This supplement provides author and title indexes, abstracts, and AD numbers for the 1989, 1990, and 1991 additions to the continuing bibliography. It also contains a complete title index designed to be used in conjunction with the 17 published bibliographies and refers to them by year and number.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREFACE</td>
<td>v</td>
</tr>
<tr>
<td>REPORTS (Abstracts)</td>
<td>1</td>
</tr>
<tr>
<td>PAPERS</td>
<td>33</td>
</tr>
<tr>
<td>INDEXES</td>
<td></td>
</tr>
<tr>
<td>Titles</td>
<td>37</td>
</tr>
<tr>
<td>Corporate Authors</td>
<td>40</td>
</tr>
<tr>
<td>Personal Authors</td>
<td>41</td>
</tr>
<tr>
<td>AD Numbers</td>
<td>42</td>
</tr>
<tr>
<td>APPENDIX</td>
<td>43</td>
</tr>
<tr>
<td>Titles (1953 - 1991)</td>
<td></td>
</tr>
</tbody>
</table>
PREFACE

This is Supplement 17 to the report titled, "Bibliography of In-House and Contract Reports" AD-877 653L; Supplement 1, AD-890 066L; Supplement 2, AD-905 548L; Supplement 3, AD-B005 275L; Supplement 4, AD-B010 642L; Supplement 5, AD-B019 966L; Supplement 6, AD-055 468; Supplement 7, AD-A068 744; Supplement 8, AD-A084 111; Supplement 9, AD-A099 803; Supplement 10, AD-A113 006; Supplement 11, AD-A128 400; Supplement 12, AD-A141 778; Supplement 13, AD-A160 607; Supplement 14, AD-A173 750; Supplement 15, AD-A195 953; and Supplement 16, AD-A215 154. It is a continuing bibliography of reports prepared by and for the U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia. This bibliography includes reports that were published from 1 October 1989 through 1 October 1991.

Reports with AD numbers can be purchased by Department of Defense agencies from the Defense Technical Information Center; other agencies and individuals can purchase copies from the National Technical Information Service, Springfield, Virginia 22161-2171. Reports with a "B" in the AD number are limited in distribution to U.S. Government agencies unless permission for release is granted from the controlling office. Reports are available on an interlibrary loan from the Scientific and Technical Information Center, U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia 22060-5546.

Colonel David F. Maune, EN, was Commander and Director, and Mr. Walter E. Boge was Technical Director of the Engineer Topographic Laboratories during the report preparation.
THE AUTONOMOUS LAND VEHICLE (ALV) PROGRAM  
SEVENTH QUARTERLY REPORT  
March 1988

Edited by:  
Gustav R. Hoyer

Martin Marietta Astronautics Group

Keywords: Autonomous Land Vehicle, Image Understanding, Computer Vision, Unmanned Vehicles, Artificial Intelligence, Robotic Combat Vehicles, Robotics

During this quarter, we finalized our hardware and software testing and integration activities in preparation for the November 5, 1987 Autonomous Land Vehicle (ALV) demonstration. In hardware integration developments, we completed the installation and check out of the Warp systolic array processor and the Local Attitude Reference System (LARS). In software development activities, we finalized the integration of all software components that, in totality, comprise the 1987 ALV Computer Software Configuration Item (CSCI), which is, in Department of Defense software requirements specification terminology, the formal name for our 1987 computer software architecture. After fine-tuning the demonstration software configuration, we performed a series of pre-demonstration test runs to verify our readiness for the November 5 performance date. Following this, we placed the demonstration software CSCI under formal configuration management control.

ETL-0498  
AD A240 746

HOURLY AND DAILY PRECIPITATION FREQUENCIES  
FOR THE UNITED STATES  
December 1988

Ruth L. Wexler

Keywords: Hourly Precipitation, Daily Precipitation, Short-Term Rainfall, Precipitation Models, Computer Programs

This report presents daily and hourly precipitation probabilities for an extensive network of stations throughout the United States, from special summaries of observations obtained over the decade 1951-1960. When data are in the format of cumulative percent frequency per precipitation rate, the daily and hourly distributions each form a fairly regular progression, per P/D or P/H, respectively (P = total precipitation, D = days, H = hours). The resultant models, in the form of succinct tables, graphs, or computer programs, provide a ready means for recovering the original observations, or estimating any selected precipitation rate for a wide spectrum of precipitation regimes in the United States, or elsewhere. The models, which serve as a check on data errors, or weather modification, also indicate to the engineer preferred areas for testing particular equipment. The methodology for the comparison among stations (or countries) of the actual short-term precipitation distributions, given only routine climatic data, should be highly useful for assessing more accurately a host of factors, as: soil moisture, trafficability, water supply crop yields, or possible malfunction of electronic equipment. The greatest advantage of the result is that they may be utilized for estimating short-term precipitation in data sparse localities.
Phase II of the program shifted away from annual system demonstrations to the use of the ALV as a "national testbed" for the purpose of hosting various experiments in autonomous land navigation technology. In hardware installation, integration and test activities, minor modifications were made to the vehicle's on-board computer hardware. We developed a new LNS navigation processor interface board, continued testing the Local Attitude Reference System (LARS), acquired a doppler radar ground speed sensor, developed a new architecture plan for real-time system development and sensor integration, introduced improved hardware documentation, and made mechanical improvements to the vehicle's mobility platform. In software developments, we continued to develop and test our prototype perception and reasoning (planning) software configuration for offroad navigation and finding the road from offroad. Our test activities on the ALV were primarily focused on documenting our vehicle hardware configuration; acceptance tests of the RF communications system; road checks of the vehicles handling characteristics following the installation of new automotive components; experimenting with our prototype perception and reasoning offroad software; validating our evolving concepts for offroad navigation; and perfecting our vehicle teleoperation hardware and software components and procedures. We also conducted several nighttime tests in preparation for future nighttime on and offroad experiments.
During this quarter, our activities primarily focused on validating our evolving concepts for off-road navigation; continued experiments with our prototype off-road software architecture; correcting performance problems in our off-road software; and perfecting our vehicle teleoperation hardware and software components and procedures. In hardware installation and integration activities, minor modifications were made to the vehicle’s on-board hardware. We installed a more capable video switch, modified the vehicle’s control unit board, modified the Bendix LNS, and installed a new stereo camera system to support the Mars Rover program. In software developments, activities centered on the continued testing and refinement of our prototype perception and reasoning (planning) software configuration for off-road navigation and finding the road from off-road. We performed a number of software development tasks needed to support various hosted experiments on the ALV. We continued our research in video/range sensor fusion and inverse perspective algorithm comparison, developed a perception processing approach based on a 3-D vehicle model using the Warp, and developed a prototype multispectral image classification methodology using neural networks on the Warp. Our test activities concentrated on performance testing of the hardware installations made and supporting various experiments on the ALV testbed. These included our own off­-road autonomous navigation tests, data collection for Advanced Decision Systems and Carnegie-Mellon University (CMU), and experiments by CMU and the Martin Marietta Mars Rover program. Our program staff representative made a coordination visit to the Jet Propulsion Laboratory (JPL) to determine their intentions and requirements regarding future experiments.
RESEARCH IN KNOWLEDGE-BASED VISION TECHNIQUES FOR THE AUTONOMOUS LAND VEHICLE PROGRAM
FINAL ANNUAL REPORT
August 1989

Editors: Contributions by:
R. Nevatia W. Franzen G. Medioni
K. Price S. Gazit S. Peng
P. Saint-Marc

University of Southern California

Keywords: Autonomous Land Vehicle, Motion Analysis, Target Detection and Description, Knowledge-Based Vision

This report describes our research activities for the period of June 1, 1988 through May 31, 1989, and along with the previous annual reports it constitutes the "Final Technical Report." The researchers basic approach to detecting and tracking motion is to extract and match features, such as lines and regions, from a sequence and to generate motion estimates from these. Presented are: one report on spatio-temporal analysis for tracking edges through very closely spaced sequences; a report on matching edge-based contours using edges from multiple scales with low resolution guiding high resolution matches; and an analysis of estimating 3-D motion and structure of moving objects with uniform acceleration.
DEVELOPMENT OF AN INTEGRATED MOBILE ROBOT SYSTEM
AT CARNEGIE MELLON UNIVERSITY
July 1989

Steven Shafer
William Whittaker
Carnegie Mellon University

Keywords: Strategic Computing, Machine Vision, Autonomous Land Vehicle

This report describes progress in development of an integrated mobile robot system at the Carnegie Mellon Robotics Institute from July 1987 to June 1988. The program includes a broad agenda of research in the development of mobile robot vehicles, focused on the NAVLAB computer-controlled van. In the year covered by this report, we addressed major issues in both hardware and software for autonomous mobile robots.

* Evolution of NAVLAB Vehicle. We built the NAVLAB mobile robot vehicle in our previous work under this contract, by outfitting a commercial truck chassis with computer-controlled drive and steering controls and a set of on-board computer workstations. The NAVLAB serves as a mobile navigation laboratory that allows researchers to interact intensively with the system during testing and execution. This year has seen a continued evolution and improvement of the NAVLAB mechanism, sensors, controller, and Virtual Vehicle interface to higher-level planning and perception software.

* Evolution of the CODGER Blackboard. Last year, as part of this research program, we designed and implemented the CODGER Blackboard system for robot perception and reasoning on a distributed collection of processors. This year, in response to our experience in using CODGER for mobile robot control, we have upgraded it to deal with geometric models and uncertainty in perception and map data.

* Experiments With the Driving Pipeline. To control the NAVLAB and Terregator mobile robot vehicles, we developed the Driving Pipeline architecture last year for coordinating road following, obstacle avoidance, and vehicle motion control. In our ongoing research, we have performed numerous experiments with this system that demonstrates its value.

This hardware and software is the basis for the New Generation System (NGS) for robot vision and navigation, which integrates many independent technologies to produce an integrated mobile robot system.
This report summarizes the Small Business Innovative Research (SBIR) Phase I research effort performed by Precision Navigation, Incorporated, for the U.S. Army Engineer Topographic Laboratories' DIGICOMP project. The feasibility of using Precision Navigation's proprietary magnetometer and clinometer technologies in a battery-powered, handheld, tilt-compensated digital compass replacement for the standard issue Army M2 compass has been successfully assessed. The magnetometer and clinometer technologies have proven to be low-power and accurate enough for use in a battery-powered, tilt-compensated compass system. During the research effort, the magnetometer sensor was extensively characterized and optimized for linearity, zero-drift, and power consumption.
ETL-0548

VISION-BASED NAVIGATION AND PARALLEL COMPUTING
FIRST ANNUAL REPORT
August 1989

Larry S. Davis  
Daniel DeMenthon  
Thor Bestul  
David Harwood  

University of Maryland  

Keywords: Autonomous Navigation, Computer Vision, Parallel Processing, Search

This report describes research performed during the period May 1988-May 1989 under DARPA support. The report contains discussion of four main topics:

1. On-going research on visual navigation, focusing on a system named RAMBO, for the study of robots acting on moving bodies.

2. Development and implementation of parallel algorithms for image processing and computer vision on the Connection Machine and the Butterfly.

3. Development of parallel heuristic search algorithms on the Butterfly that have linear speedup properties over a wide range of problem sizes and machine sizes.

4. Development of Connection Machine algorithms for matrix operations that are key computational steps in many image processing and computer vision algorithms.

This research has resulted in twelve technical reports, and several publications in conferences and workshops.
This report presents the results of the Dynamic Image Interpretation for the Autonomous Vehicle Navigation project for the time period February 26, 1985 through July 12, 1989. The purpose of the project is to develop algorithms and tools to enable a robotic ground vehicle to navigate autonomously through realistic landscapes. In this final annual report, we summarize our accomplishments in constructing robust algorithms used for vehicle navigation as well as tools that have been developed to more efficiently utilized these algorithms.
DIGITAL MULTICOLOR RECORDERS AND SCANNER
THE TECHNOLOGY AND THE EQUIPMENT
December 1989

Stephen P. Hollandsworth
James W. Gladden

Keywords: Ink Jet, Laser Xerography, Electrostatic Recording, Thermal Transfer, Ion Deposition, Cycolor, Laser Photography, Halftone Dot, Photomultipliers, Photodiode, CCD's, Scanners

State-of-the-art, electronic, non-impact digital multicolor printers and recorders and scanners are reviewed in this technical note. A review of the various non-impact technologies (ink jet, laser xerography, electrostatic, thermal transfer, ion deposition, Cycolor, and laser color photography) are also presented. Also discussed are three types of radiant energy sensors (photomultipliers, photodiodes and CCD's) used for scanning full color imagery. In addition, halftone dot and continuous tone reproduction are explained and discussed.

EXPERT SYSTEM FOR MINEFIELD SITE PREDICTION — PHASE III
November 1989

Jonathan W. Doughty
Anne L. Downs

PAR Government Systems Corporation

Keywords: Expert System, Minefield Site Prediction, GIS (Geographic Information System), Quadtree, Window System, Terrain Analysis, Minefield Doctrine

This report reviews the major system components of the Minefield Site Prediction Expert System (MSPES) and discusses enhancements made to the systems under Phase III of this contract. Phase III extended the knowledge base and significantly enhanced the operation of the system, both in the processing methods and analyst interaction with the system. Additional detailed descriptions of the MSPES and its architecture may be found in Phase I and Phase II Reports (ETL-0492 and ETL-0534). Phase III MSPES development continued on the Sun 3/160, using the Sun operating system and the X Window System graphics software package. A knowledge base was implemented which incorporates enemy location factors.
AN EVALUATION OF THE ERDAS IMAGE PROCESSING SYSTEM AND ITS POTENTIAL ROLE IN THE DIGITAL TOPOGRAPHIC SUPPORT SYSTEM

December 1989

John E. Anderson

Keywords: Image Processing, Remote Sensing, Geographic Information Systems (GIS), Multispectral Imagery

The evaluation of the Earth Resource Data Analysis System (ERDAS) image processing system was initiated as part of the softcopy exploitation work unit in the Data Base Development Branch of the Topographic Developments Laboratory at ETL. The work unit's main goal is to advise on the feasibility of integrating an image processing capability into the Digital Topographic Support System (DTSS). ERDAS is a commercially available image processing package which was selected as the test-bed for the evaluation. ERDAS was selected based upon three major criteria formulated at the beginning of the project: (1) Semi-powerful, user-friendly, interactive image processing capability, (2) Compatibility with the ARC/INFO geographic information system chosen by DTSS, and (3) VAX/VMS host compatibility. A fourth element, not cited, was cost.

The test-bed system consists of a 386/20 personal computer, Mitsubishi color monitor, polygon digitizing tablet, and ERDAS 7.3 version software running under a DOS 3.31 host. All image processing functions relevant to military terrain analysis were explored using acquired SPOT panchromatic and multi-spectral imagery over Fort Hood, Texas. These functions included image display, correction, spectral and spatial enhancement, roam/zoom, training field selection, supported supervised and unsupervised classification algorithms, and annotation and colorization of final images. Other features explored were special image algebraic routines including IHS to RGB, image warping or "geo-referencing", and 3-D image capabilities using elevation data.

The results of this evaluation have demonstrated that with few inexpensive upgrades to the DTSS PAWS configuration, an ERDAS or ERDAS-like image processing capability will greatly enhance the detail and accuracy of terrain and mobility products. This improvement will enable battlefield commanders to "see" the battlefield and to make more timely and accurate tactical decisions.
AUTOMATED SEGMENTATION AND EXTRACTION OF AREA TERRAIN FEATURES FROM RADAR IMAGERY
January 1990

Pi-Fuay Chen
Richard A. Hevenor

Keywords: Radar Image, Feature Extraction, Texture, Segmentation, Bayes Classifier, Region Growing, Edge Enhancement

An automated method for segmenting and extracting certain area terrain features from Synthetic Aperture Radar (SAR) imagery is presented. First, the input radar image is edge-enhanced by passing it through a Sobel operator in order to obtain the required edges for further processing. The unwanted noise, both from the original image source and from the edge operation, is reduced with a low-pass filter. The next step is a region growing process in which pixels of similar gray values in the filtered image are grouped and merged together. A method of selecting an optimum threshold that is essential for region growing is described. The pixels in the image after the region growing operation are further grouped into exactly four different categories, each with its own gray value. The four categories of pixels are then finally classified as water, fields, forests, or urban areas depending upon their gray values. A texture measurement scheme and a Bayes classifier are also incorporated into this effort for verifying the classification results.

FRACTURES IN ROCK: AN ANNOTATED BIBLIOGRAPHY
January 1990

Judy Ehlen

Keywords: Bibliography, Fractures, Data Analysis, Engineering, Rock Mechanics, Geology, Joint Propagation

This bibliography lists many papers concerned with fractures. Subjects addressed include: descriptive and quantitative characteristics of fractures, mechanisms of fracture initiation and propagation, methods for obtaining information on fractures in the field, and procedures for analyzing and interpreting the data in the laboratory. Papers on engineering applications are also included. Each entry is annotated and key words are given.
THREE APPROXIMATE METHODS FOR ESTIMATING THE BEST SUBSET OF GPS SATELLITES FOR SATELLITE POSITION CALCULATIONS
February 1990

Michael A. Crombie

Keywords: Spatial Position Accuracy, Global Positioning System (GPS), Position Dilution of Precision (PDOP)

Three methods approximating the best subset of four or five of N observable GPS satellites to be used for calculating spatial positions are evaluated. Position Dilution of Precision (PDOP) is used as the measure of effectiveness. Three GPS constellations are considered. The user spatial positions are taken from circular orbits ranging from 100 to 2400 nautical miles above the earth and from orbital inclinations ranging from 0 degrees to 90 degrees in 15 degree increments.

KNOWLEDGE-BASED VISION TECHNIQUES TASK B: TERRAIN AND OBJECT MODELING RECOGNITION - EXECUTIVE SUMMARY
February 1990

Daryl T. Lawton, et. al.

Advanced Decision Systems

Keywords: Model Based Vision Systems, Landmark Recognition, Perceptual Processing, Spatial Reasoning, Navigation, Autonomous Land Vehicle Systems, Image Understanding, Image Understanding Software Environments, Object-oriented Programming.

This report describes the Knowledge-Based Vision Techniques Task B: Terrain and Object Modeling Recognition project. Its primary objective has been to develop terrain and object autonomous land vehicle. This is fundamental for the eventual operation of concealed autonomous robots in complex outdoor environments. Our work has been organized into three major areas which correspond to the three volumes of this report. "Autonomous Systems for Navigation and Terrain Recognition" (Volume I) is concerned with terrain recognition and map building for an outdoor robot. This involves using limited a priori terrain maps to interpret imagery obtained from a vehicle and also how to build a usable representation of terrain from a freely moving vehicle with no a priori terrain information and also possessing limited recognition capabilities. "Tech Base Vision Research" (Volume II) involves basic research and development in several areas critical for eventual incorporation on an outdoor robot. This includes new approaches to perceptual processing, geometric modeling, inference, and the architecture of model-based vision systems. "Image Understanding Software Environments" (Volume III) concerns the software environments we have developed to support image understanding research and technical transfer to integrative applications such as the autonomous land vehicle project. This executive summary presents an overview and critical processing results for the work in all three volumes.

February 1990

Daryl T. Lawton, et. al.

Advanced Decision Systems

Keywords: Landmark Recognition, Qualitative Reasoning, Navigation, Spatial Representation, Model Based Vision Systems, Perceptual Grouping and Organization, Path Planning, Road Following, Object Recognition, Autonomous Land Vehicle Systems

This volume, "Autonomous Systems for Navigation and Terrain Recognition", presents a model-based vision system and a theory of spatial representation for navigation and terrain recognition by an autonomous land vehicle. This first involves techniques to generate and match predicted image structures from a priori terrain grid data. These predictions are used to direct perceptual processes to find structures such as road regions, horizon lines, terrain patch discontinuities, and anomalies using object models. This has been successfully applied to data from the Martin Marietta ALV Test Site. We then present a new theory of spatial representation called Qualitative Navigation. This allows for navigation using locally coupled scene descriptions called viewframes without use of a global coordinate system. An exploring robot can then build maps and navigate without a priori terrain information while utilizing limited object recognition capabilities and landmarks with potentially very large positional uncertainty. We extensively tested qualitative navigation in simulations of a mobile robot and developed techniques for viewframe extraction and matching. These techniques used a generic terrestrial scene model which includes several constraints on the formation of perceptual structures based upon the relative direction of gravity, the horizon line determined by the orientation to the immediate ground plane, and the projected egocentric directions from the observer on this plane.
This volume, "Tech Base Vision Research", describes research in several areas of computer vision necessary for the development of autonomous vehicles and general machine vision systems. The volume is organized into the areas of (1) perceptual processing, (2) shape and object representations, and (3) prototype image understanding systems. The research in perceptual processing has been organized into three areas: perceptual organization of extracted image structures; segmentation using texture and color to form environmentally meaningful image regions; and multi-level stereo. The work in shape descriptions and object representations is part of an integrated attempt to combine generalized cylinder representations, which are used to describe complex objects, with perceptually based predictions and model-based inference for an integrated machine vision system. Two particular model-based vision systems have been developed using these representations. MOBI was created early in the project as a vision system for a robot which could successfully navigate and build maps, in real-time, of indoor environments consisting of walls, hallways, doors and rooms. It served as a catalyst to develop the SUCCESSOR system which combines all of the research described in this volume in modeling, perceptual organization, and inference in the framework of a general and extendible model based vision system.
This volume, "Image Understanding Software Environments," presents our work in developing software environments for image understanding research and applications. This work was initially motivated to support internal developments and to expedite technical transfer from ADS to the autonomous land vehicle system integrators. We have developed two different image understanding (IU) environments, Power Vision and View/Shark, and an exploratory prototype on the MAC II. The Power Vision environment was developed on the Symbolics LISP machine. It defines a basic architecture for IU software environments in terms of a small number of modular components and programming constructs which are built around objects commonly used in image understanding such as images, curves, regions, junctions, and groups. Algorithms are developed using these objects and a language called DEFIU for writing code and manipulating defined objects in terms of local neighborhood-level operations. Shark and View were developed to produce a machine independent image understanding environment. Shark is a CommonLISP/CLOS-based toolkit for building user interfaces. View is a CLOS-based set of image understanding constructs which is completely object-oriented and makes extensive use of the inheritance of CLOS to achieve abstraction and user-specific extendibility. We ported the CommonLISP-based IU environment onto the Apple Mac II series of personal computer workstations. Note: This abstract was summarized for this bibliography.
ETL-0561

BUILT-UP AREA FEATURE EXTRACTION:
FIRST YEAR REPORT
February 1990

David M. McKeown, Jr.
Aviad Zlotnick
Carnegie Mellon University

Keywords: Feature Extraction, Road Networks, Scene Interpretation, Built-up Area

This report describes research performed by the Digital Mapping Laboratory at Carnegie Mellon University on the analysis of aerial images of built-up areas during the first year of the Contract. This research can be divided into three major parts: (1) extracting road networks from images; (2) detecting and delineating buildings; and (3) basic research to support extraction of the above features. Previous work in large-scale spatial databases and in knowledge-based systems for scene interpretation is described. Research results performed under this Built-Up Area Feature Extraction contract are described. New research in road network extraction is discussed. New work in the use of structural analysis to hypothesize and verify buildings using monocular cues in complex imagery is also discussed. Finally, the current state of research including successes, failures, and goals for the second year continuation are described.

ETL-0562

BUILT-UP AREA FEATURE EXTRACTION
SECOND YEAR TECHNICAL PROGRESS REPORT
February 1990

David M. McKeown, Jr.
Carnegie Mellon University

Keywords: Feature Extraction, Scene Interpretation, Monocular Analysis, Built-up Area

This report describes research performed by the Digital Mapping Laboratory at Carnegie Mellon University on the analysis of aerial images of built-up areas during the second year of the Contract. During this year we have built on previous research, in road network extraction and in the detection and delineation of buildings using monocular analysis, accomplished during the first year of this research contract. We have expanded our research in monocular analysis to include the detailed analysis of shadows. Our shadow analysis research has resulted in three techniques for the interpretation of monocular imagery: building prediction, grouping of related building hypotheses, and building hypothesis verification. In addition, we have implemented a technique to acquire estimates of building heights using the length of cast shadows.
A PROGRAMMING ENVIRONMENT FOR PARALLEL VISION ALGORITHMS
FINAL TECHNICAL REPORT
April 1990

Christopher Brown
University of Rochester

Keywords: Butterfly Computer, Parallel Processors, Computer Vision

Under this contract, the University of Rochester developed and disseminated papers, ideas, algorithms, analysis, software, applications, and implementations for parallel programming environments for computer vision and for vision applications. The work has been widely reported and highly influential. The most significant work centered on the Butterfly Parallel Processor, the MaxVideo pipelined parallel image processor, and the development of the real-time computer vision laboratory. For the Butterfly, the Psyche multi-model operating system was developed and the CONSUL autoparallelizing compiler was designed. Much basic and influential performance monitoring and debugging work was completed, resulting in working systems and novel algorithms. There was also significant research in systems and applications using other parallel architectures in the laboratory, such as the MaxVideo parallel pipelined image processor. The University of Rochester developed a heterogeneous parallel architecture involving pipelined and MIND parallelism and integrated it with a robot head.

PARALLEL ALGORITHMS FOR COMPUTER VISION
FINAL REPORT
April 1990

Tomaso Poggio
Massachusetts Institute of Technology

Keywords: Computer Vision, Parallel Algorithms, Connection Machine

The main effort in this project has been directed towards the development of an integrated vision system - the Vision Machine - based on a parallel super computer. The core of the Vision Machine is in fact a set of parallel algorithms for visual recognition and navigation in an unstructured environment. The present version of the Vision Machine has been demonstrated to process images in close to real time by: (1) computing first several low-level cues, such as edges, stereo disparity, optical flow, color and texture; (2) integrating them to extract a cartoon-like description of the scene in terms of the physical discontinuities of surfaces; and (3) using this cartoon in a recognition stage, based on parallel model matching. In addition to the development of the parallel algorithms, their implementation and testing, we have also done substantial work in several areas that are very closely related. These include: (1) design and fabrication of VLSI circuits to transfer some of the software algorithms to potentially cheap and fast hardware; (2) initial development of techniques to synthesize by learning vision algorithms; and (3) several projects involving autonomous navigation of small robots.
Keywords: Mobile Robot System

This report describes progress in development of an integrated mobile robot system at the Robotics Institute at Carnegie Mellon University from July 1988 to December 1989. This research was sponsored by the Defense Advanced Research Projects Agency and monitored by the US Army Engineer Topographic Laboratories. This program pursued a broad agenda of research in the development of mobile robot vehicles, and focused on the NAVLAB computer-controlled van. In the period covered by this report, July 1988 to December 1989, we addressed major software issues for mobile robot vehicles:

* Evolution of the CODGER Blackboard and the Driving Pipeline Architecture
* Kinematic Path Planning for Wheeled Vehicles.

This software is central to the New Generation System (NGS) for robot vision and navigation, which combines many independent technologies to produce an integrated mobile robot system.

Keywords: Granite, Landforms, Process, Fractures, Weathering

This bibliography addresses the study of granite landforms throughout the world from a variety of different perspectives. It summarizes the content of more than 150 papers and books. The subjects addressed include theories of origin for the respective landforms, the weathering processes acting upon these landforms, and the composition, texture and structure (mainly jointing) of granitic rocks as they relate to landform development.
AUTOMATED EXTRACTION OF AIRPORT RUNWAY PATTERNS FROM RADAR IMAGERY

June 1990

Richard A. Hevenor
Pi-Fuay Chen

Keywords: Radar Image Feature Extraction, Computer Vision, Edge Enhancement, Connected Component

A method is presented to extract linear terrain features from Synthetic Aperture Radar imagery. An input radar image is smoothed with an edge-preserving smoothing operation. Edge detection is performed using a Sobel operator, and both the magnitude and directional images are computed. The edges are then strengthened using several iterations of a relaxation operation in which both the magnitude image and the directional image are updated with each iteration. The output of the relaxation operation is a binary edge image, which is then thinned. A connected components routine is then run in which two passes through the image are used to provide a unique label for each connected component. The connected components related only to the runway pattern are then extracted by computing certain properties of each component. A border-following algorithm is then used to follow only the outermost borders and give each of the pixels on an outermost border a maximum brightness value. A tracking algorithm is used to change the binary image array into a set of Freeman chain codes, which serve as the input to a line-forming routine that uses a standard polygon approximation algorithm. Experimental results on a real synthetic aperture radar image are presented.

AUTOMATIC LINE NETWORK EXTRACTION FROM AERIAL IMAGERY OF URBAN AREAS THROUGH KNOWLEDGE BASED IMAGE ANALYSIS

August 1989

Dr. H. Kazmierczak
Forschungsinstitut fur Informationsverarbeitung/Mustererkennung

Keywords: Image Processing, Structural Pattern Recognition, Blackboard Oriented Symbolic Processing, Knowledge Based Image Analysis, Image Understanding, Aerial Imagery, Urban Areas

Different methods for automatic detection of line objects applied to aerial images to extract streets from urban scenes are investigated. First, test results achieved from two existing methods of low level iconic image processing by stream following (line tracking) and structured parallel operations (image filtering, feature extraction) are given. Second, a medium level iconic image processing method developed for edge and area segmentation is described and results from image segmentation are presented symbolically. Then two preliminary approaches of high level symbolic processing by knowledge based blackboard oriented structure analysis are tested. One is originating with preprocessing by low level edge filtering, the other by medium level area segmentation. First results from the image understanding method for street network extraction are presented.
Dr. Walter B. Zavoli
Gene E. Bloch
Etak, Inc.

Keywords: Etak Navigator; Dead Reckoning; Electronic Map Display; Digital Map Display; Vehicle Navigation; Off-Road Navigation; UTM Conversion

Etak modified its land vehicle navigation device, the Navigator, for test and evaluation by the U.S. Army Engineer Topographic Laboratories. The Navigator is a low-cost off-the-shelf commercial device that exhibits accurate navigation along with a highly useful electronic map display. The device uses a combination of dead reckoning and map matching. As part of this contract, Etak found that it could create the necessary maps from DMA 1:50,000 scale source material, to an accuracy of 50 meters, and that the Navigator could input and display vehicle positions and waypoints in UTM coordinates. In almost 1400 km of drive testing in Fort Hood, Texas, the modified Navigator showed that as a dead-reckoning device it is accurate to 2% of distance traveled, while its map-matching algorithms gives the Navigator performance comparable to that of an absolute navigation device with an average error of 50 meters. This navigation device demonstrates useful performance for certain classes of Army vehicles. Other vehicles may require more robust and hence more costly devices. It is suggested that digital map displays like that of the Navigator could be a useful standard presentation device for all Army vehicle navigation.

Thomas L. Adams
Advanced Decision Systems

Keywords: Radar User Interface, Model-Based Reasoning

ASTA (Assistant for Science and Technology Analysis) provides analytical support for the S&T radar analyst. ASTA automates many of the typical calculations the analyst must perform, maintains consistency, integrates external databases and radar models and provides an easy to use graphical user interface. ASTA provides expert guidance in the analysis of radar systems, accepting values for system attributes, either directly from analyst entry or from the integrated databases, and incrementally infers high-level operational system attributes. The ASTA knowledge base is comprised of hundreds of radar facts, fundamental properties, and heuristic rules used by the rule-based inference engine. The basic inference capability is augmented by many information management tools including a graphical explanation system. ASTA employs a graphical, window-based user interface designed to present radar information in a form familiar to radar analysts.
COOPERATIVE AUTONOMOUS AGENTS TESTBED
FIRST ANNUAL REPORT
August 1990

Charles Dolan
David Payton
Karel Zikan

Hughes Research Laboratories

Keywords: Planning, Autonomous Agents, Transportation Planning

Efforts during the first year of the contract were concentrated on developing a mathematical formalism for resupply planning. The formalism not only allows efficient plans to be constructed, but also allows those plans to be internalized plans (i.e., flexible plans). Internalized plans allow re-supply agents to be opportunistic in a changing environment. The formalism is based on expressing the re-supply problem as a flow of commodities on a graph. An economic analogy allows the re-supply agents to act as if they were self-serving agents while still accomplishing the global goals.

VISION-BASED NAVIGATION AND PARALLEL COMPUTING
SECOND ANNUAL REPORT
August 1990

Larry S. Davis
Daniel DeMenthon
Thor Bestul

University of Maryland

Keywords: Autonomous Navigation, Artificial Intelligence, Computer Vision, Search, Parallel Processing

This report summarizes the research performed during the period May 1989 through May 1990, the first year of the contract period. The focus of the research program is visual navigation, with an emphasis on the use of massively parallel algorithms to support basic navigational tasks in vision and planning. The first section describes research performed on a project called RAMBO. (RAMBO is an acronym for Robot Acting on Moving BOdies). The project attempts to develop and integrate Connection Machine algorithms for low-level vision, intermediate level vision and visual planning to allow a mobile robot to pursue (in simulation) a moving three dimensional target through space in order to maintain visual contact with points on the surface of the target. The next section describes our past year's work on cross-country navigation. We first describe massively parallel algorithms for route planning in digital terrain maps. Then we describe our research on the problem, and present new methods. The last section presents brief descriptions of other research projects whose results were reported under this contract during the past year.
HYPERSPECTRAL SIGNATURES (400 to 2500 nm) OF VEGETATION, MINERALS, SOILS, ROCKS, AND CULTURAL FEATURES:
I. LABORATORY AND FIELD MEASUREMENTS
December 1990

Melvin B. Satterwhite
J. Ponder Henley

Keywords: Reflectance, Hyperspectral, Spectra, Vegetation, Soil Rocks, Catalog, Spectroradiometric, Arid, Semiarid

The objective of this catalog was to document the visible near-infrared reflectance spectra (400-2500 nm) of vegetation, soils, rocks, and man-made materials, and to provide information about their unique physical and chemical properties. Spectra were taken of representative samples of a particular plant species of soil type and selected conditions so that a specific feature could be evaluated. Seasonal differences in vegetation spectra were measured for tree, shrub, herbaceous, and grass species. Soils having different textures and moisture potentials were measured. These spectra summarize results of ongoing research in different environments, although many of the field spectra were taken in semiarid and arid environments.

AUTOMATED SAR CHANGE DETECTION FOR COMBAT SUPPORT PHASE I (U)
December 1990

Tim Patterson
Advanced Decision Systems (ADS)

Keywords: Synthetic Aperture Radar (SAR), Morphological Filtering, Image Registration, Change Detection

The objective of this project is to design and develop a computer system for automatic change detection using synthetic aperture radar (SAR) to support the timely collection of tactical battlefield intelligence. The system will also report significant changes in the terrain with an emphasis on obstructions to vehicle movement. This Phase I effort has built a breadboard change detection system that has been tested on operational battlefield imagery. Preliminary test results show improvement over current vehicle detection techniques by more than an order of magnitude.
WHAT IS A HILL? AN ANALYSIS OF THE MEANING OF
GENERIC TOPOGRAPHIC TERMS
January 1991

Robert R. Hoffman

Keywords: Aerial Photo Interpretation, Psychology of Perception, Artificial Intelligence, Terrain Description

This report is part of the effort to generate artificial intelligence systems for aerial photo interpretation. Such a system requires symbolic definitions of generic topographic terms, especially if the system is to interact with a human operator. The author analyzes the meanings of terms such as "hill," "plain," and "terrace," and adjectival descriptors such as "blocky," "rugged," and "large." A review of literature on topography, geomorphology, and terrain analysis reveals that generic topographic terms occur frequently in descriptions of terrain, especially those intended to communicate the perceptual form of terrain. Yet such concepts—rooted in perception, judgement, and experience—are rarely defined. A terrain analysis data base of over 1,000 propositions about the knowledge of expert aerial photo interpreters was analyzed to extract and categorize approximately 100 generic terms and 250 generic descriptors. The author’s approach to defining these terms is based on concepts from ecological optics and the psychology of perception. The definitions themselves are built on concepts from the literature of terrain analysis and topography. This study has implications for practicing terrain analysts and aerial photo interpreters, as well as for the field of artificial intelligence. It suggests some new methods for describing terrain and some clarifications of traditional terminology.

ADRIES PROTOTYPE SYSTEM DEVELOPMENT PROGRAM (1986-1990)
June 1990

Gil Ettinger    Rick Chester   Tom Shaffer
Tod Levitt     Tom Esselman  Mike Black

Advanced Decision Systems

Keywords: Synthetic Aperture Radar (SAR), Signal Processing, Knowledge-Based Systems, Artificial Intelligence, Parallel Computer Processing, Distributed Computer Processing

The Advanced Digital Radar Imagery Exploitation System (ADRIES) program has undertaken the design and development of automated techniques to aid in the interpretation and analysis of multiple resolution synthetic aperture radar (SAR) imagery of military land scenes. This report summarizes the accomplishments achieved during the four years of the program. The program culminated in the development of the Intelligent Tactical Screener (INTACTS) system, and end-to-end image exploitation prototype system that integrates contextual and terrain reasoning to identify complex military forces in viewed scenes. It is the first system to define means of using and combining multiple knowledge sources supporting image exploitation in a uniform and coherent paradigm that achieves high efficiency and accuracy through a hierarchical reasoning process.
Science Applications International Corporation

Keywords: Synthetic Aperture Radar, Artificial Intelligence, Signal Processing, Parallel Computer Processing, Knowledge-Based Systems, Distributed Computer Processing

The ADRIES program is a three-year, multiple contractor research effort aimed at the development and demonstration of technology to support the automation of tasks required to effectively exploit multiple resolution digital radar imagery. The research focuses on techniques for exploiting Advanced Synthetic Aperture Radar (ASARS) imagery. ADRIES has three major objectives: First, to develop technology in support of automating the image exploitation process. This objective is not limited to image processing, but includes knowledge engineering, distributed processing, and other applicable areas. Second, to develop the Sensor National Testbed (SNTB). The SNTB is a collection of sequential and parallel computer architectures, and associated software, providing a research environment for exploring parallel processing for image understanding. Third, to demonstrate the applicability of the ADRIES program to a real world problem. This final report describes only the latest version of the SAIC contribution to the ADRIES software/hardware system. These contributions include: Spot Mode Detection, Other Source Analysis, Region Database, Image Database, Communication and System Services, and the Executive Controller software components. During this second year, the work at SAIC dell into three general areas: software and integration support for the INTACTS demonstration; continued development of the SNTB; and test and evaluation planning on the completed INTACTS system.

Science Applications International Corporation

Keywords: Synthetic Aperture Radar, Artificial Intelligence, Signal Processing, Parallel Computer Processing, Knowledge-Based Systems, Distributed Computer Processing

The ADRIES program is a three-year, multiple contractor research effort aimed at the development and demonstration of technology to support the automation of tasks required to effectively exploit multiple resolution digital radar imagery. The research focuses on techniques for exploiting Advanced Synthetic Aperture Radar (ASARS) imagery. ADRIES has three major objectives: First, to develop technology in support of automating the image processing exploitation process. This objective is not limited to image processing, but includes knowledge engineering, distributed processing, and other applicable areas. Second, to develop the Sensor National Testbed (SNTB). The SNTB is a collection of sequential and parallel computer architectures, and associated software, providing a research environment for exploring parallel processing for image understanding. Third, to demonstrate the applicability of the ADRIES program to a real world problem. This final report describes only the latest version of the SAIC contribution to the ADRIES software/hardware system. These contributions include: Spot Mode Detection, Other Source Analysis, Region Database, Image Database, Communication and System Services, and the Executive Controller software components.
Azriel Rosenfeld

University of Maryland

Keywords: Image Understanding, Navigation, Vision, Edge Detection, Path Planning

The research on the contract dealt with image understanding applications to both navigation and recognition. Thirteen technical reports were issued on the contract during this period referred to by numbers in brackets in the remainder of the report. Research on navigation was concerned with the following specific topics which are discussed in further detail in this report: (a) analysis of superimposed moving patterns [1,2]; (b) path and motion planning [5,13]; (c) structure from motion [6]; (d) motion uncertainty [8]; (e) motion illusions [11]; and (f) motion recovery in the presence of discontinuities [12]. Recognition research was concerned with: (g) recognition of compact shapes by energy function minimization [3]; (h) learning of invariant shape properties [4]; (i) slant-insensitive shape descriptors [7]; and (j) edge detection [9] and line fitting [10].

Charles Thorpe
Takeo Kanade

Carnegie Mellon University

Keywords: Autonomous Navigation, 3-D Perception, Road Following, Obstacle Detection, Terrain Modeling

Research supported by this contract includes perception for road following, terrain mapping for off-road navigation, and systems software for building integrated mobile robots. We overview our efforts for the year, and list our publications and personnel, then provide further detail on several of our sub-projects. During the past year, this contract has supported research on color vision for road following; 3-D perception for terrain mapping and cross-country mobility; and system building for autonomous navigation. We have demonstrated autonomous navigation on a variety of roads, including single lane dirt, gravel, and paved; and multi-lane roads with and without lane markings. Our perception modules use a variety of techniques for video processing (clustering theory, symbolic feature detection, neural nets), and for range data analysis (landmark navigation, reflectance processing). We have also integrated position-based navigation (JNS and GPS), and combinations of all these techniques into mobile robot systems and demonstrations. Our scientific papers this year include a book (Vision and Navigation: the CMU Navlab), three PhD dissertations, and an MS thesis.
The goal of this research is to develop techniques for automatically acquiring and representing knowledge about complex cultural and natural environments for such purposes as intelligence analysis, planning, navigation, and manipulation. Our research strategy is to (1) develop representations and techniques for storing (or incrementally learning) semantic and geographic information about a specific geographic areas to permit both mission planning and knowledge-based interpretation of sensed data, (2) develop representations for natural and manmade objects, (3) develop techniques to predict distinctive features of these objects that can be used to identify them, and (4) develop techniques for building three-dimensional descriptions of an environment from data gathered by range or intensity sensors moving through this environment. In this report we describe our progress and plans in these areas.

Soil samples collected at Twentynine Palms, California, and eastern Saudi Arabia were analyzed for particle size distribution, moisture content, spectral reflectance characteristics and soil color. The results of the comparison show that, overall, the Twentynine Palms samples are finer grained than the eastern Saudi Arabian samples. Soil moisture in both sets of samples is low. The samples from eastern Saudi Arabia contain quantities of calcite and gypsum not found in the Twentynine Palms samples. The spectral reflectance of the soils from eastern Saudi Arabia is overall higher than that for the Twentynine Palms soils, and shows variations in infrared reflectance due to chemical differences that are not seen in the Twentynine Palms soils.
AN AUTOMATED SOFTWARE SYSTEM FOR UPDATING DIGITAL TERRAIN DATABASES FROM ALL-SOURCE IMAGERY, PHASE I SBIR
February 1991

J. Curlander         A. Stocker
W. Kober             J. Thomas

Vexcel Corporation    Space Computer Corporation

VEXCEL Corporation's Phase I SBIR research effort for ETL concentrated on the feasibility of creating the primary tools for the prototype development in Phase II of a digital change detection work station. This system is intended to be capable of detecting long-term (6 months to 1 year) and/or seasonal changes from all-source imagery. The system is intended to be hosted on a SUN-4 platform operating under a UNIX/C software environment. The emphasis of the present Phase I effort was on the two major technical challenges for the development of such a system: precision image registration and robust change detection and analysis. Most of this effort was directed toward automated SAR-optical image registration and automated change cuing experiments. Change cuing is an initial step in change detection for identifying regions where possible change events may have occurred. The automated registration and cuing efforts were successful over the data sets tested. The data sets did not contain appreciable terrain-induced distortions. Theoretical improvements for algorithms are recommended for addressing such terrain-induced registration complications in Phase II.

NEURAL NETWORKS FOR OBJECT DETECTION USING ALL-SOURCE IMAGERY
February 1991

David Lavine
Srinivasan Rahavan
Naresh C. Gupta
Barbara A. Lambird

LNK Corporation

Keywords: Multi-Sensor Fusion, Image Analysis, Neural Networks, Gabor Transform, Automated Feature Extraction

Fusion of information from multiple sources is a key ingredient in many decision-making processes. This fusion often benefits from hierarchical decision-making which analyzed the data at various levels of abstraction. This report describes a system for performing fusion with a hierarchy of neural networks to provide this abstraction capability. The fusion system is demonstrated by extracting natural and man-made features from synthetic aperture radar (SAR) and optical imagery. The system is designed to be extensible to a much wider range of feature types and to other types of input data, including data from other types of sensors and collateral data. The uniqueness of the sensor fusion system lies in the efficient use of appropriately tailored neural networks, combining different paradigms to perform different tasks.
NEW METHODS OF CHANGE DETECTION USING
MULTISPECTRAL DATA
May 1991

Charles Sheffield
Gil Richardson
Earth Satellite Corporation

This report discusses the final phase of a project to develop multispectral change detection methods with emphasis on human activities. Two new algorithms were developed and tested: a Spectral/Spatial Classifier and a Feature Vector Spectral Classifier. The Spectral/Spatial method appears to be a powerful new tool. The Feature Vector results were inconclusive.

THERMAL INFRARED SPECTRA OF NATURAL AND MAN-MADE MATERIALS: IMPLICATIONS FOR REMOTE SENSING

John Eastes

**Keywords:** Thermal Infrared Spectra, Spectra of Natural Materials, Spectra of Manmade Materials, Remote Sensing

This report is a compilation of laboratory thermal infrared reflectance spectra recorded over various spectral ranges between 4000 and 400 cm⁻¹ (2.5 - 25.0 micrometers) for natural and manmade materials of potential interest to both military and civilian sectors. Knowledge of the position and shape of significant spectral features as detected by remote spectrometers or spectral radiometers is necessary to discriminate between targets on the basis of either spectral emittance or reflectance. Many of the samples in this study display spectral features in either, or both of the 3- to 5- micrometer or the 8- to 14- micrometer regions of the spectrum in which terrestrial remote sensing is possible. Such information can be used to devise image enhancement strategies for data in hand or to design new instruments or experiments utilizing thermal multispectral data.
REMOTE SENSING FIELD GUIDE - DESERT
September 1991

The Desert Processes Working Group:
Jack N. Rinker
Carol S. Breed
John F. McCauley (Emeritus)
Phyllis A. Corl

Keywords: In support of military operations, Army terrain analysts are frequently required to provide terrain information about an area, and to do so quickly. Examples of needed information include: location of engineering materials, potential ground water drilling sites, influence of the terrain on cross-country movement, potential for dust generation, potential for cover and concealment, and sites suitable for ambush and defilade. The task is not easy because of the lack of sources for detailed and reliable information. Such information is not yet available in data bases, nor in existing maps, and neither can it be obtained by computer analysis of digital imagery. It can, however, be derived by the manual, or "eyeball," evaluation of image patterns. Although airborne or satellite imagery is now available for most of the world, the translation of these image patterns into forms usable by the terrain analysts has not been done. To bridge this gap, for at least one climatic zone, the Desert Processes Working Group has developed this Remote Sensing Field Guide directed towards desert operations. Although developed for military uses, this guide can serve all who travel and work in desert regions.

A HYBRID METHODOLOGY FOR DETECTING CARTOGRAPHICALLY SIGNIFICANT FEATURES USING LANDSAT TM IMAGERY
September 1991

Robert S. Rand

Keywords: A general Change Detection (CD) methodology is investigated that involves a hybrid mix of image processing, spectral transformation, and statistical pattern recognition techniques. The Hybrid Methodology attempts to combine various forms of supporting and conflicting evidence for change into a resulting change map. The approach involves differencing registered multiband scene pairs that have undergone a spectral transformation, generating threshold masks, and applying a classifier to the masked multiband scene pairs.
Keywords: This report describes a capability to produce prototype 1:50,000 scale multispectral image maps using Landsat TM data. These image maps are in the standard UTM projection, contain imbedded 1,000 meter grid lines with labeled UTM coordinates, and can easily be used in conjunction with conventional military maps of the same scale. Annotation that gives the title of the standard DMA map of the area, the Landsat TM band combinations, as well as a bar scale and compass were also imbedded into the product.
This forecast consolidates information on the Digital Terrain Data requirements of the U.S. Army aviation community, assesses and analyzes the requirements, and identifies emerging issues. Special Operations Aircraft (SOA) is the primary near-term user of DTD, but the LHX program and simulation efforts will be the drivers for future requirements. It is anticipated that the majority of DTD manipulation and use will occur at the Ground Mission Planning System (GMPS), although DTD will also be used operationally for navigation and map display. Existing and planned DTD products from the Defense Mapping Agency (DMA) will satisfy the majority of aviation requirements. However, the aviation community has a need for additional Vertical Obstruction Data (VOD).

This report documents the results of DoD's Phase 1 Tactical Terrain Data (TTD) Prototype Evaluation. The concept of Tactical Terrain Data as the data base to support joint land combat evolved from an initial Army requirement for digital topographic data (DTD) forwarded to DMA in October 1984. The evaluation community consisted of the respective Army, Navy and Air Force laboratories; the U.S. Army Engineer Topographic Laboratories (USAETL), the Naval Ocean Research and Development Activity (NORDA), and the Rome Air Development Center (RADC), as well as many tactical, test, training, and simulation systems and programs. The key aspects of the data set that were evaluated were: accuracy, resolution, content, and data structure. The report presents a set of conclusions and makes recommendations to the Defense Mapping Agency concerning the future direction of TTD production.
DIGITAL TERRAIN ELEVATION DATA RESOLUTION AND REQUIREMENTS STUDY - INTERIM REPORT
November 1990

James R. Ackeret

Keywords: Digital Terrain Elevation Data (DTED), Digital Terrain Data (DTD) requirements, Computer Image Generation (CIG), Resolution, Terrain Visualization, Terrain Classification, Threat Analysis, Line of Sight (LOS)

The DTED resolution requirement has been a controversial subject for many years among users of U.S. Army battlefield and simulator systems. The controversy has focused on the higher cost of producing high resolution DTED and the additional time required to produce a world-wide database at this resolution. The purpose of this study is to report the influence of DTED resolution on various terrain elevation applications. TRADOC Analysis Command, White Sands Missile Range, (TRAC-WSMR), also participated in this study by conducting an in-depth threat analysis. This interim report documents the results of the USAETL DTED resolution analysis and the TRAC-WSMR threat analysis for the determination of the most desirable DTED resolution for various Army tactical and simulation applications.

PDEF: A STANDARD FILE FORMAT FOR DATA INTERCHANGE
January 1991

Michael M. McDonnell

Keywords: Geographic Information System, Data Interchange, Spatial Data Storage, Data Exchange, Reformatting

This report explains a new method of encoding data in a set of files that allows advantages over current formats and methods. A new format is necessary because all current widely-available file formats retain restrictions (such as fixed field lengths) that are no longer necessary with modern programming languages. In particular, the ability to be parsed by FORTRAN programs was formerly an important requirements. The limitations of FORTRAN lead to file formats that are clumsy and difficult to work with. The proposed format has a simple syntax and flexible semantics. The format is efficient both for computers and people. It is efficient for computers because it makes use of the powerful parsing tools available for the C programming language. It is efficient for people because data descriptions are in a human-readable form and the content of a data file can be understood without a user's manual. The bulk of this report is in appendixes which give illustrative examples. Examples are presented for raster, quadtree, and vector data formats since these formats are especially prevalent in spatial data systems, a specialty of the U.S. Army Engineer Topographic Laboratories. PDEF stands for Protean Data Exchange Format.
Ackeret, James R. See Lambert, Robin B.


Barr, Samuel. See Rinker, Jack N., Dr.


Bradley, John P. See Lambert, Robin B.


Brink, Anne. See Benton, John.


Cox, Thomas M., Jr. See Fosburgh, Bryn.

Davis, Donald A. See Anderson, John E.


Fatale, Louis A. See Lambert, Robin B.

Frodge, Sally L. See Lanigan, Carl A.


Joy, Richard T. See Lambert, Robin B.


PAPERS (continued)


Rose, Barbara G. See Lambert, Robin B.


Smith, Harold L. See Niles, Anthony R.


# TITLES

<table>
<thead>
<tr>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADRIES Prototype System Development Program (1986-1990)</td>
<td>23</td>
</tr>
<tr>
<td>Advanced Digital Radar Imagery Exploitation System (ADRIES) Annual Report</td>
<td>24</td>
</tr>
<tr>
<td>Assistant for Science and Technology Analysis (ASTA)</td>
<td>20</td>
</tr>
<tr>
<td>Automated Extraction of Airport Runway Patterns from Radar Imagery</td>
<td>19</td>
</tr>
<tr>
<td>Automated SAR Change Detection for Combat Support Phase I</td>
<td>22</td>
</tr>
<tr>
<td>Automated Segmentation and Extraction of Area Terrain Features From Radar Imagery</td>
<td>11</td>
</tr>
<tr>
<td>Automated Software System for Updating Digital Terrain Databases from All-Source Imagery, Phase I SBIR, An</td>
<td>27</td>
</tr>
<tr>
<td>Automatic Line Network Extraction from Aerial Imagery of Urban Areas Through Knowledge Based Image Analysis</td>
<td>19</td>
</tr>
<tr>
<td>Autonomous Land Vehicle (ALV) Program, Seventh Quarterly Report, The</td>
<td>1</td>
</tr>
<tr>
<td>Bibliography of In-house and Contract, Supplement 16</td>
<td>8</td>
</tr>
<tr>
<td>Built-up Area Feature Extraction: First Year Report</td>
<td>16</td>
</tr>
<tr>
<td>Built-up Area Feature Extraction, Second Year Technical Progress Report</td>
<td>16</td>
</tr>
<tr>
<td>Comparison of Soils from Twentynine Palms, California and Saudi Arabia, A</td>
<td>26</td>
</tr>
<tr>
<td>Cooperative Autonomous Agents Testbed, First Annual Report</td>
<td>21</td>
</tr>
<tr>
<td>Development of an Integrated Mobile Robot System at Carnegie Mellon University</td>
<td>5</td>
</tr>
<tr>
<td>TITLE</td>
<td>PAGE</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Digital Multicolor Recorders and Scanner - The Technology and the Equipment</td>
<td>9</td>
</tr>
<tr>
<td>Digital Terrain Elevation Data Resolution and Requirements Study - Interim Report</td>
<td>32</td>
</tr>
<tr>
<td>Dynamic Image Interpretation for Autonomous Vehicle Navigation, Final Report</td>
<td>8</td>
</tr>
<tr>
<td>ETAK Navigator Modification Final Report</td>
<td>20</td>
</tr>
<tr>
<td>Expert System for Minefield Site Prediction — Phase III</td>
<td>9</td>
</tr>
<tr>
<td>Feasibility of a Reduced Power-Consumption Magnetometer for Use in a Digicomp Lensatic Compass</td>
<td>6</td>
</tr>
<tr>
<td>Fractures In Rock: An Annotated Bibliography</td>
<td>11</td>
</tr>
<tr>
<td>Hourly and Daily Precipitation Frequencies for the United States</td>
<td>1</td>
</tr>
<tr>
<td>Hybrid Methodology for Detecting Cartographically Significant Features Using Landsat TM Imagery, A</td>
<td>29</td>
</tr>
<tr>
<td>Hyperspectral Signatures (400 to 2500 nm) of Vegetation, Minerals, Soils, Rocks, and Cultural Features: I. Laboratory and Field Measurements</td>
<td>22</td>
</tr>
<tr>
<td>Knowledge-Based Vision Techniques for the Autonomous Land Vehicle Program - Fourth Annual Report</td>
<td>26</td>
</tr>
<tr>
<td>Knowledge-Based Vision Techniques Task B: Terrain and Object Modeling Recognition - Executive Summary</td>
<td>12</td>
</tr>
<tr>
<td>Knowledge-Based Vision Techniques Task B: Terrain and Object Modeling Recognition - Volume II: Tech Base Vision Research</td>
<td>14</td>
</tr>
<tr>
<td>Knowledge-Based Vision Techniques Task B: Terrain and Object Modeling Recognition - Volume III: Image Understanding Software Environments</td>
<td>15</td>
</tr>
<tr>
<td>Landforms of Granitic Rocks: An Annotated Bibliography, The</td>
<td>18</td>
</tr>
<tr>
<td>TITLE</td>
<td>PAGE</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Multispectral Image Maps From Landsat Thematic Mapper Data</td>
<td>30</td>
</tr>
<tr>
<td>Neural Networks for Object Detection Using All-Source Imagery</td>
<td>27</td>
</tr>
<tr>
<td>New Methods of Change Detection Using Multispectral Data</td>
<td>28</td>
</tr>
<tr>
<td>Parallel Algorithms for Computer Vision, Final Report</td>
<td>17</td>
</tr>
<tr>
<td>Perception for Outdoor Navigation, First Year Report</td>
<td>25</td>
</tr>
<tr>
<td>PDEF: A Standard File Format for Data Interchange</td>
<td>32</td>
</tr>
<tr>
<td>Phase 1 Tactical Terrain Data (TTD) Prototype Evaluation</td>
<td>31</td>
</tr>
<tr>
<td>Programming Environment for Parallel Vision Algorithms, Final</td>
<td>17</td>
</tr>
<tr>
<td>Technical Report, A</td>
<td></td>
</tr>
<tr>
<td>Remote Sensing Field Guide - Desert</td>
<td>29</td>
</tr>
<tr>
<td>Research in Knowledge-Based Vision Techniques for the Autonomous</td>
<td>4</td>
</tr>
<tr>
<td>Land Vehicle Program, Final Annual Report</td>
<td></td>
</tr>
<tr>
<td>Robust Image Understanding - Techniques and Applications, First</td>
<td>25</td>
</tr>
<tr>
<td>Annual Report</td>
<td></td>
</tr>
<tr>
<td>Thermal Infrared Spectra of Natural and Man-Made Materials:</td>
<td>28</td>
</tr>
<tr>
<td>Implications for Remote Sensing</td>
<td></td>
</tr>
<tr>
<td>Three Approximate Methods for Estimating the Best Subset of GPS</td>
<td>12</td>
</tr>
<tr>
<td>Satellites for Satellite Position Calculations</td>
<td></td>
</tr>
<tr>
<td>U.S. Army Aviation Digital Topographic Data Requirements Forecast</td>
<td>31</td>
</tr>
<tr>
<td>Vision-Based Navigation and Parallel Computing, First Annual Report</td>
<td>7</td>
</tr>
<tr>
<td>Vision-Based Navigation and Parallel Computing, Second Annual Report</td>
<td>21</td>
</tr>
<tr>
<td>What is a Hill? An Analysis of the Meaning of Generic Topographic</td>
<td>23</td>
</tr>
<tr>
<td>Terms</td>
<td></td>
</tr>
</tbody>
</table>
## CORPORATE AUTHORS

<table>
<thead>
<tr>
<th>NAME</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Decision Systems</td>
<td>12, 13, 14, 15, 20, 22, 23</td>
</tr>
<tr>
<td>Carnegie Mellon University</td>
<td>5, 16, 18, 25</td>
</tr>
<tr>
<td>Earth Satellite Corporation</td>
<td>28</td>
</tr>
<tr>
<td>Etak, Inc.</td>
<td>20</td>
</tr>
<tr>
<td>Forschungsinstitut f&quot;ur Informationsverarbeitung/Mustererkennung</td>
<td>19</td>
</tr>
<tr>
<td>Hughes Research Laboratories</td>
<td>21</td>
</tr>
<tr>
<td>LNK Corporation</td>
<td>27</td>
</tr>
<tr>
<td>Martin Marietta Astronautics Group</td>
<td>1</td>
</tr>
<tr>
<td>Martin Marietta I&amp;CS</td>
<td>2, 3</td>
</tr>
<tr>
<td>Massachusetts Institute of Technology</td>
<td>17</td>
</tr>
<tr>
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APPENDIX — TITLES

1953 - 1991
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Algorithms for Digital Terrain Data Modeling
ETL-0302 1982
All-Weather Mapping Contour Plotting Program
ETL-0382 1985
Alternative Theories of Inference in Expert Systems for Image Analysis
Altimeter, Surveying, 4500 Meters, 2-Meter Divisions
1350-TR 1954
Analog Graphic Processing for 3-D Terrain Displays, Profiles, and Elevation Layer Tints
ETL-0026 1975
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ETL-CR-71-4 1971
Analysis and Development of Digital Mapping System Software
ETL-CR-74-5 1974
Analysis and Development of Image Statistics and Redundancy Removal
ETL-0239 1980
Analysis and Simulation of Discrete Digital Image Matching
ETL-0278 1981
Analysis and Test Results of a Gyrocompass With Reduced Susceptibility to Shock, Vibration, and Motion
ETL-0501 1988
Analysis and Tests of Environmental Effects on Gyrocompassing Accuracy
ETL-0378 1984
Analysis of Air Photo and Radar Imagery of Barro Colorado Island, Panama, An
ETL-0540 1989
Analysis of a Relaxation Scheme to Improve Terrain Elevation Data, An
ETL-0298 1982
Analysis of Edge Detection Algorithms on DIAL
ETL-0371 1985
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AD 882 165L 1967
Analysis of Interactive Image Cleansing Via Raster-Processing Techniques
ETL-0347 1983
Analysis of LANDSAT Systems for Cartographic and Terrain Information (Report No. 9 in the ETL Series on Remote Sensing)
ETL-0103- 1977
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AD 705 673 1970
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AD 827 858L 1967
Analysis of Radar Calibration Data (Supplement)
AD 836 943L 1968
Analysis of SECOR Data — Vol. I
AD 865 488L 1968
Analysis of SECOR Data — Vol. II
AD 865 489L 1969
Analysis of the Max-Min Texture Measure, An
ETL-0280 1982
Analysis, Storage and Retrieval of Elevation Data with Applications to Improve Penetration
ETL-0179 1979
Analytic Aerotriangulation: Triplets and Sub-Blocks Including Use of Auxiliary Data
AD 631 072 1965
Analytical Aerial Triangulation
1510-TR 1958
TITLE REPORT NO. YEAR
Analytical Aerial Triangulation Error Analysis AD 271 442 1961
and Application of Compensating Equations to the General Block Triangulation and Adjustment Program (Interim)
Analytical Aerial Triangulation Error Analysis AD 401-689 1962
and Application of Compensating Equations to the General Block Triangulation and Adjustment Program (Final)
Analytical Aerial Triangulation with Large Computer (Analytical Simultaneous Block Triangulation Technique)
Analytical Aerial Triangulation with Small Computer 34-TR 1966
Analytical Aerotriangulation Using Triplets in Strips. 13-TR 1963
Analytical Photogrammetric Position System (APPS) AD 668 683 1965
ETL-TR-74-2 1973
Analytical Photogrammetric Position System (APPS) ETL-TR-74-4 1974
to Support the Field Army
Apparent Temperature and Emissivity of Natural Surfaces at Microwave Frequencies AD 872 878L 1970
Appendix III Narrative Report for Geoscience Overlays ETL-0330 1983
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<td>1977</td>
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50
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<th>YEAR</th>
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<td>1974</td>
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<td>ETL-0111</td>
<td>1977</td>
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51
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<th>TITLE</th>
<th>REPORT NO.</th>
<th>YEAR</th>
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<tr>
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<td>ETL-0053</td>
<td>1976</td>
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<td>Charging Equipment, Mobile (CEM)</td>
<td>ETL-0089</td>
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<td>Chemical Array Studies</td>
<td>ETL-0130</td>
<td>1977</td>
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<td>ETL-0199</td>
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<td>Combined Engineering and Service Tests of the Multiplex Van Section of the Motorized Photomapping Train</td>
<td>1520-TR</td>
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<td>YEAR</td>
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<td>1968</td>
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<td>1980</td>
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<td>ETL-0472</td>
<td>1987</td>
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<td>YEAR</td>
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<td>Control Unit for Army Artillery Inertial Survey System (GEISHA)</td>
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<td>Controlled Color for Contact Printing Aerial Imagery</td>
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<td>ETL-CR-72-14</td>
<td>1972</td>
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<td>Corona Study Relevant to Electrostatic Printing Process</td>
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<td>1971</td>
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<td>Correlation of Noisy Images</td>
<td>ETL-0230</td>
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<td>Cumulative Probability Tables for Testing Consensus in Ranking Experiments</td>
<td>ETL-0418</td>
<td>1986</td>
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<td>ETL-0150</td>
<td>1978</td>
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<td>Data Integrity Factors Affecting the Construction of the Mapping, Charting, and Geodesy Data Base</td>
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<td>1983</td>
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<td>Data Weighing Analysis</td>
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<td>Decision Path Approach to Guidance for Climatic Environmental Test Planning (MIL-STD-810C)</td>
<td>ETL-0183</td>
<td>1979</td>
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<td>Defense Mapping Agency (DMA) Raster-to-Vector Analysis</td>
<td>ETL-0383</td>
<td>1984</td>
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<td>ETL-0383A</td>
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<td>ETL-0384</td>
<td>1984</td>
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<td>ETL-0157</td>
<td>1978</td>
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<td>Demonstration and Evaluation of the Utilization of Side-Looking Airborne Radar for Military Terrain Analysis</td>
<td>ETL-0023</td>
<td>1975</td>
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<td>YEAR</td>
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<td>1969</td>
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<td>Design and Analysis of a High-Production Mini-Computer System for Regridding Digital Terrain Elevation Matrices</td>
<td>ETL-0240</td>
<td>1980</td>
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<td>Design and Development of a Position and Azimuth Determining System (PADS)</td>
<td>ETL-CR-71-18</td>
<td>1971</td>
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<td>Design and Development of an Advanced Electron Beam Control System</td>
<td>ETL-0032</td>
<td>1975</td>
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<td>Design and Fabrication of a 70 Millimeter Interference Imaging System</td>
<td>ETL-CR-71-8</td>
<td>1971</td>
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<td>Design and Fabrication of an Experimental Multiband Camera</td>
<td>ETL-CR-71-28</td>
<td>1971</td>
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<td>Design and Feasibility Study of an Off-Line Digital Orthoprinter for Field Use</td>
<td>ETL-0149</td>
<td>1978</td>
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<td>Design and Feasibility Study of HOC as a Van Mounted Stereo Model Digitizer</td>
<td>ETL-0109</td>
<td>1977</td>
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<td>Design, Fabrication, and Test of a Position and Azimuth Determining System (PADS)</td>
<td>ETL-CR-73-6</td>
<td>1973</td>
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<td>Design Issues in Video Disc Map Display</td>
<td>ETL-0362</td>
<td>1984</td>
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<td>Design, Modification, Fabrication, and Test of a Prototype Miniaturized North Reference Unit (MINRU)</td>
<td>ETL-0276</td>
<td>1979</td>
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<td>Design of a Laser Experiment for the Verification of the Inverse Scattering Theory</td>
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<td>Design of a Map Update Capability for Engineer Topographic Units</td>
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<td>Design of an Experimental Program for Evaluation of LBR Systems</td>
<td>ETL-0182</td>
<td>1979</td>
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<td>1961</td>
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<td>Volume 2</td>
<td>AD 270 205L</td>
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<td>AD 270 207L</td>
<td>1961</td>
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<td>Volume 4</td>
<td>AD 270 210L</td>
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<td>AD 270 209L</td>
<td>1961</td>
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<td>YEAR</td>
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<td>Design Studies and Prototype Model Development of a Small North Orienting Device (Miniaturized Gyrocompass)</td>
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<td>1975</td>
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<td>1967</td>
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<td>YEAR</td>
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<td>1966</td>
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<td>YEAR</td>
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<td>Engineering Tests of a Temperature-controlled Processing Unit, Deep-tank, for Photomechanical Film</td>
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<td>1959</td>
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<td>1957</td>
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<td>1957</td>
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<td>1963</td>
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<td>1955</td>
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<td>ETL-0250</td>
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<td>1976</td>
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<td>ETL-0145</td>
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<td>48-TR</td>
<td>1969</td>
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<td>YEAR</td>
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<td>37-TR</td>
<td>1968</td>
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<td>ETL-0322</td>
<td>1983</td>
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<td>REPORT NO.</td>
<td>YEAR</td>
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<td>Holographic Ray Tracing and Spot Diagrams</td>
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<td>Holographic Terrain Displays</td>
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<td>ETL-CR-72-2</td>
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<td>REPORT NO.</td>
<td>YEAR</td>
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  Terrain and Object Modeling Recognition -
  Volume III: Image Understanding Software
Environments
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  Phase III of a Joint OCE/NASA Demonstration
Landforms of Granitic Rocks: An Annotated
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  Surveying Instrument, Model 11NG531A
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  Surveying Instrument, Model 11NG531B
Linear Feature Extraction from Radar Imagery
Linear Feature Extraction from Radar Imagery,
  SBIR Phase II Base Contract
Linear Feature Extraction From Radar Imagery:
  SBIR Phase II, Option I
Linear Feature Extraction From Radar Imagery:
  SBIR Phase II, Option II
L.N.K. Software Systems for Transferring,
  Merging, and Displaying DFAD/DTED Data on
  AMS/CAPIR
Local Gravity Field Modeling
Long Range Survey System
Long Range Surveying System
Low Cost Gyrocompass
Low Light Level Photography
Manual and Automated Line Generalization and
  Feature Displacement
Manual for Maintenance and Operation of the
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Mini Raster-to-Vector Conversion
Mod II Power Supply for Army Artillery Inertial Survey System (GEISHA)
Modeling and Contouring Irregular Surfaces Subject to Constraints
Modes of Satellite Triangulation Adjustment, Vol. I
Modes of Satellite Triangulation Adjustment, Vol. II
Modification of a Cartographic Mapping Camera from Type T-11 to Type KC-4B (with Automatic Exposure Control)
Modification of the MUSAT Aerotriangulation Programs to Accommodate Bathymetric Image Points
Modifications to FOTONAP
Mono Versus Stereo Analytical Photogrammetry, Part 1
Mono Versus Stereo Analytical Photogrammetry, Part 2
<table>
<thead>
<tr>
<th>TITLE</th>
<th>REPORT NO.</th>
<th>YEAR</th>
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<td>YEAR</td>
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<td>ETL-0564</td>
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<td>Research Institute Lectures on Geography</td>
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<td>AD 831 840</td>
<td>1968</td>
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<tr>
<td>Research Studies Related to Mapping, Geodesy, and Position Determination</td>
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<td>1962</td>
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<td>RN-13</td>
<td>1965</td>
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| Robust Image Understanding - Techniques and Applications - First Annual Report | ETL-0580 | 1990 |
| RPIE Symbol Placement Accuracy | ETL-0076 | 1976 |
| Ruggedized Geodetic SECOR | AD 722 642 | 1967 |
| Ruggedized Geodetic SECOR System | ETL-0367 | 1984 |
| RWPF Spatial Data Study | ETL-TR-72-7 | 1972 |
| Sand and Dust Considerations in the Design of Military Equipment | RN-16 | 1965 |
| Satellite Angulateration | RN-32 | 1969 |
| Satellite Geodesy Based on Stellar Orientation of Lines Between Unknown Stations | ETL-0361 | 1984 |
| Satellite Observations of Widespread Fog | ETL-0064 | 1976 |
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| Scale Problems in Geographic Research | ETL-0270 | 1981 |
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| Scene Classification Results Using the Max-Min Texture Measure | ETL-0126 | 1977 |
| Selected Bibliography of Corps of Engineers Remote Sensing Reports | ETL-ETR-71-4 | 1971 |
| Semiautomatic Coordinate Reader | ETL-0051 | 1975 |
| Semi-Automatic Pass Point Determination Using Digital Techniques | ETL-0297 | 1983 |
| Sensing Array System with Image Statistics Processing, A | ETL-0544 | 1989 |
| Sentinel Satellite Positional Precision Derived from the NAVSTAR Global Positioning System |  |  |</p>
<table>
<thead>
<tr>
<th>TITLE</th>
<th>REPORT NO.</th>
<th>YEAR</th>
</tr>
</thead>
<tbody>
<tr>
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<td>AD 805 606L</td>
<td>1966</td>
</tr>
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<td>Service Tests and Subsequent Modifications and Test of Compass Sun, Universal, 0 to 90 Degrees North and South Latitudes, with Case Shaded Relief Images for Cartographic Applications</td>
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<td>Shape from Projecting a Stripe Pattern</td>
<td>ETL-0259</td>
<td>1981</td>
</tr>
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<td>Side-Looking Radar Data Requirements for Automated Mapping on the UNAMACE</td>
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<td>Side-Looking Radar Presentation Viewing and Measuring Instrument</td>
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</tr>
<tr>
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<td>ETL-0185</td>
<td>1979</td>
</tr>
<tr>
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<td>ETL-0441</td>
<td>1986</td>
</tr>
<tr>
<td>Simple Computer Database System for UNIX, A</td>
<td>ETL-0494</td>
<td>1988</td>
</tr>
<tr>
<td>Simplified Electrostatic Color Printing</td>
<td>ETL-0421</td>
<td>1986</td>
</tr>
<tr>
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<td>ETL-0007</td>
<td>1975</td>
</tr>
<tr>
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<td>ETL-ETR-74-4</td>
<td>1974</td>
</tr>
<tr>
<td>(Report No. 3 in the ETL Series on Remote Sensing)</td>
<td>ETL-RN-74-10</td>
<td>1974</td>
</tr>
<tr>
<td>Single Photo Analysis of Sampled Aerial Imagery</td>
<td>ETL-0458</td>
<td>1987</td>
</tr>
<tr>
<td>Smart Mapping, Charting and Geodesy Control Generator, Phase I, A</td>
<td>ETL-0523</td>
<td>1988</td>
</tr>
<tr>
<td>Smart Mapping, Charting and Geodesy Control Generator, Phase II, A</td>
<td>ETL-0394</td>
<td>1985</td>
</tr>
<tr>
<td>Software Conversion of Standard Linear Format (SLF) to Standard Interchange Format (SIF)</td>
<td>ETL-0449</td>
<td>1987</td>
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<td>AD 202 318</td>
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<td>RN-7</td>
<td>1962</td>
</tr>
<tr>
<td>Some Relations Between the Geometrical Quality of Topographic Mapping and Aerial Photogrammetry</td>
<td>ETL-0424</td>
<td>1986</td>
</tr>
<tr>
<td>Sparse Area Stereo Matching Experiment</td>
<td>ETL-0520</td>
<td>1988</td>
</tr>
<tr>
<td>Spatial Data Structures for Robotic Vehicle Route Planning</td>
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<td>1979</td>
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<td>Spatial Light Modulators: Test and Evaluation</td>
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<td>1971</td>
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Spatial Target Location Errors Derived From Measurements Collected From Sixteen Satellite Constellations

Spectral Reflectivity Data: A Practical Acquisition Procedure

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Stars' Position Determined by Combining Micrometric Observations with an Observed Known Star in a Vertical Plane Close to the Meridian

State-of-the-Art Assessment of Automatic Name Placement, A

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Status of Aerial Color Photography in Government Agencies

Stereo Analysis of a Specific Digital Model Sampled from Aerial Imagery

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Stereoscopic Terrain Display for Measurement Applications

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Studies in Zinc Oxide Photoconductivity

Studies of Gravity in Space According to Bjerhammer
<table>
<thead>
<tr>
<th>TITLE</th>
<th>REPORT NO.</th>
<th>YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study and Analysis of the Position and Azimuth Determining System (PADS) Field Maintenance Concept</td>
<td>ETL-CR-74-22</td>
<td>1974</td>
</tr>
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<td>ETL-CR-73-12</td>
<td>1973</td>
</tr>
<tr>
<td>Study and Prototype Model Design of a Miniaturized Gyrocompass, Interim</td>
<td>AD 462 322</td>
<td>1964</td>
</tr>
<tr>
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<td>AD 465 330</td>
<td>1965</td>
</tr>
<tr>
<td>Study of a Digital Interface Design for the Quick Response Multicolor Printer (QRMP)</td>
<td>ETL-0327</td>
<td>1983</td>
</tr>
<tr>
<td>Study of Classification and Nomenclature of Vegetation</td>
<td>ETL-0058</td>
<td>1976</td>
</tr>
<tr>
<td>Study of Digital Matching of Dissimilar Images</td>
<td>ETL-0248</td>
<td>1980</td>
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<tr>
<td>Study of Environmental Monitoring and Information Systems</td>
<td>ETL-CR-72-1</td>
<td>1972</td>
</tr>
<tr>
<td>Study of Knowledge-Based Systems for Photo Interpretation</td>
<td>ETL-0235</td>
<td>1980</td>
</tr>
<tr>
<td>Study of Lithographic Fountain Solutions</td>
<td>AD 830 674L</td>
<td>1967</td>
</tr>
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<td>1965</td>
</tr>
<tr>
<td>Study of Raster Metafile Formats</td>
<td>ETL-0363</td>
<td>1984</td>
</tr>
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<td>Study of Solution of a Large System of Linearized Normal Equations and the Inversion of the Associated Coefficient Matrix</td>
<td>AD 676 849</td>
<td>1968</td>
</tr>
<tr>
<td>Study of the Application of Piezoelectric Techniques to a Small North-Orienting Device</td>
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<td>REPORT NO.</td>
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<tr>
<td>Study of the Effect of Corona Conditions on Electrostatic Processes</td>
<td>ETL-CR-72-17</td>
<td>1972</td>
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<tr>
<td>Study of the Effects of Nonhomogeneous Target Backgrounds on Photogrammetric Coordinate Measurement</td>
<td>AD 722 790</td>
<td>1969</td>
</tr>
<tr>
<td>Study of the Long Range Position Determination System</td>
<td>AD 505 912</td>
<td>1969</td>
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<tr>
<td>Study to Establish a Method of Selecting Input Photographic Material for Automated Compilation Equipment</td>
<td>ETL-CR-71-24</td>
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<td>1970</td>
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<td>ETL-0319</td>
<td>1981</td>
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<td>Target Location Errors Derived From a Hypothetical Target Tracking System</td>
<td>ETL-0531</td>
<td>1989</td>
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<tr>
<td>Technical Data on KC-Film, Toners, and Processes</td>
<td>ETL-0224</td>
<td>1980</td>
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<tr>
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<td>ETL-0400</td>
<td>1985</td>
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<td>Television Display of Topographic Information</td>
<td>ETL-CR-70-7</td>
<td>1970</td>
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<td>REPORT NO.</td>
<td>YEAR</td>
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<tr>
<td>----------------------------------------------------------------------</td>
<td>--------------</td>
<td>------</td>
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<tr>
<td>Television Display of Topographic Information, Phase II</td>
<td>ETL-CR-71-23</td>
<td>1971</td>
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<tr>
<td>Terrain Analysis Procedural Guide for Climate (Report No. 5 in the ETL Series on Guides for Army Terrain Analysts)</td>
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<tr>
<td>Terrain Analysis Procedural Guide for Geology (Report No. 3 in the ETL Series on Guides for Army Terrain Analysts)</td>
<td>ETL-0207</td>
<td>1979</td>
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<tr>
<td>Terrain Analysis Procedural Guide for Roads and Related Structures (Report No. 2 in the ETL Series on Guides for Army Terrain Analysts)</td>
<td>ETL-0205</td>
<td>1979</td>
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<tr>
<td>Terrain Analysis Procedural Guide for Vegetation (Report No. 1 in the ETL Series on Guides for Army Terrain Analysts)</td>
<td>ETL-0178</td>
<td>1979</td>
</tr>
<tr>
<td>Terrain Analyst Synthesizer Station</td>
<td>ETL-0231</td>
<td>1980</td>
</tr>
<tr>
<td>Terrain Analyst Work Station (TAWS): 1AD After Action Report</td>
<td>ETL-0470</td>
<td>1987</td>
</tr>
<tr>
<td>Terrain Data of Mount Hayes D-4 Quadrangle, Fort Greely, Alaska (Report No. 4 in the ETL Series on Remote Sensing)</td>
<td>ETL-TR-74-7</td>
<td>1974</td>
</tr>
<tr>
<td>Terrain Effects Analysis Routine for an MGI System</td>
<td>ETL-0010</td>
<td>1975</td>
</tr>
<tr>
<td>Terrain Eigenvector Dyad Analysis</td>
<td>AD 649 347</td>
<td>1967</td>
</tr>
<tr>
<td>Terrain Factor Analysis and Automatic Color Coded Mapping Utilizing the IDECS</td>
<td>ETL-CR-72-13</td>
<td>1972</td>
</tr>
<tr>
<td>Test and Evaluation of 9 by 18 Rectifier for 12- and 24-inch Focal Length Photography</td>
<td>1460-TR</td>
<td>1956</td>
</tr>
<tr>
<td>Test and Evaluation of Target Map Coordinate Locator Equipment</td>
<td>14-TR</td>
<td>1963</td>
</tr>
<tr>
<td>TITLE</td>
<td>REPORT NO.</td>
<td>YEAR</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>------------</td>
<td>------</td>
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<tr>
<td>Test and Evaluation of the Analytical Photogrammetric Positioning System, Advanced (APPS-II)</td>
<td>ETL-0293</td>
<td>1982</td>
</tr>
<tr>
<td>Test and Evaluation of the Direct Viewing Stereoplotter, Wernstedt-Mahan Type</td>
<td>1471-TR</td>
<td>1957</td>
</tr>
<tr>
<td>Test and Evaluation of the Headliner, Model 400</td>
<td>1568-TR</td>
<td>1959</td>
</tr>
<tr>
<td>Test and Evaluation of the Interim Halcon Mapping System</td>
<td>3-TR</td>
<td>1961</td>
</tr>
<tr>
<td>Test and Evaluation of the Interim Stereoplotter, Topographic, Projection Type, High Precision</td>
<td>1493-TR</td>
<td>1957</td>
</tr>
<tr>
<td>Test and Evaluation of the Kelsh Plotter, Model 5000, Manufactured by the Instruments Corp.</td>
<td>1311-TR</td>
<td>1953</td>
</tr>
<tr>
<td>Test and Evaluation of the Near Real Time Exploitation System</td>
<td>ETL-0281</td>
<td>1982</td>
</tr>
<tr>
<td>Test and Evaluation of the Prototype Side-Looking Radar Restitutor</td>
<td>29-TR</td>
<td>1966</td>
</tr>
<tr>
<td>Test and Evaluation of the Santoni Cartographic Stereomicrometer</td>
<td>1644-TR</td>
<td>1960</td>
</tr>
<tr>
<td>Test and Evaluation of the 720 Plotter</td>
<td>1348-TR</td>
<td>1954</td>
</tr>
<tr>
<td>Test and Evaluation of the Stereopontometer and Adapted Multiplex</td>
<td>1381-TR</td>
<td>1954</td>
</tr>
<tr>
<td>Test and Evaluation of the Stereopontometer with Kelsh Type Stereoplotters</td>
<td>1425-TR</td>
<td>1955</td>
</tr>
<tr>
<td>Test and Evaluation of Ultrasonic Scribing Equipment</td>
<td>1641-TR</td>
<td>1960</td>
</tr>
<tr>
<td>Test and Investigation of the Photonymograph (PN-4)</td>
<td>1537-TR</td>
<td>1958</td>
</tr>
<tr>
<td>Test of Map-Read Magnetic Declination Accuracy MAN/GSH-1</td>
<td>ETL-148</td>
<td>1978</td>
</tr>
<tr>
<td>Test of Reconnaissance Photographic Transposer</td>
<td>1566-TR</td>
<td>1959</td>
</tr>
<tr>
<td>Test Results of a Singer, Kearfott Division Modified Land Navigation System</td>
<td>ETL-0238</td>
<td>1980</td>
</tr>
<tr>
<td>Test Results of the Lear Siegler, Singer and Sperry Gyro Heading Reference Systems</td>
<td>ETL-0288</td>
<td>1982</td>
</tr>
<tr>
<td>Test Results of the Litton Low-Cost Semi-Strapped-Down Inertial Land Navigation System</td>
<td>ETL-0202</td>
<td>1979</td>
</tr>
<tr>
<td>Test Strategy for High Resolution Image Scanners, A</td>
<td>ETL-0345</td>
<td>1983</td>
</tr>
<tr>
<td>Testing and Evaluation of the Shiran System by Advanced Data Reduction Methods</td>
<td>AD 707 418</td>
<td>1969</td>
</tr>
<tr>
<td>Testing of an Experimental Viscous-Friction Coupled Small North Orienting Device</td>
<td>AD 822 011</td>
<td>1967</td>
</tr>
<tr>
<td>Tests and Evaluation of an Automatic Point Reading, Plotting, and Grid Ruling Machine</td>
<td>8-TR</td>
<td>1962</td>
</tr>
<tr>
<td>TITLE</td>
<td>REPORT NO.</td>
<td>YEAR</td>
</tr>
<tr>
<td>-------</td>
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<tr>
<td>Tests and Evaluation of an Earth Curvature Correction Device</td>
<td>10-TR</td>
<td>1963</td>
</tr>
<tr>
<td>Tests and Evaluation of the AS-11A Stereoplotter</td>
<td>50-TR</td>
<td>1969</td>
</tr>
<tr>
<td>Tests and Evaluation of the Zeiss Stereotype Stereoplotting Instrument</td>
<td>1567-TR</td>
<td>1959</td>
</tr>
<tr>
<td>Tests and Evaluation of Ultrawide-Angle Mapping Photography</td>
<td>6-TR</td>
<td>1961</td>
</tr>
<tr>
<td>Tests and Evaluations of Precision Coordinatographs</td>
<td>1-TR</td>
<td>1961</td>
</tr>
<tr>
<td>Tests of Basic Geometrical Qualities of Photogrammetric Plotting Instrument</td>
<td>RN-5</td>
<td>1962</td>
</tr>
<tr>
<td>Tests on the Change Detector</td>
<td>ETL-0370</td>
<td>1985</td>
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<td>Texture Analysis and Cartographic Feature Extraction Texture Tone Study — Category Maps, Gradient and Homogeneity Images</td>
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<td>YEAR</td>
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<td>AD 721 647</td>
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Use of a Vidicon to Digitize Certain Types of
Target Image in a Photographic Background
Use of Array Algebra in Terrain Modeling
Procedures
Use of Edges of Photographic Images as
Specifiers of Image Quality
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Positioning System (APPS), A
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in Human Engineering Laboratories Battalion
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Vegetation and Terrain Relationships in
South-Central New Mexico and Western Texas
Vegetation Data Extraction Software
·Documentation/User's Manual
Vegetative Cover Effects on Soil Spectral
Reflectance
Vertical Obstruction Study, Final Report
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ETL-0358 1984
ETL-0229 1980
ETL-0548 1989
RN-21 1967
ETL-0408 1985
ETL-0572 1990
ETL-0432 1986
<table>
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<tr>
<th>TITLE</th>
<th>REPORT NO.</th>
<th>YEAR</th>
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<tr>
<td>Voice Interactive Systems Technology (VIST) Research</td>
<td>ETL-0349</td>
<td>1984</td>
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<td>1984</td>
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<td>ETL-0200</td>
<td>1979</td>
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<td>ETL-0576</td>
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<td>1975</td>
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<td>AD 847 667</td>
<td>1969</td>
</tr>
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<td>World Areas More Humid Than the Canal Zone during the Wet Season (Note 3 of “Studies to Aid TECOM in Analyses of Environmental Risks to Materiel”)</td>
<td>ETL-RN-74-8</td>
<td>1974</td>
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<td>World Areas with Higher Precipitation Intensities and Frequencies than the Tropic Test Center, Canal Zone</td>
<td>ETL-0022</td>
<td>1975</td>
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<td>ETL-RN-74-6</td>
<td>1974</td>
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<tr>
<td>World Areas with Lower Temperatures than the Arctic Test Center During Winter (Note 1 of “Studies to Aid TECOM in Analyses of Environmental Risks to Materiel”)</td>
<td>ETL-RN-74-5</td>
<td>1974</td>
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<tr>
<td>World Weather Extremes</td>
<td>ETL-0416</td>
<td>1985</td>
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<td>Xerox 6500 Color Copier</td>
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<td>1977</td>
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<td>YEAR</td>
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<td>Zoom Transfer Scope</td>
<td>ETL-ETR-72-5</td>
<td>1972</td>
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