LABORATORY FOR APPLICATIONS OF REMOTE SENSING

Annual Report to the University

Fiscal 1975

Purdue/LARS
1220 Potter Drive
47906

September, 1975

1974-75 Report to the University
The Laboratory for Applications of Remote Sensing

This report covers the period July 1, 1974 through June 30, 1975. It provides a summary of research and development activities and the training functions carried out with contract funds. It also documents the amount of staff and student involvement and the manner in which funds were expended as a function of academic unit.

The report shows a contract funds expenditure of $2,107,406 which is a 7% increase over the previous year. There was also an increase in the number of graduate degrees granted by the University which were supported by LARS facilities.

We are pleased to transmit this report to you and look forward to another year of contribution to the several disciplines involved in the remote sensing field.

David A. Landgrebe
Director

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LARS PROGRAM REVIEW

FOR FISCAL YEAR 1975

RESEARCH ACCOMPLISHMENTS

I. IMPACT OF LARS LEADERSHIP ON THE DEVELOPMENT OF REMOTE SENSING TECHNOLOGY PRIOR TO FY75.

In less than a decade the science and technology identified as "remote sensing" has evolved from mainly an image-oriented endeavor to a numerically-oriented one with capability to secure detailed, quantitative information of features hundreds of miles away. Much of the innovative research spearheading this evolution has taken place at Purdue/LARS. Its scientists are recognized as leaders in their specialities the world over.

In 1964 largely due to the influence of Dr. Ralph Shay, head of the Purdue Department of Botany and Plant Pathology, Purdue was selected by NASA as the research center to develop and test the feasibility of using multispectral scanner (MSS) data to inventory agricultural features. Three independent but parallel lines of investigation were merging at that time to trigger the need for such a study; the attempt to track plant infestations by aerial photography, the development of a multispectral scanner system by Michigan's Institute of Science and Technology (IST) and the rapid progress in developing satellite capability by NASA. The feasibility studies at Purdue were so successful they led to a grant from NASA in 1966 to establish the Purdue Laboratory for Agricultural Remote Sensing (LARS) later to become the Laboratory for Applications of Remote Sensing.

The LARS group were mainly instrumental in the application of pattern recognition, a type of multivariant analysis and associated processing steps, to the processing and analysis of multispectral data, an approach which led the way to preparing multispectral data in computer compatible form. This development allayed the early fears that digitizing and quantitizing multispectral data would result in an unmanageable volume of data, especially the volume possible with satellite imagery.

The early conception and development by LARS scientists of an X-Y coordinate system made possible the application of pattern recognition to remotely sensed imagery. The first successful classification of a crop species, wheat, was accomplished as early as 1967 from MSS data from an aircraft over an agricultural area by a LARS team. This was rapidly followed by successful classifications of other landscape features as crop species, various soils, forest cover, waters of different quality and surface geological features. These were the first attempts to use truly quantitative pattern recognition techniques to analyze MSS data. Building on this background LARS became one of, if not, the leading center in applying mechanical data analysis procedures not only to identifying but also to efficient and accurate means of measuring the areal extent of such earth cover types as crops, soils, water, etc.

In 1969 NASA, which was involved in defining specifications for a new research MSS system asked the USGS and LARS to help develop suitable specifications. LARS participation in this project led to adoption of several Purdue recommendations in design.

In this same year, LARS was designated by NASA as one of three university centers of excellent in research on remote sensing.

LARS was invited by NASA to share in the decision to make a large regional study of the spread of corn blight in 1971. When it was decided to undertake this effort, NASA invited LARS to direct and manage the project, known as the Southern Corn Leaf Blight Watch Experiment, the largest agricultural experiment ever attempted involving NASA, the USDA, the Willow Run Laboratory, University of Michigan (now ERIM), LARS and seven land grant universities.

In 1971 LARS designed and put into operation a remote terminal system which was the first successful demonstration of the use of computers in tying together distributed groups of scientists at different sites for the transfer of technology.

Research by the LARS group in theory and in subsequent testing of the efficiency and adequacy of the number and width of wave length bands in sensor systems influenced the decision by NASA to use four bands on LANDSAT I.

LARS people have developed and documented a software system known as LARSYS which is the principal system used the world over for handling and analyzing data from multispectral scanners. This system, first implemented in 1967 and continuously improved in two subsequent iterations in 1969, LARSYS Version II and in 1973, LARSYS Version III, has now been adapted in total or modified and adopted in part by almost every governmental and/or university group working with analysis of MSS data.

Evidence of NASA's respect for the research leadership shown by LARS, was the awarding of the NASA Scientific Achievement Medal to D.A. Landgrebe, as director of LARS, in 1973.

LARS has been in the forefront in developing efficient applications of remotely-sensed data, particularly LANDSAT data, to earth resources studies, an activity made possible because of the unique organizational structure of LARS within Purdue University and the cooperative interdisciplinary approach which has developed at the Laboratory.

There is much evidence during FY75 of the continuing important role LARS plays in the total field of remote sensing. During the past year, 40 invitational talks, symposia, etc. on remote sensing subjects were given by Purdue staff associated with LARS, many before national and international groups.

LARS was selected to prepare a land use inventory of the 33,000,000 hectares of the U.S. side of the Great Lakes Drainage Basin, a Canadian-U.S. project, funded by the Environmental Protection Agency.

LARS has also been chosen by NASA to provide the technical leadership for the field measurements project, an important phase of the world wide Large Area Crop Inventory Experiment (LACIE).

Important elective or appointive professional assignments held by LARS people in FY75 include memberships on the NASA Headquarters ERTS selection

panel; on the committee of scientists and engineers to make recommendations to NASA on specifications of the next generation of satellite sensors; on the Biology and the Data Management Panels of the Committee on Remote Sensing of Programs for Earth Resource Surveys (CORSPERS), National Academy of Sciences; on the International Committee on Remote Sensing for Development, National Academy of Sciences; and on the Executive Committee on Remote Sensing of the International Society of Soil Science.

In May 1975, D. A. Landgrebe was asked by NASA to chair the select panel of experts assigned the task of defining specifications for the thematic mapper, a scanner that will be mounted in LANDSAT D in approximately 1979. Four other LARS personnel were among the 40 who participated in the panel discussions held at Purdue University. The panel has recommended a six channel MSS of approximately 40 meter resolution.

Other significant assignments held this year by members of the LARS staff include:

Resource participant, two week study, Snowmass, Colorado, sponsored by National Academy of Engineering to advise U.S. government to nation's need for operational space applications in 1990;

Consultant to Food and Agriculture Organization of the United Nations, the government of Sudan and the International Development Research Center of Canada on using remote sensing to inventory natural resources of Sudan;

Invitational witness to testify before U.S. Senate Subcommittee on Aeronautical and Space Science;

In an address in June 1975, a top NASA official in a key note address before the NASA Earth Resources Survey Symposium, Houston, Texas, stated that the first major milestone in the development of remote sensing technology was the demonstrated application of applying pattern recognition theory to classifying agricultural crops by scientists at LARS, Purdue.

II. WORK IN PROGRESS

A. DATA PROCESSING AND ANALYSIS RESEARCH

Research in the use of computers for analysis of remote sensing data continued on a broad front in FY75. Efforts ranged from developing techniques for enhancing the quality of multispectral imagery to advancing the state-of-the-science of pattern recognition.

1. Data Analysis Research

Use of Spectral Information

Since its inception, LARS research has concentrated on the multispectral aspect of remote sensing data -- i.e., the character of the data in discrete bands of the electromagnetic spectrum and the interrelationships between these spectral bands. Although a significant amount of useful information has been extracted from the spectral domain, as evidenced by the accuracy of ground cover mapping which has been achieved, new ways for more effectively and efficiently extracting this information continue to be pursued. FY75 saw the completion of two important theses dealing with pattern recognition techniques and contributing significantly in this respect. In one investigation, a "decision tree approach" to classification was developed which used layered decision logic to improve the accuracy and efficiency of classification. This approach also expands the range of problems which can be dealt with using machine-oriented analysis. The other investigation saw extension of the maximum likelihood approach to classification, from classification of single observations to classification of aggregates of observations comprising a single "object" in the data. The experimental results obtained are impressive in terms of both accuracy and efficiency of classification.

Spatial Information

Only recently has attention been turned to utilizing the information contained in the spatial organization (shape, context, etc.) of remote sensing data. At LARS efforts in this area were accelerated in FY75.

In one of the theses noted above, a procedure was developed for delineating objects in multispectral imagery. This capability, coupled with the technique of classifying aggregates of observations, is seen to offer great potential for many practical land use applications.

The use of two-dimensional Fourier transforms and various measures of texture were also investigated as means of extracting spatial information from the remote sensing imagery.

Special Techniques

Some practical aspects of utilizing the data analysis results received concerted attention. In particular, the coding and use of arbitrarily shaped

geographical boundaries (counties, census tracts, etc.) have been pursued to improve the compatibility of the results with user-informational needs. Also, "change detection," the detection of variation in ground cover over periods of time, has become of great interest to planners wishing to utilize remote sensing data from earth-orbiting satellites. Problems of accurate data registration (congruence of data from multiple earth satellite passes) and the effects of classification error make change detection a challenging problem. Progress has been made in this area during FY75.

2. Data Handling Research

Multispectral Image Registration

Research conducted since 1967 at LARS has produced techniques for automatically registering digital remote sensor image data. These techniques have come into wide use for increasing the dimensionality of remote sensor data sets for increased pattern recognition accuracy, change detection and improved analysis efficiency. The need exists for greater accuracy and efficiency in the registration process and the work during this year investigated several new registration methods. Three correlation methods and five enhancement methods were studied by applying them to LANDSAT satellite imagery from Montana, Indiana, Missouri, and Kansas test sites. An improved algorithm for approximating the geometric differences between images to be registered was investigated also. This extensive analysis is expected to result in improved algorithm specification which will significantly lower the cost and improve the accuracy of this important remote sensing data handling process.

Preprocessing Algorithms

Several image preprocessing algorithms were researched with the general goal of improving the quality of LANDSAT image data. Research on an optimum constrained scanner instantaneous field of view compensation filter was completed and is being applied to LANDSAT data. This digital filtering algorithm is expected to enable a 50 percent or better improvement in the resolution of this important form of data enabling smaller objects to be more clearly distinguished.

Work was also conducted on other image enhancement algorithms to sharpen digital images and to enhance features in images such as lineaments which are clues to mineralization and other geological features. An evaluation of the benefits of these enhancements on area classification accuracy is in progress. The overall goal is to define image enhancement algorithms which will improve the visual and numerical quality of remote sensor imagery at an acceptable processing cost.

B. MEASUREMENTS RESEARCH

1. Field Measurements

The activities in the Field Measurements Research Program at LARS continue to concentrate on the development of specialized instrumentation and systems for the acquisition of *in situ* spectral reflectance and emittance data. Work continued on the improvement of the field spectroradiometer system that has previously been designed, developed and constructed at LARS. The system consists of a basic wide range spectroradiometer that has been adapted to the field measurements task with the development of several auxiliary electronic and instrumentation systems. During the fiscal year, special systems for the measurement of spectral transmittance of plant leaves were designed and constructed. In addition, a semi-automatic system that can acquire the temperature profile of a plant canopy was also designed and constructed. Calibration procedures for the system were developed that enable the LARS system to be correlated with field systems operated by other laboratories.

For the first time the field spectroradiometer system was deployed to test sites at relatively large distances from West Lafayette. During the fiscal year the system was operated at test sites located in Garden City, Kansas and Williston, North Dakota as part of a project to acquire spectral data over winter wheat and spring wheat in the principal wheat growing areas in the United States. Details of the project are described elsewhere in this report. An important feature of this work is that the system can be calibrated and maintained at test sites far removed from the home base in West Lafayette.

2. Vegetative Canopy Modeling

Research on the reflective and emissive properties of vegetative canopies was continued during the 1975 fiscal year. One of the project concerns the development of microscale vegetative canopies along with analytical and laboratory analyses that will ultimately enable a study of the dependance of the spectral reflectance properties of the canopy upon the characteristics of the individual reflecting elements within the canopy. In addition a unique experiment for measuring the optical depth of a vegetative canopy in the field has been developed and implemented. In parallel with the work on the reflective properties of vegetative canopies, research on the emissive properties of canopies has continued during the fiscal year. Detailed temperature measurements and spectral emissive measurements of the canopies will be related to the agronomic variables associated with the canopy. This work will be actively continued into fiscal year 1976.

3. Use of Thermal Data From Skylab For Land Use Mapping

Eight channel Skylab multispectral scanner data obtained from the S192 multispectral scanner aboard the Skylab were used in a two level land use analysis of Allen County, Indiana. Normally multispectral data from the summer months are used with land use analysis since the presence of healthy vegetation in the scene enhances the separability of land use classes. The

Skylab space station however, contained a thermal channel which this research showed to be of use in performing a land use analysis on a data set from a winter time month (January, 1974). The data set includes one visible channel, four near infrared channels, two middle infrared channels, and one far infrared channel. The results indicated that a good quality far infrared (thermal) channel is very valuable for land use mapping during the winter time months; in fact, without the thermal channel it was impossible to perform a reasonable quality land use analysis of the multispectral data set involved.

4. Thermal Infrared Camera System

A high resolution, high speed thermal infrared camera scanner was acquired during the fiscal year. The camera has been extensively modified and upgraded for a series of projects both within and without the university. Funding to support the research associated with a thermal camera system is expected to commence during fiscal year 1976. The camera has been modified to produce multispectral data on surface targets and could be modified for use in aircraft, although this is not currently planned.

5. Electrical Determination of Soil Moisture Profile

This project has extended over a three year period and was concluded during this fiscal year. Several electrical methods of determining soil moisture content were explored. Since the magnetic permeability and electrical conductivity in soils are known to be unreliable indicators of soil moisture content, the research focused on the electrical permittivity of soils. The first part of the research gave an assessment of permittivity as an indicator of soil moisture content based upon experimental studies performed in the laboratory. The conclusion was that the electrical permittivity of soils is a useful indicator of available soil moisture content.

In the second part of the research, two methods of determining the permittivity profile on soil were examined in light of the experimental findings of the research. The second of these two methods, a method of Slichter, appeared to be feasible. The results of the Slichter method were extended to the proposal of an instrument design that could measure available soil moisture profile from a surface measurement to an expected resolution of from 10 to 20 centimeters. Extension of the results to airborne remote sensing problems were considered.

6. Atmospheric Modeling

Two programs which enable the inclusion of atmospheric scattering and absorption properties on multspectral data sets were implemented. Such atmospheric corrections on multispectral data sets are useful in temporal overlays of data in which the atmospheric conditions during the acquistion of the multi-temporal data sets are markedly different.

This project was terminated during the fiscal year and will not be continued into fiscal year 1976.

C. CROP INVENTORY SYSTEMS RESEARCH

In response to the current great need for information on world crop production, scientists at LARS continued to concentrate in FY75 on developing a remote sensing capability to achieve such information on a world wide scale. Remote sensing is potentially a useful tool for obtaining both acreage and yield information, the two kinds of knowledge essential to accurate estimation of production.

The feasibility of crop indentification by analysis of MSS data has been clearly demonstrated. In 1971 Corn Blight Watch Experiment major crop species were accurately identified using aircraft scanner data. More recently LANDSAT MSS data collected over Indiana, Illinois, and Kansas were successfully classified. Classification accuracies were similar to those previously obtained from aircraft data. Of most significance, areas as large as 2,000 square miles were successfully classified in one analysis.

Several research projects are currently being carried-out in support of the Large Area Crop Inventory Experiment (LACIE) being conducted by NASA, USDA, and NOAA. LACIE is to develop, test, and demonstrate the feasibility of global crop production inventories, with multispectral remote sensing data acquired from LANDSAT as one of the major inputs. If successful, this experiment could lead to an operational crop inventory system using remote sensing.

The spectral strata project has the objective of defining and implementing multivariate pattern recognition techniques to determine and delineate areas in LANDSAT data having crops with sufficient similarity that training statistics from one sample unit can be successfully applied to other sample units in the same strata.

LARS is providing the technical leadership and coordination for the field measurements project which includes participants from NASA, USDA, and several universities. Its objective is to acquire, process, and analyze data from several sensor systems to determine the temporal-spectral characteristics of wheat and to provide a fully documented data set for other remote sensing research problems.

Another project was funded in the spring to use the most advanced multivariate data analysis techniques available to classify LANDSAT data for Indiana and Kansas to identify the major crops present and determine their acreages.

D. EARTH SCIENCES RESEARCH

1. Spectral Properties of Soils

A growing body of evidence suggests that the multispectral reflectance from surface soils may be related to a broad array of chemical and physical properties of both surface soils and subsoils. During FY75 reflectance measurements covering the spectral range from 0.5 μm to 2.37 μm were obtained with the field spectroradiometer for 71 soils of the United States, 17 soils from West Germany, 12 soils from Greece and three from Sudan. In stepwise regression analysis studies organic matter content, percent clay

and silt, cation exchange capacity and iron oxides were found to be related significantly to soils spectra. Continuing research in this area is helping to unravel the complex riddle of the quantitative effects of specific soil components on soil reflectance. A better understanding of these basic soil properties will aid in the application of remote sensing technology to the characterization and mapping of soil resources on a regional, national and global basis.

2. Land Use Inventory of the Great Lakes Drainage Basin

One of the milestones at LARS in FY75 was the completion of a land use inventory of the 33,000,000 hectares (82 million acres) in the U. S. portion of the Great Lakes Drainage Basin. This project, funded by the Environmental Protection Agency, is one of several tasks currently being pursued by the United States and Canada in an attempt to improve the water quality of the Great Lakes.

The LARS task involved the computer-aided analysis of multispectral scanner data from LANDSAT-1 to produce county maps and area estimates of different land use activities. These data will be used to incorporate with other data to provide estimates of sources and quantities of pollution resulting from land use activities.

This project represents a very important first - - the first time satellite data from a very large area have been analyzed digitally to provide a product of direct use to the customer.

3. Soil Classification and Survey

a. Program in Indiana

With financial support from the State of Indiana, the Soil Conservation Service (SCS), U.S. Department of Agriculture, in cooperation with Purdue University made a commitment in 1974 to complete within ten years a detailed soil survey for the entire state. In FY75 the state SCS continued to work with LARS in the development of a program to utilize computer-aided analysis of LANDSAT data as a tool in soil survey.

Satellite data may be of benefit in (1) identifying major soils groups and boundaries, (2) planning and scheduling work for more efficient field study, (3) determining landscapes which require greater study, and (4) providing a tool for quality control for uniformity of soil surveys across large areas.

A significant part of this cooperative program was the assignment of SCS soil scientist Richard Gilbert to work full time at LARS.

b. Program in Missouri

Request of the Soil Conservation Service in Missouri, Purdue University/ LARS

In FY75 the Soil Conservation Service in Missouri requested Purdue University/LARS to participate in a cooperative program involving the analysis of a frame (13,600 square miles) of LANDSAT data obtained over central Missouri. The objective is to produce a high quality spectral classification of the entire LANDSAT frame. Soil surveyors in Missouri will evaluate the utility of the spectral map as a soil survey tool in the field and the laboratory.

In addition, a current land use map will be prepared for one of the countries. This map will be useful for prediction of erosion losses and sedimentation.

4. Mapping Soils and Vegetation in the Tropical Savanna of Western Sudan

LANDSAT-I MSS data obtained over the savanna of Kordofan Province in western Sudan were analyzed to characterize and map soils and vegetation. Results from the computer-aided analysis of the satellite data were used to produce a series of maps delineating important differences in soils and vegetation. Results from this study prompted the Sudanese Ministry of Agriculture to request technical assistance in training Sudanese scientists and assisting them with computer-aided analysis of LANDSAT data from another 70,000 km^2 of Sudan's western savanna.

5. Mapping Soils and Geologic Features in Spain

In a study funded by the International Institute for Aerial Survey and Earth Science, The Netherlands, false color images and non-supervised classification results derived from LANDSAT-I multispectral scanner data were used (1) to study the soils in a very complex soils/geology area along the Guadiana River in southwestern Spain, and (2) to examine the geology of an area around Montalban in eastern Spain. In both studies the satellite imagery was found to be useful in delineating important differences between soils and geologic features. The study is being continued to obtain a sufficient amount of ground observation data to train the computer for supervised classifications of the two study areas.

6. Use of Satellite Data in Mineral Exploration

In FY75 a project was proposed and funded to study mineral exploration with the use of data from several sensors. Emphasis is being placed on the application of digital preprocessing and analysis techniques to the quantitative correlation between various types of remote sensors, geophysical and geological data. Anticipated results from this continuing research are a definition of techniques and/or combinations of sensor data which may identify and locate features related to deposition of minerals.

7. Dolomite Reef Study of Northwestern Indiana

In FY75, a study was initiated to study the utility of multispectral scanner data from LANDSAT and aircraft scanners are being examined with the objective of locating limestone deposits in Northwestern Indiana. This study is continuing into FY76.

8. Study of Highway Relocation around Ft. Wayne, Indiana

In FY75 a project was initiated to study the utility of multispectral scanner data from LANDSAT and Skylab in the route selection for a dual lane by-pass around Ft. Wayne, Allen County, Indiana. In this study, satellite data are being compared and related to aerial photography, agricultural soils map, engineering soils map, and a 7½ minute topographic quadrangle map of the area.

E. ECOSYSTEMS RESEARCH

Forestry Projects

1. Forestry Applications Project for the Sam Houston National Forest

This project, The Forestry Applications Project (FAP) a part of the SR&T NASA Contract, is for the purpose of developing computer-aided analysis techniques used to identify forest features. This long range project has as its goal to transfer Purdue /LARS developed technology to the Southern Region of the U.S. Forest Service. Conclusions and recommendations developed during the first year's investigation include latitude and resolution constraints, improvement in the cost effectiveness of analysis procedures, and statistical evaluation constraints of classification results, particularly those related to species identification.

2. Tennessee Valley Authority

The Tennessee Valley Authority (TVA) contracted with Purdue/LARS for assistance in transferring the LARS technology to the TVA. The TVA used its own personnel to classify data from Knox County, Tenn., into spectral classes and land use classes.

3. Strip Mine Identification in Southern Indiana

During FY75, Purdue/LARS has worked closely with the Division of Reclamation in Indianapolis to provide them general information concerning computer processing of satellite data and specific information with regards to their areas of interest. Warrick, Pike, and Sullivan counties were mapped for strip mines during FY75. These maps were provided to the Division of Reclamation and they used them to identify strip mine reclamation in the field. Through his project, the Division of Reclamation expects to develop the competence to use computer processing and satellite data to identify accurately and efficiently areas of strip mines.

4. Ecological Inventory Derived from SKYLAB Data

This is the second year for this project, which has the southern San Juan Mountains of Colorado as its test site and utilizes SKYLAB and LANDSAT data. Results of this investigation to date have shown that an increased classification accuracy can be obtained with the SKYLAB data over and above the LANDSAT data. This is caused by additional spectral bands of SKYLAB S192 data. Recommendations concerning future satellite scanner systems parameters are made based upon a wavelength band selection

study carried out in this investigation.

Another project carried out through this same investigation studied topographic influences on spectral data. Data obtained from the Defense Mapping Agency in a digital format was overlaid on SKYLAB and LANDSAT digital data. This topographic data consisted of elevation, three channels of aspect, and one channel of slope. This investigation is still in progress but results are expected to indicate spectral classification can be substantially improved if topographic influences are understood and incorporated into classification techniques.

The Water Resources Projects

1. Surface Temperature Analysis

Public Service Indiana (PSI) contracted with Purdue/LARS to provide thermal data near the Cayuga Power Station on the Wabash River. LARS has been involoved in collecting data over this test site for the past five years, also LARS has developed in past research projects the capability to use absolute calibration procedures. PSI requested the data be sent to them in order to fulfill the requirements of the Environmental Protection Agency (EPA) concerning possible detrimental reactions to thermal effluents from this power plant.

WAPORA, Inc., a consulting firm working for the American Electric Power Company, contracted with Purdue/LARS to obtain and process thermal data over the Wabash River south of Terre Haute as a new possible power plant site. These data were collected for the use of the ERA evaluating detrimental effects of thermal effluent from power plants.

2. Thermal Plume Modeling

Thermal data collected and processed by Purdue/LARS to date have been only for the surface of the water. Effects of the thermal effluent on fish and algae population, however, occur below the surface of the water. In order to understand how the plume develops below the surface, a modeling investigation commenced early this year. The model, which is currently under development, will use thermal data derived from existing processing techniques as an input parameter. Other parameters such as heat discharge, flow rates, channel slope, and other factors will be incorporated into the model. As an output product the model will provide investigators with cross sectional profiles of isotherms within the river.

3. Hydrological Features Survey of SKYLAB Data

Previous investigations have conclusively proven that spectral discrimination can not be made between the snow and clouds from wavelength bands being used in current LANDSAT series. A similar investigation using SKYLAB data, however, indicated that the bands available on this satellite which included middle infrared wavelength bands not present on LANDSAT, could effectively be utilized to make this discrimination.

Results from the snow mapping project indicated that several classes of snow could be discriminated and compared favorably with vegetation densities in the area. These density distributions are being related to topographic data also being used in the study.

SKYLAB-Colorado Geological Investigation

The Geological Investigation of the SKYLAB-Colorado project has been directed at the problem of mapping lithology and structure through the application of machine data processing techniques to remotely sensed data. Multistage data sets (SKYLAB, LANDSAT, and aircraft) were used in an effort to locate areas for detailed mineral exploration. Procedures developed during this investigation will enable geologists to define areas for intensive exploration by other more conventional, but expensive, techniques.

EDUCATIONAL ACTIVITIES

I. INTRODUCTION

While the primary activity of LARS is to provide an interdisciplinary research facility for the analysis and application of remote sensing data; an increasingly important secondary activity is the transfer of technology developed to the user community. This "user community" is broad based, ranging from Purdue University personnel on outward to other universities, state and federal agencies, business and industry, and foreign personnel. In addition to the specific programs described in detail in the following pages of this report, the Laboratory also:

A. Provides a funded research program and facility for 21 academic and 36 professional staff of the University who add to their teaching the knowledge gained in their remote sensing activities.

B. Provides funding for salaries, equipment, operational expenses and thesis research for graduate students from many areas of the University.

C. Provides an experienced, capable staff for offering seminars, symposia, workshops, training programs, short courses, etc. for interested scientists.

D. Attracts scientists as visitors from many parts of the world who seek advice from the LARS staff members.

E. Provides a local facility for those in diverse University courses to learn about the current aspects of the technology and applications of remote sensing. Resources are also available in such related activities as photointerpretation, data acquisition, and processing and data analysis and interpretation.

F. Develops educational aids and teaching materials on remote sensing for use of the University staff.

G. Provides job training and salaried part-time jobs of a technical nature for many undergraduate students.

II. GRADUATE TRAINING WITH LARS STAFF AND FACILITIES

A. DEGREE CANDIDATES FY75

Adam, James, M.S., Atmos. Sci., Prof. Jurica, No thesis title assigned.

Bartolucci-Castado, Luis A., Ph.D., Geosc., Profs. R. M. Hoffer and D. W. Levandowski, "Applications of Spectral Signature Mixing to Water Resources."

Berkebile, John, Ph.D., For. and Nat. Resources, Prof. R. M. Hoffer, No thesis title assigned.

Brayer, John, Ph.D., EE, Prof. K. S. Fu, "Web Grammars and Their Application to Pattern Recognition."

Burch, Randy, M.S.M.E., ME, Prof. David DeWitt, "Crop Canopy Modeling and Thermal Measurements."

Cochran, Jeff, M.S., For. and Nat. Resources, Prof. R. E. Bailey, No thesis option.

Chu, Nim, Ph.D., EE, Prof. C. D. McGillem, No thesis title assigned.

Fleming, Mike, M.S., For. and Nat. Resources, Prof. Roger Hoffer, No thesis option.

Grady, Louann, M.S., CS, Supervisor, Howard Grams, Non-thesis option.

Hawkins, Bob, M.S.E.E., EE, Prof. Philip H. Swain, Non-thesis option.

Hebeisen, Cheryl, M.S., CS, Supervisor, Dr. Howard Grams, Non-thesis option.

Hitchcock, Harry, Ph.D., For. and Nat. Resources, Prof. Roger Hoffer, Non-thesis option.

Horvath, Emil, M.S., Agron., Supervisor, Dr. Marvin Bauer, "Correlation of Multispectral Reflectance and Agronomic Characteristics of Corn."

Jo, Soochul, Ph.D., EE, Prof. L. F. Silva, Non-thesis option.

Jordon, Steven, M.S., Geosc., Prof. D. W. Levandowski, Non-thesis option.

Kardos, Kris, M.S.N.E., NE, Prof. R. E. Bailey, Non-thesis option.

Lehman, Terry, Ph.D., Geosc., Prof. Don Levandowski, Non-thesis option.

Li, Robert, M.S.E.E., EE, Prof. K. S. Fu, No thesis title assigned.

McDonald, Ellen, M.S., CS, Supervisor, Howard Grams, Non-thesis option.

Mobasseri, Bijan, Ph.D., EE, Prof. C. D. McGillem, No thesis title assigned.

Montgomery, Oscar, Ph.D., Agron., Prof. M. Baumgardner, "Effects of the Physical and Chemical Properties of Soil on the Spectral Reflectance of Soils."

Mundy, Steve, M.S.C.E., CE, Prof. K. Curtis, Non-thesis option.

Schenck, Brett, M.S., For. and Nat. Resources, Prof. Roger Hoffer, Non-thesis option.

Seberger, Lewis J., Ph.D., EE, Prof. Clare McGillem, Thesis not assigned.

Singer, Michael F., M.S., CS, Supervisor, P. E. Anuta, Non-thesis option.

Svedlow, Martin, Ph.D., EE, Supervisor, P. E. Anuta, Prof., Clare McGillem, Thesis not assigned.

Vanderbilt, Vern, Ph.D., EE, Prof. Leroy Silva, "Modeling Canopy Reflectance."

Walker, Carl, M.S., Agron., Prof. Joe Yahner, "A Model to Estimate Yields for Indiana Soil."

Whitsitt, Stephen J., Ph.D., EE, Prof. D. A. Landgrebe, "Predicting Performance in Multiclass Statistical Pattern Recognition."

B. DEGREES GRANTED FY75

Beck, Robert H., M.S., Soil Sci., Supervisor, Dr. William McFee, "Spectral Characteristics of Soils Related to the Interaction of Soil Moisture, Organic Carbon, and Clay Content."

Benson, Raymond W., M.S., CS, Supervisor, P. E. Anuta, Non-thesis option.

Borger, Robert, M.S., Geosc., Prof. D. W. Levandowski, Non-thesis option.

Donahue, Steve, Ph.D., Agron., Prof. Ray Bula, "Effect of pH and High Rates of Nitrogen Fertilizer on Stand Reduction in Orchardgrass (Dactylis Glomerata L.)"

Gill, Joseph, M.S., Ag. Econ., Prof. William Miller, "The Economic Impact of Controlling Non-Point Pollution From Cropland."

Kettig, Robert L., Ph.D., EE, Prof. D. A. Landgrebe, "Image Data by Extraction and Classification of Homgeneous Objects."

Mapes, Kathleen S., M.S., CS, Supervisor, Prof. Philip H. Swain, Non-thesis option.

Montgomery, Oscar, M.S., Agron., Prof. Baumgardner, "Effects of the Physical and Chemical Properties of Soil on the Spectral Reflectance of Soils."

Riemer, Terry E., Ph.D., EE, Prof. C. D. McGillem, "Optimum Constrained Image Restoration Filters."

Seberger, Lewis J., M.S., CS, Supervisor, P. E. Anuta, Non-thesis option.

Stockton, John G., Ph.D., Agron., Profs. Marvin E. Bauer and Byron O. Blair, "The Use of ERTS-1 Multispectral Imergy for Crop Identification in a Semi-Arid Climate."

Svedlow, Martin, M.S., EE, Supervisor, P. E. Anuta, Prof. C. D. McGillem, "Image Registration: Some Iterative Algorithms and a Measure for Data Overlay Quality."

Wu, Chia-Lin, Ph.D., EE, Prof. D. A. Landgrebe, "The Decision Tree Approach to Classification."

III. SPECIFIC EDUCATIONAL PROGRAMS

Technology Transfer programs under Professor John C. Lindenlaub, a new program area established last fiscal year, proliferated in response to growing awareness of and demand for more communication on remote sensing. The major components of Technology Transfer activities were:

A. Remote Terminal Project

In 1970 NASA approved and funded at LARS the establishment of a computer network dedicated to the analysis of remote sensing data. The aim of this project is in part educational:

> to provide a training facility to potential remote sensing researchers and users
>
> to facilitate the communication of new remote sensing technology to remote sensing researchers and users

During FY75 remote terminals were in operation at nine locations: two at LARS; one each at NASA/Goddard Space Flight Center, Maryland; NASA/Wallops Island, Virginia; NASA/Langley, Virginia; two at NASA/Johnson Space Flight Center, Houston, Texas; one at Indiana State University, Terre Haute, Indiana; and one at EROS Data Center, Sioux Falls, South Dakota.

The LARSYS Educational Package (see Figure 1) is a set of instructional materials developed to train people to analyze remotely sensed multispectral data using LARSYS, a computer software system developed at Purdue. During the past year, the Educational Package has been revised and updated to correspond to changes in the computer software system as well as to increase the effectiveness of the package from an educational standpoint. In addition, a seventh unit was added to the package covering the analysis of LANDSAT data using LARSYS. The Educational Package has proven to be very successful in the training of data analysts using the LARSYS software system. The use of these materials continues to be monitored and additional revisions are being made when necessary to increase the quality and effectiveness of the Educational Package.

In mid-summer and early fall of 1974, LARS staff members instructed forty-four Lockheed analysts, through NASA/JSC, in Automatic Data Processing (ADP). This was accomplished during two six-week sessions held on site at Johnson Space Flight Center in Houston, Texas. Participating were John Lindenlaub, Doug Morrison, Tina Cary, Larry Biehl, Philip Swain, and Paul Anuta.

THE LARSYS EDUCATIONAL PACKAGE

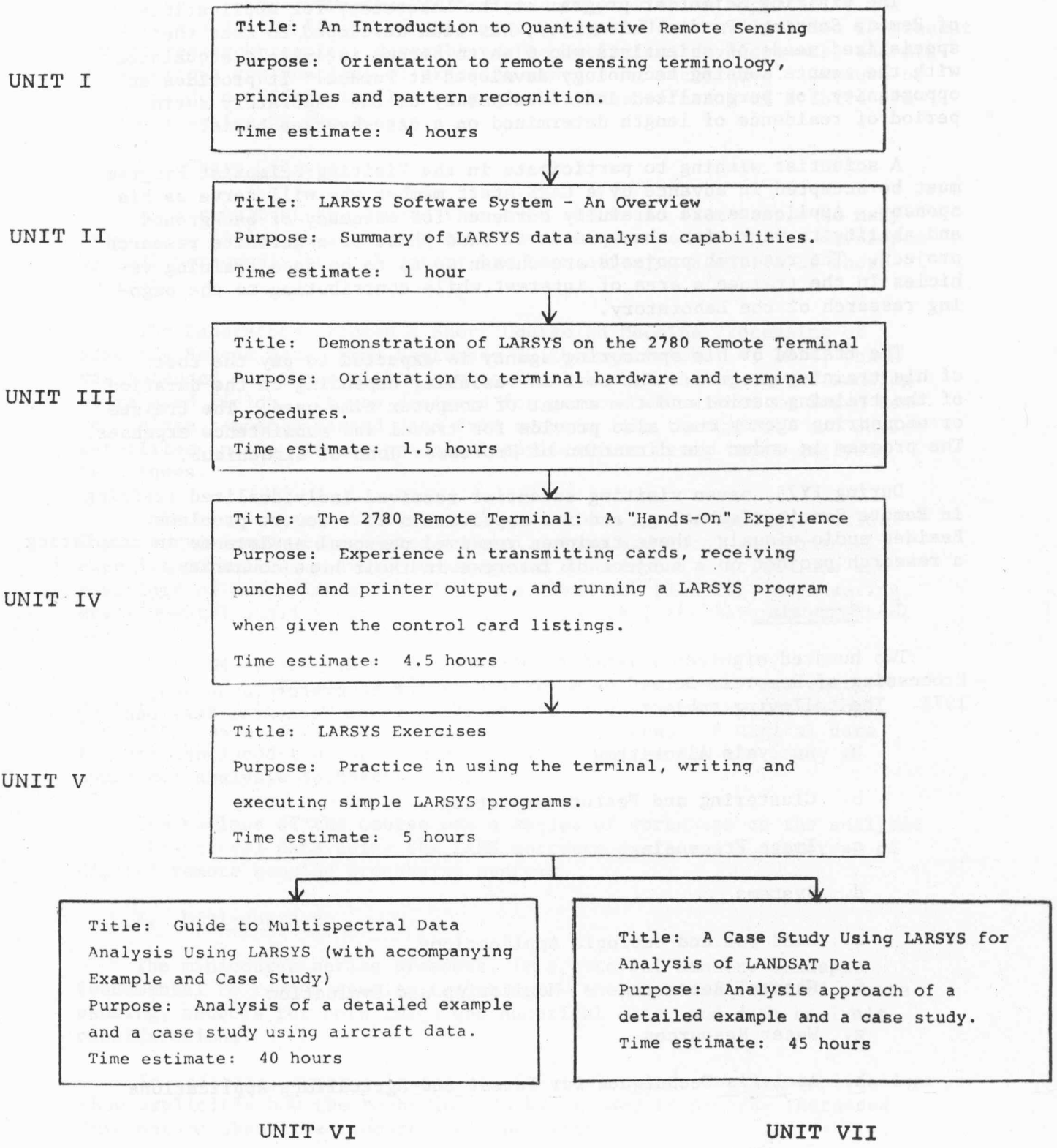


Figure 1

B. Visiting Scientist Program

The visiting Scientist program at the Laboratory for Applications of Remote Sensing, Purdue University, has been developed to meet the specialized needs of scientists who wish to become intimately acquainted with the remote sensing technology developed at Purdue. It provides an opportunity for personalized individual study at the Laboratory during a period of residence of length determined on a case-by-case basis.

A scientist wishing to participate in the Visiting Scientist Program must be accepted in advance by a LARS staff member who will serve as his sponsor. Applicants are carefully screened for adequacy of background and ability to work with the sponsor on some phase of a definite research project. The research projects are chosen so as to be good training vehicles in the trainee's area of interest while contributing to the ongoing research of the Laboratory.

The trainee or his sponsoring agency is expected to pay the cost of his training program. The cost is variable, depending on the duration of the training period and the amount of computer time used. The trainee or sponsoring agency must also provide for travel and subsistence expenses. The program is under the direction of Professor John C. Lindenlaub.

During FY75, seven visiting scientist received individualized training in Remote Sensing Technology and its application to resource problems. Besides audio visuals, these trainees received personal assistance in completing a research project on a subject of interest in their home countries.

C. Symposia

Two hundred eighteen scientists attended the symposium on Machine Processing of Remotely Sensed Data offered by the Laboratory June 3-5, 1975. The following subjects were presented in eight Technical Sessions:

a. Analysis Algorithms

b. Clustering and Feature Selection

c. Image Processing

d. Systems

e. Land Use and Geologic Applications

f. Natural Resources - Monitoring and Evaluation

g. Water Resources

h. Analysis Techniques for Forest and Agriculture Applications

Sixty-three papers were presented covering the central theme of theory, implementation and applications of machine processing of remotely sensed data. The symposium was designed to provide an opportunity for researchers in the fields of data processing and data utilization to present recent research results, describe new technological developments, and discuss various applications of existing processing techniques. Because of the demand, consideration is being given to the offering of a third symposium sometime in the future.

D. Short Courses

As a result of the demand from over the world from people in many scientific fields to learn the techniques of remote sensing as developed by LARS personnel, the Laboratory has been offering a series of short courses.

The Laboratory offered a Short Course on Machine Processing of Remotely Sensed Data, from September 30 through October 4, 1974, which was intended for those with a professional background in remote sensing or related fields. It was designed for persons who wished to learn how to analyze remotely sensed data from systems like the LANDSAT and Skylab satellites and to discuss potential applications using these analysis techniques.

This course was attended by 34 scientists from around the world. These participants represented federal, state and local governmental agencies as well as private industry and educational institutions and a variety of disciplines: agriculture, land use planning, engineering, environmental quality control, forestry, geology, the natural sciences, etc.

The week began with a discussion on radiation theory and energy-matter interactions, the physical basis of remote sensing technology. Presentations on measurement systems and the concept of digital data formats concluded the background material required for the study of numerical analysis techniques.

The nucleus of the course was a series of workshops on the analysis of multispectral data using the LARS software system as a prototype of digital remote sensing processing systems.

E. Mini-courses

The minicourse series presents, in a tutorial manner, concepts fundamental to remote sensing technology - the physical basis of remote sensing, sensors for both image and numerical data, and data analysis considerations.

In addition, numerous examples of actual remote sensing applications show explicitly how the technology is being used to provide increased information about the resources of the Earth.

Each minicourse includes a set of slides, an audio tape and a study guide and requires about 45 minutes to an hour of student time.

Throughout the minicourses, student activities reinforce the concepts when they are presented and aid the student in evaluating his mastery of the material.

The minicourses are designed for use by individuals and small groups. The content is modularized so that, after completing the two introductory units, a student may select only those clusters of minicourses relating to his interests. (see Figure 2).

These materials have been used effectively in a wide variety of learning situations and by students with varied background preparation: as course work by graduate and undergraduate students, as continuing education for professionals acquainted with remote sensing, and as a demonstration of the utility and availability of remote sensing technology for governmental personnel.

Work on the minicourse series is now nearing the final stages. The series will be available for sale after January, 1976.

F. The Focus Series

Recent technological developments in remote sensing and the broadening of its use have quickly caused much of the existing educational material in remote sensing to be outdated. Today only a very small body of current, instructional materials on the subject is availalle commercially, and there is, as yet, no fully-integrated textbook on remote sensing. While a person entering the field can easily find numerous technical reports he may have considerable difficulty locating materials which describe the concepts basic to remote sensing technology as it is developing today.

In recognition of this need, the FOCUS series is being developed as a way to explain and illustrate basic remote sensing concepts. Each pamphlet in the series is designed to illuminate a single concept through one page of concisely written text supported by illustrations. Extensive care is taken to minimize the use of technical terms in the descriptions and to include definitions where confusion might occur.

The educational aim of the series has affected its design in a number of ways. The format of the pamphlets was designed so that they could be attractive to the reader as well as being relatively inexpensive. Secondly, each issue contains a list of suggestions for further reading to guide a student wishing to pursue the topic in greater depth. In preparing these bibliographies, authors give preference to titles which are available in the open literature.

The challenge in preparing a FOCUS issue is to present a complex topic in such a way that it is neither unnecessarily complicated nor in any way misleading to the reader who has no prior understanding of the concept. In order to insure that this requirement is met, each FOCUS is subjected to rigorous in-house review by a variety of people: remote

FORMAT OF THE MINICOURSE SERIES

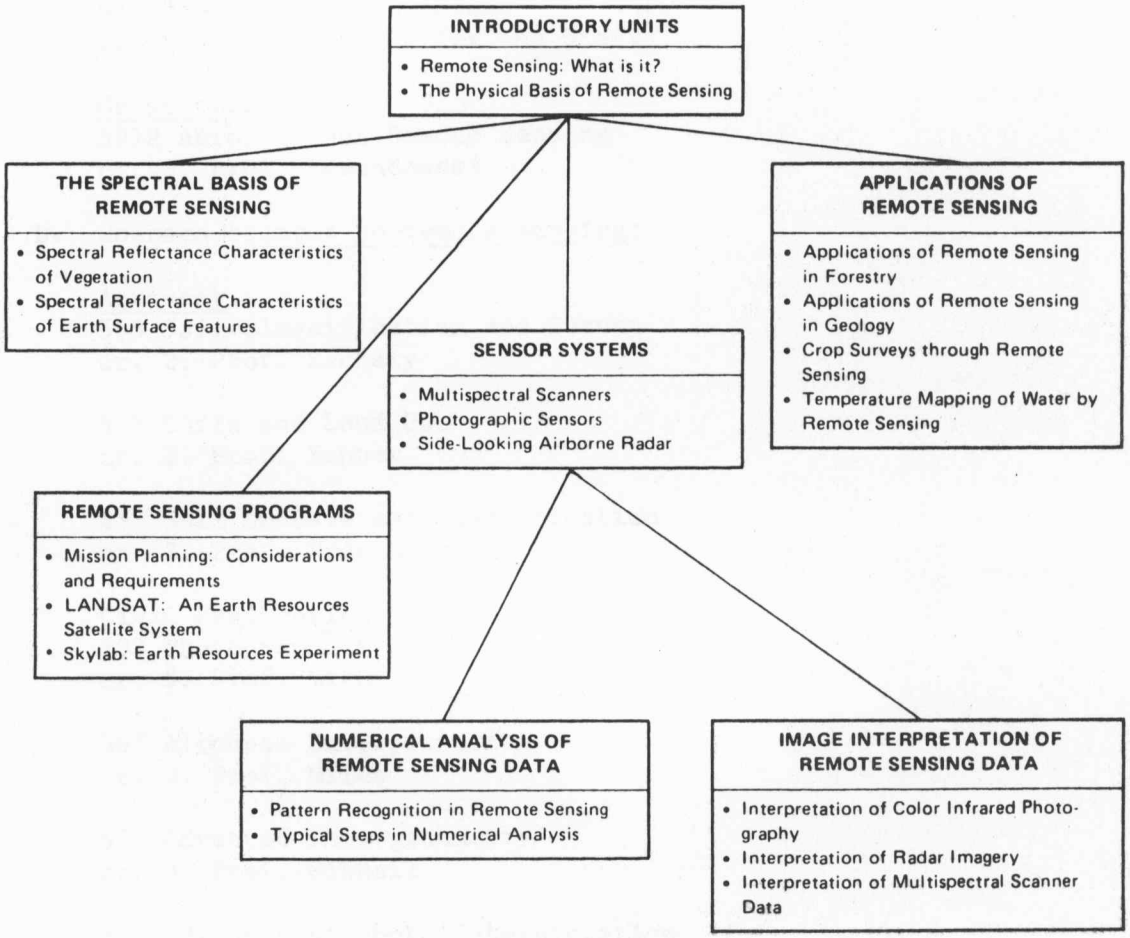


Figure 2

sensing specialists, technicians, educationalists, communicators, engineers, and scientists.

G. EROS Data Center

Purdue/LARS has developed a "demonstration package" for use at the EROS Data Center. The materials were developed for use by EROS personnel so that they could demonstrate to visitors and visiting scientists the remote terminal concept and the potentials of numerical processing of remotely sensed data. The materials, when used in conjunction with the 2780 remote terminal, serve to demonstrate key analysis steps, intermediate results, and final output of a land use analysis of multitemporal LANDSAT data collected at Sioux Falls, South Dakota.

IV. FORMAL UNIVERSITY COURSES DEALING WITH PHASES OF REMOTE SENSING

A. Courses with definite emphasis on remote sensing:

Electrical Engineering
577 Engineering Aspects of Remote Sensing
cr. 3. Prof. Lindenlaub

Forestry
291 Introduction to Remote Sensing
cr. 1. Prof. Hoffer

558 Remote Sensing of Natural Resources
cr. 3. Prof. Hoffer

579 Remote Sensing Seminar
cr. 0 or 1. Prof. Hoffer and Staff

Geosciences
591R Aerology and Remote Sensing
cr. 3. Prof. Levandowski

B. Courses related to remote sensing:

Agronomy
565 Soil Classification and Survey
cr. 2. Prof. Zachary

585 Soils and Land Use
cr. 2. Prof. Yahner

655 Soil Genesis and Classification
cr. 3. Prof. Franzmeir

Civil Engineering
503 Photogrammetry
cr. 3. Prof. Mikhail

567 Airphoto Interpretation
cr. 3. Prof. Miles

603 Advanced Photogrammetry
cr. 3. Prof. Mikhail

667 Advanced Airphoto Interpretation
cr. 3. Prof. Miles

Electrical Engineering
644 Communications I
cr. 3. Communications Sciences Area Staff

645 Communications II
cr. 3. Communications Sciences Area Staff

661 Image Processing
cr. 3. Prof. Huang

662 Introduction to Artificial Intelligence and Pattern
cr. 3. Prof. Funkunaga

697W Fourier Transform and Applications
cr. 1. Prof. Landgrebe

697Y Orthogonal Signal Representation
cr. 1. Prof. Landgrebe

697Z Power Spectrum Estimation
cr. 1. Prof. Landgrebe

Forestry
557 Aerial Photo Interpretation
cr. 3. Prof. Miller

STAFF, FISCAL, AND FACILITY SUMMARY

I. Staff

During the 1974-1975 fiscal year, 178 people (87 FTE) from 16 departments in four schools were assigned to LARS projects. This included 7.5 FTE faculty, 31.5 FTE professional, 13.5 FTE graduate students, 16.0 FTE undergraduate students, 5.5 FTE service staff, and 13.0 FTE clerical staff. The number of staff involved at LARS from the various schools and departments are shown in the attached table. Since LARS is not an administrative unit, all staff involved with LARS projects are from the various administrative units shown on the table.

A list of the professorial and professional staff who have contributed to LARS projects during the 1974-1975 fiscal year is included in this report. The contribution of each to the interdisciplinary effort at LARS should be recognized and commended.

II. Fiscal Summary

- Research budget of $2,107,406 from 20 grants and contracts.
- Instituted a self-supporting activity on February 1, 1975, named the LARS Computational Facility with $281,494 income for 1975.
- General Fund support from University of $71,269.
- Projection of research funding in 1975-1976 is $2,100,000.

Staff Involvement at LARS in Number of Staff

July 1, 1974 - June 30, 1975

Department	Faculty	Professional	Graduate Students	Undergrad Students	Service	Clerical
Agriculture						
Agronomy	5	6	5		1	
Forestry and Conservation	1	2	2			
Agriculture Economics	1		1			
Horticulture	1		1			
Agricultural Information		1				
Entomology					1	
Engineering						
Experiment Station		23	1	44	9	25
Electrical	5	4	11			
Civil	1		1			
Mechanical	1		1			
Nuclear	1		2			
Science						
Geoscience	5	2	5			
Computer Science			7			
Statistics	1					
HSSE						
Education	1					
Communications		1				
TOTAL	23	38	37	44	11	25

Professorial Staff

July 1, 1974 - June 30, 1975

A. Agriculture

1. M. F. Baumgardner - Professor of Agronomy and LARS Program Leader
2. B. O. Blair - Professor of Agronomy
3. B. L. Dahl - Assistant Professor of Landscape Architecture
4. D. P. Franzmeir - Associate Professor of Agronomy
5. R. M. Hoffer - Professor of Forestry and Conservation and Program Leader
6. W. L. Miller - Associate Professor of Agriculture Economics
7. J. E. Newman - Professor of Agronomy
8. J. B. Peterson - Professor of Agronomy (post retirement appointment) and Associate Director of LARS

B. Engineering

1. R. E. Bailey - Professor of Nuclear Engineering
2. D. P. DeWitt - Associate Professor of Mechanical Engineering
3. D. A. Landgrebe - Professor of Electrical Engineering and Director of LARS
4. J. C. Lindenlaub - Professor of Electrical Engineering and LARS Program Leader
5. C. D. McGillem - Professor of Electrical Engineering
6. E. M. Mikhail - Associate Professor of Civil Engineering
7. F. V. Schultz - Professor of Electrical Engineering
8. L. F. Silva - Associate Professor of Electrical Engineering and LARS Program Leader

C. Science

1. V. L. Anderson - Professor of Statistics
2. G. M. Jurica - Assistant Professor of Geoscience
3. M. Lewellen - Visiting Instructor of Geoscience
4. D. W. Levandowski - Professor of Geoscience
5. W. N. Melhorn - Professor of Geoscience
6. T. R. West - Associate Professor of Geoscience

D. Humanities, Social Science and Education

1. J. D. Russell - Associate Professor of Education

Professional Staff

July 1, 1974 - June 30, 1975

A. Agriculture

1. M. E. Bauer - Research Agronomist in Agronomy and LARS Program Leader
2. T. C. Builta - Technical Editor in Agricultural Information
3. J. E. Cipra - Research Agronomist in Agronomy and LARS Associate Program Leader
4. R. H. Gilbert - Research Agronomist in Agronomy
5. F. E. Goodrick - Data Analyst in Forestry and Conservation
6. S. J. Kristof - Research Agronomist in Agronomy
7. R. P. Mroczynski - Photo-Interpreter in Forestry and Conservation
8. C. F. Walker - Administrative Assistant
9. R. A. Weismiller - Research Agronomist in Agronomy and LARS Associate Program Leader

B. Engineering

1. P. E. Anuta - Research Engineering in Electrical Engineering and LARS Associate Program Leader
2. L. T. Barnes - Editor
3. L. L. Biehl - Project Manager/Engineer
4. T. M. Cary - Research Analyst
5. M. D. Collins - Computer Operations Shift Supervisor
6. B. J. Davis - Statistician/Analyst
7. S. M. Davis - Education and Training Specialist
8. J. B. Etheridge - Applications Programmer
9. D. M. Freeman - Manager of Data Reformatting
10. J. W. Gorsuch - Technical Assistant
11. H. L. Grams - Manager of Computer Operations
12. J. K. Ho - Applications Programmer
13. W. C. Hockema - Computer Operations Supervisor
14. K. J. Philipp - Reformatting Operations Assistant
15. T. L. Phillips - Deputy Director of LARS
16. B. J. Pratt - Administration Assistant
17. P. R. Roberts - Administration Assistant
18. B. F. Robinson - Research Engineer in Electrical Engineering and LARS Associate Program Leader
19. C. R. Sand - Computational Facility Manager
20. S. K. Schwingendorf - Applications Programmer
21. N. H. Shen - Research Programmer
22. W. M. Simmons - Manager of Applications Programming
23. P. W. Spencer - Applications Programmer
24. P. H. Swain - Senior Research Engineer and LARS Program Leader
25. L. L. Wilson - Pictorial Interface Supervisor
26. M. L. Yanner - Research Analyst
27. W. C. Zurney - Reformatting Operations Assistant

C. Science

1. J. A. Henderson - Research Analyst in Geoscience
2. S. G. Luther - Research Analyst in Geoscience

D. Humanities, Social Science and Education

1. D. P. Morrison - Education and Training Coordination

LARS Research Funding

July 1, 1974 to June 30, 1975

Sponsor	Amount
NASA PY	$218,867
Skylab Colorado	94,451
Skylab Wabash Valley	69,010
Department of Transportation	1,172
Computer Science Corporation	3,951
Texas Terminal	42,139
Lockheed	71,249
Indiana State	33,339
Great Lakes	64,616
U. S. Geological Survey	44,932
Forest Service	16,079
Visiting Scientist	7,822
Landsat Colorado	10,209
Wallops	11,405
Goddard	10,143
SRT 75-76	70,837
SRT 74-75	1,317,386
Tennessee Valley Authority	2,746
Public Service Indiana	1,228
Wapora	15,825
TOTAL	$2,107,406

LARS Research Expenditures

July 1, 1974 - June 30, 1975

A. Salaries		
Agriculture	$169,536	
Science	68,153	
Engineering	434,132	
HSSE	18,076	
Salaries Total		$689,897
Overhead		477,789
Fringe Benefits		65,502
Supplies		580,158
Capital		6,088
Computer		852,203
Recharges		610,412
Travel		46,181
Total Research		$2,107,406

Engineering

Research Expenditures

1974-1975

	Engineering Experiment Station	Civil	Electrical	Mechanical	Nuclear	TOTAL
	1280	1284	1285	1288	1290	
Salaries	$295,732	$3,230	$119,930	$7,595	$7.645	$434,132
Overhead	205,295	2,213	82,954	5,203	5,223	300,888
Fringe Benefits	18,672	425	15,180	1,044	406	35,727
Computer	852,203					852,203
Travel	46,181					46,181
Supplies	582,558					582,558
Capital	6,088					6,088
Recharges	(609,849)		(165)		(398)	(610,412)
TOTAL	$1,396,880	$5,868	$217,899	$13,842	$12,876	$1,647,365

H.S.S.E.

Research Expenditures

1974-1975

	Education	Communication	TOTAL
	1355	1366	
Salaries	$5,326	$12,750	$18,076
Overhead	3,648	9,151	12,799
Fringe Benefits	1,061	2,644	3,705
TOTAL	$10,035	$24,545	$34,580

Agriculture

Research Expenditures

1974-1975

	Ag. Inf.	Agronomy	Entomology	Forestry & Conservation	Hort.	TOTAL
	1147	1150	1158	1159	1165	
Salaries	$4,432	$109,771	$2,004	$49,812	$3,517	$169,536
Overhead	3,266	76,381	1,304	34,276	2,409	117,636
Fringe Benefits	781	13,485	(98)	7,934	251	22,353
Supplies	(50)	(922)		(491)	(185)	(1,648)
TOTAL	$8,429	$198,715	$3,210	$91,531	$5,992	$307,877

Science

Research Expenditures

1974-1975

	Geoscience	Computer	Statistics	TOTAL
	1397	1398	1399	
Salaries	$50,151	$17,863	$139	$68,153
Overhead	34,135	12,236	95	46,466
Fringe Benefits	3,705	12		3,717
Supplies	(598)	(154)		(752)
TOTAL	$87,392	$29,958	$234	$117,584

LARS Computational Facility

Self-Supporting Activity

February 1, 1975-June 30, 1975

Income for Services		$281,494
Salaries and Wages	$70,591	
Supplies and Expenses	$176,608	
Capital	$8,708	
Carry Forward	$25,587	
TOTAL EXPENDITURES		$281,494

LARS General Funds

July 1, 1974-June 30, 1975

17-Funds Allocation		$71,269
Salaries	$34,629	
Supplies	28,766	
Travel	331	
Capital	7,570	
TOTAL GENERAL FUND EXPENDITURES		$71,269

Future Funded Projects

Project	FY76	FY77	Duration
SR&T	$1,300,00	130,000	6/75-5/76
PY	206,000		6/75-5/76
Skylab W.V.	6,000		6/75-8/75
Skylab Col.	17,000		6/75-5/76
EDC	14,000		6/75-8/75
LANDSAT Col.	46,000		3/75-2/76
LANDSAT Crops	80,000	26,000	6/75-8/76
Wallops Terminal	4,632		6/75-7/75
Goddard Terminal	17,757		6/75-12/75
ISU Terminal	9,000		6/75-8/75
Missouri	21,000		6/75-10/75
Cities Service	6,000		6/75-10/75
Continuing Education	1,600		6/75-6/75
Visiting Scientist	4,000		6/75-5/76
TOTAL Funding	1,732,989	156,000	
Probable Additional Funding	359,395	1,008,000	
Projected Funding	2,092,384	1,164,000	

Projects in Progress

Project	Prob	FY76	FY77	Duration
SR&T	.7		1,300,000	6/76-5/77
PY	.5		70,000	6/76-5/77
Skylab W.V.	.9	7,000		6/75-8/76
EDC Terminal	.9	60,000		6/75-6/76
ISU Terminal	.3	30,000		8/75-5/76
Wallops Terminal	.3	18,000		8/75-6/76
Cities Service	.8	24,000		6/75-5/76
Monthly Short Course	.8	30,000		6/75-5/76
Skylab Col.	.9	23,661		6/75-9/75
Indiana Land Use	.1	170,000		9/75-8/76
ODU Terminal	.0	30,000		9/75-5/76
Great Lakes	.8	35,000		6/75-8/75
Visiting Scientist	.5	20,000		6/75-5/76
USGS	.2	20,000		6/75-5/76
Int. Dev. Res. Center	.2	37,000		9/75-4/76
OWRR	.1	50,000		6/75-8/78
TVA	.1	8,000		6/75-12/75
Joint Service Elect Proj.	.1	40,000		6/75-5/76
Goddard Imagery Enhancement	.2	30,000		6/75-5/76
Computer Aided Inst	.1	100,000	50,000	9/75-8/76
National Science Foundation				
Lindenlaub	0	125,000	125,000	6/75-5/78
Anuta	.1	60,000	42,000	8/75-8/76
Blair	.2	28,000	71,000	6/75-5/77
Landgrebe	.2	73,000	134,000	6/75-5/77
Silva (Biothermography)	.1	96,000	20,000	1/76-12/76
Silva (Soil Moisture)	.3	8,000		1/76-6/78
UNPP Bangladesh	.3	102,000		7/75-6/76
Ice Pack Mapping (Vol Col)	.4	6,000		6/75-5/76
USAID (Lindenlaub)	.1	16,000	8,000	10/75-9/76
Bolivia (Geo)	.4	42,000		8/75-7/76
Bolivia (Forestry)	.2	42,000		8/75-7/76
Nicaragua	.3	100,000		9/75-8/76
Raw Total		1,430,661	1,840,000	
Probable Additional Funding		359,395	1,008,000	

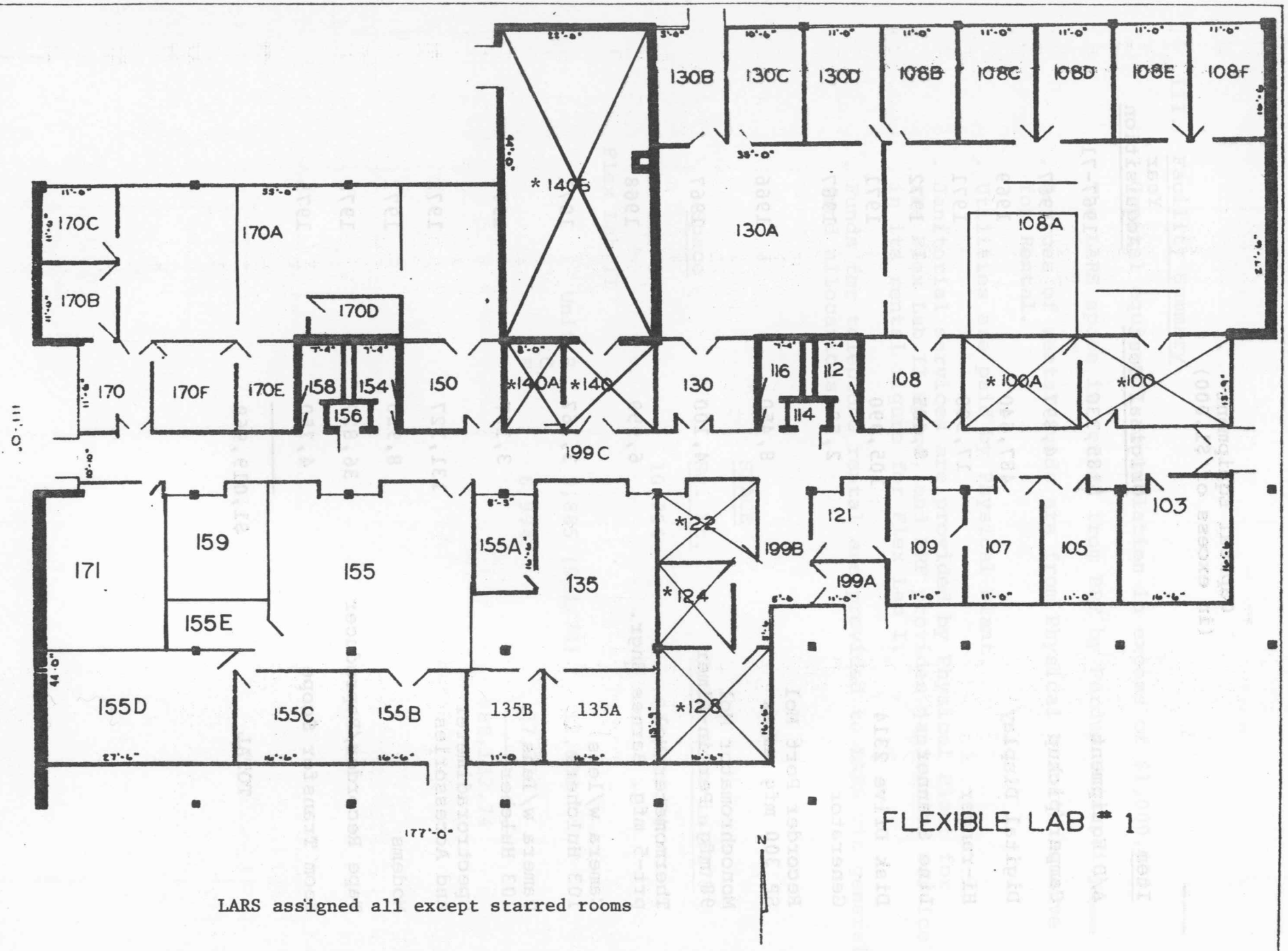
III. Facility Summary

- Capital equipment accumulation in excess of $1,000,000.
- The LARS space is rented from PRF by Purdue University.
- Sources of rental funds are from Physical Plant's Reserve for Rental.
- Utilities are paid by Physical Plant.
- Janitorial services are provided by Physical Plant for the Flex Lab II space, and PRF provides janitorial service in its rental figure for Flex Lab I.
- Funds for telephone rental are provided to LARS via general fund allocations.

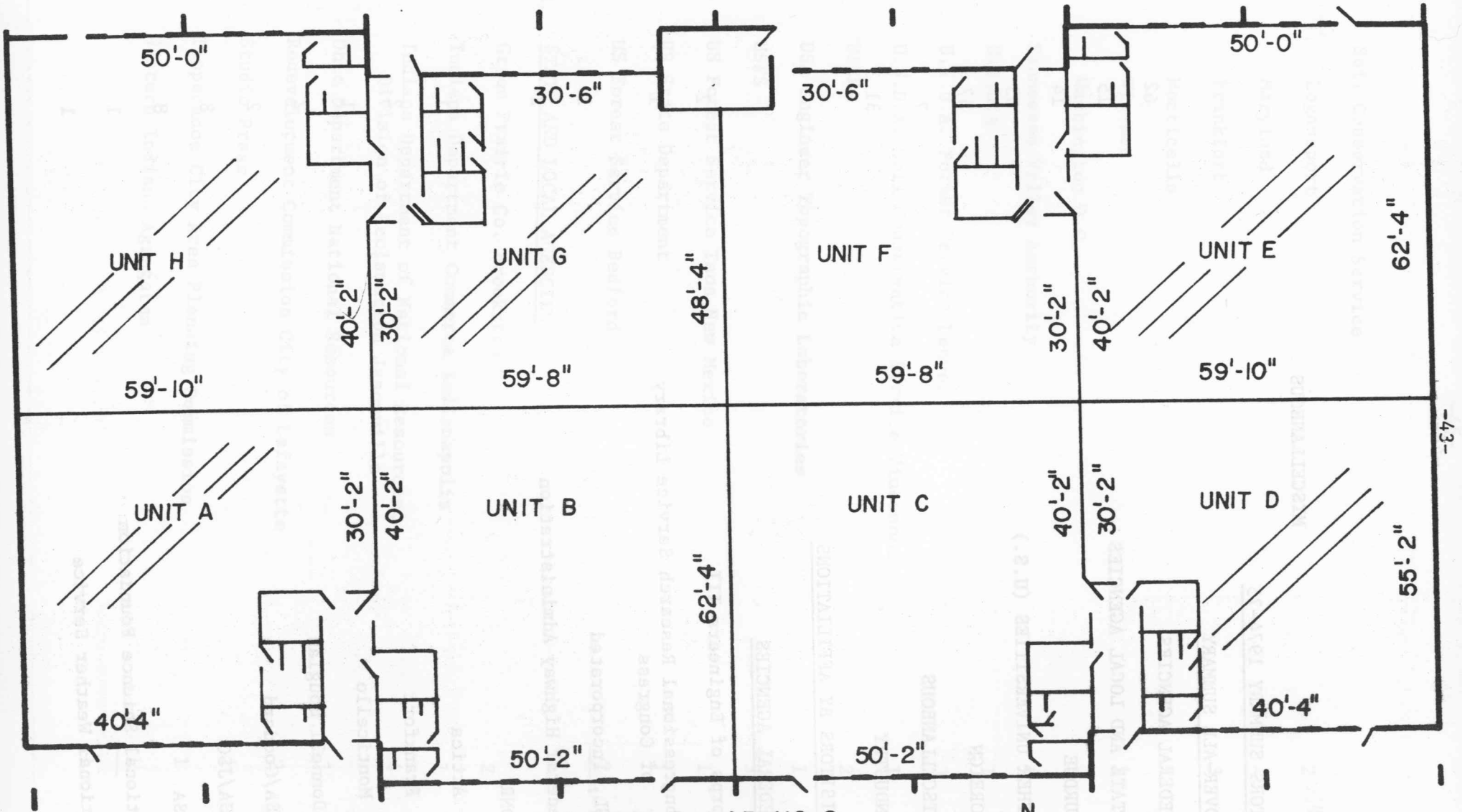
	SPACE	
Space	Sq. Ft.	Total Rent in FY75
Flex Lab I	10,754	$48,226.74
Flex Lab II		
Unit B	3,885 (9/1/74)	12,630
C		
F	6,994	27,276
		$88,132.74

Capital Equipment
(in excess of $1,000)

Item	Original Cost	Year Acquisition
A/D Equipment	$185,336	1967-71
Camper/pickup	4,897	1967
Digital Display	487,640	1969
Hi-ranger	17,500	1971
Line Scanner	8,605	1972
Disk Drive 2314	105,990	1971
Generator	2,534	1967
Recorder Port Mol SP 300 mfg ampex	8,450	1966
Monochromator Mol 98 mfg. Perkin-Elmer	4,100	1967
Thermometer Mol prt-5 mfg. Barnes Engr.	6,959	1968
Camera w/lens 103 Hulchers	3,167	1971
Camera w/lens 103 Hulchers	3,167	1971
Spectroradimeter and Accessories	131,127	1972
Modems	8,920	1971
Tape Recorder/Reproducer	36,827	1972
Zoom Transfer Scope	4,750	1975
TOTAL	$1,019,969	



LARS assigned all except starred rooms



FLEXIBLE LAB NO. 2
UNITS B, C, & F ASSIGNED TO LARS FY75

MISCELLANEOUS

I. VISITORS SUMMARY 1974-75

A. OVER-ALL SUMMARY

FEDERAL AGENCIES	62
STATE AND LOCAL AGENCIES	15
PURDUE	14
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FOREIGN	37
MISCELLANEOUS	7
INDUSTRY	31

B. VISITORS BY AFFILIATIONS

1. FEDERAL AGENCIES

Corps of Engineers III	2
Congressional Research Service Library of Congress	1
ESL, Incorporated	1
Federal Highway Administration	2
IDNR	
Attica	1
Frankfort	2
Monticello	1
McDonnell Douglas	2
NASA/Goddard	2
NASA/JSC	8
NASA	8
National Science Foundation	1
National Weather Service	1

Soil Conservation Service	
Logansport	2
Maryland	1
Frankfort	3
Monticello	3
Winamac	1
Washington D.C.	1
Tennessee Valley Authority	4
U.S.D.A.	1
U.S.D.A. Forest Service Denver	3
U.S.D.A. Soil Conservation Service Vincennes	1
USEPA	2
USA Engineer Topographic Laboratories	1
USFS	3
US Forest Service Taos New Mexico	1
US State Department	1
US Forest Service Bedford	2
	62

2. STATE AND LOCAL AGENCIES

Green Prairie Co. Brookston	2
Indiana Department Commerce Indianapolis	1
Indiana Department of National Resources, Division of Reclamation Jasonville	4
Ohio Department National Resources	3
Redevelopment Commission City of Lafayette	2
Studio Press	1
Tippecanoe City Area Planning Commission	1
Western Indiana Agregates	1
	15

3. PURDUE

Civil Engineering	1
Forestry	1
OCA	1
Pharmacy	1
Student Housing	2
Old Masters Program	4
Miscellaneous	2
Creative Arts	1
Mechanical Engineering	1
	14

4. OTHER UNIVERSITIES

Ball State	2
Colorado State University	6
Memplis State University	1
Notre Dame	10
Ohio State University	1
Texas A&M University	5
University of California	1
University of Illinois	2
University of Minnesota	1
University of Utah	2
Washington State University	1
University of Southern California	1
	33

5. INDUSTRY

Amoco Produces Co.	1
Board of Landscape Architure Accreditation	1
ERIM	3
General Electric	3
General Foods Corp. Technical Center	1
Hendricks	5
Hewlett Pacard	2
Lockheed	3
MEAD Technology	4
Oak Ridge National Loboratory	1
Sandia Laboratories	3
Geer Dubois, New York	1
John McDonald & Crew, New York	3
	31

6. FOREIGN

Africa	
Spectral Africa(pty)	1
Bolivia	
Service Geologico of Bolivia	2
Brazil	1
Canada	
SASK Research Council	1
Steveson and Kellogg	1
CSIRO Minorology	2
Finland	
Technical Research Center	1

Indonesia	
Geological Survey of Indonesia	1
Israel Mi	
Ministry of Ag. Soil Conservation of Drainage Dept.	1
Japan	
National Institute of Aeronautics and Space	2
Nihon University	1
Science and Technology Agency of Japan Government	1
Tokai University	1
Kalul	
Cartographic Institute	1
Korea	
Ministry of Agriculture	3
Lesotho	
Lesotho Government, Agriculture Research Station	1
Libya	
Industrial Research Center	1
Mexico	
National University of Mexico	1
University of Mexico	1
Ruralminas	
Foundaco Rural Meneira "Ruralminas"	1
Sibya	
Ministry of Planning and Scientific Research	1
Thailand	
Ministry of Agriculture of Cooperations	3
Royal Thai Airforce	2

Turkey	
Department of Soil	1
U.K.A.E.A.	1
West Germany	
DRVIR	2
Banco Central De Nicaragua	1
England	
Consulting Civil Engineer	1
	37

7. MISCELLANEOUS

Central Church	2
Geography Division Bureau of the Commission	1
SWCP	1
University Church	1
Exponent	2
	7

II. PUBLICATIONS BY LARS STAFF

062874 Quiel, F. Some Limitations in the Interpretation of Thermal IR Imagery in Geology. Literature data were used to calculate the influence of different parameters on the thermal properties of soils and rocks to determine possibilities for a quantitative interpretation of thermal IR data. Surface temperature variations are mainly determined by meteorological conditions, whereas soil parameters cause only smaller variations. Soil moisture, porosity and cementation are important factors influencing surface temperatures; mineralogy is only important in consolidated rocks with low porosity or high water content, and statements are only possible about the uppermost one or two feet, using diuranl variation. The work described in this report was sponsored by Deutsche Forschungsgemeinschaft, Bonn, West Germany.

082174 Biehl, L. and Silva, L. A Multilevel, Multispectral Data Set Analysis in the Visible and Infrared Wavelength Regions. Proceedings of the IEEE, 63: 164-175, January 1975, Skylab multispectral scanner (MSS) data, digitized Skylab color infrared (IR) photography, digitized Skylab black and white multiband photography, and Earth Resources Technology Satellite (ERTS) MSS data collected within a 24 hour time period over an area in south-central Indiana near Bloomington on June 9 and 10, 1973, were compared in a machine-aided land use analysis of the area. The overall classification performance results, obtained with nine land use classes, were 87 percent correct classification using the "best" 4 channels of the Skylab MS scanner, 80 percent for the channels on the Skylab MS scanner which are spectrally comparable to the ERTS MS scanner, 88 percent for the ERTS MS scanner, 83 percent for the digitized color IR photography. Results indicate the Skylab MS scanner may yield even higher classification accuracies when a noise filtered MS scanner data set becomes available in the near future.

090174 Wu, Chia Lin, David A. Landgrebe and Philip H. Swain. A Decision Tree Approach to Classification. A logical direction for remote sensing data analysis development to move is toward more complex decision logic, since this should make possible better classification accuracy. In this work a layered decision logic is proposed and tested. The results indicate possible improvement in both classification accuracy and computational efficiency.

090274 McGillem, C. D. and Svedlow, M. Image Registration Error Variance as a Measure of Overlay Quality. The variance associated with registering two images is computed by two different methods. Both results indicate that the variance is inversely proportional to the square of the spatial bandwidth of the signals and the signal-to-noise ratio of the images. This work was sponsored by the National Aeronautics and Space Administration under Grant Number NGL-15-005-112.

091274 Hoffer, R., Fleming, M., and Krebs, P. Use of Computer-Aided Analysis Techniques for Cover Type Mapping in Areas of Mountainous Terrain. This paper describes the analysis of ERTS-1 multispectral scanner data obtained over the San Juan Mountains of Southwestern Colorado. After geometrically correcting the data to produce 1:24,000 scale line printer maps, the data were analyzed using the LARSYS (1) computer software system and a newly-developed procedure for defining training samples. Results indicated that deciduous and coniferous forest and other basic cover types could be accurately mapped using CAAT, even in these areas of rugged topography. Only marginal accuracy was achieved when attempting to map individual forest types (species groupings) because of spectral variability due to slope, aspect, elevation, and variations in stand density. When two bands of ERTS data were utilized, rather than all four wavelength bands, the accuracy of the results achieved did not substantially decrease for basic cover type mapping.

091974 Riemer, T. E. and McGillem, C. D. Optimum Constrained Image Restoration Filters. The problem of restoration of images blurred by the sensor scanning aperature is addressed. An optimum constrained oscillations or "ghost" in the connected data characteristic of less complex forms of this type of filter. The filter is applied to ERTS multispectral scanner data and resolution enhancment is observed.

101574 Wilson, L. The Digital Display Photographic Operations Manual. Designed as an introduction to the use of the camera equipment as well as a convenient reference when needed, the Digital Display Photographic Operations Manual is intended for both users and those who wish to become acquainted with the digital display's photographic operations. This manual is a comprehensive guide to using the various cameras associated with the display. It includes a description of the cameras, the photocopy unit, the films used, and processes involved in producing either color or black & white imagery from the digital display. This work was sponsored by NASA under contract number NAS-014016.

103174 Anuta, P. E. Spline Function Approximation Techniques for Image Geometric Distortion Representation. The basic theory of polynomial and polynomial spline function approximation is briefly presented and these concepts are extended to two dimensions.

110474 Lindenlaub, J. and Russell, J. An Introduction to Quantitative Remote Sensing. The booklet discusses the quantitative approach to remote sensing and serves as an introduction to the analysis of remote sensing data. It stresses the application of pattern recognition in numerically oriented remote sensing systems. The purpose is to provide a common background and orientation for users of the LARS computer software system. (Supersedes Information Note 110471, "Remote Sensing Analysis: A Basic Preparation" by John Lindenlaub.)

110574 Lindenlaub, J. C. and Davis, S. M. LARSYS Educational Package: Instructor's Notes. The Instructor's Notes includes a "Survey of the LARSYS Educational Package" along with a flowchart showing the relationship of the seven units in the series. Relevant instructor information for all the units is contained along with copies of the student notes for Units II, III, IV and V.

111774 Follestad, B. Computer Analysis of ERTS-I Imagery and Mapping of Surficial Deposits in a Test Area Within the Monticello North Quadrangle, Indiana. Surficial deposits with and without vegetative canopies have been mapped using automatic data processing techniques developed at LARS on ERTS-I multispectral data. Due to the reflectance patterns in an area covered by vegetation the resulting map suggests details that cannot be obtained by conventional air photointerpretation of color IR (scale 1:120,000) photography. In addition different scales of reproduction of ERTS-I data maps are also discussed. This work was sponsored by the Norwegian Geological Survey and the Royal Norwegian Council for Scientific and Industrial Research. Computer time used in the analysis was provided by NASA, Contract Number NAS914016.

112174 Silva, L. F., Schultz, F. V., Zalusky, J. T. Electrical Methods of Determining Soil Moisture Content. In this report electrical methods of determining soil moisture content are explored. Since the magnetic permeability and electrical conductivity of soils are known to be unreliable indicators of soil moisture content; the report focuses on the electrical permittivity of soils. The first part of the report given as assessment of permittivity as an indicator of soil moisture content, based on experimental studies performed by the authors. The conclusion is that the electrical permittivity of soils is a useful indicator of available soil moisture content.

In the second part of the report, two methods of determining the permittivity profile in soils are examined in light of the findings in Part I of this report. A method due to Becher is found to be inapplicable to this situation. A method of Slichter, however, appears to be feasible. The results of Slichter's method are extended to the proposal of an instrument design that could measure available soil moisture profile (percent available soil moisture as a function of depth) from a surface measurement to an expected resolution of 10 to 20 cm. Extension of the results to the airborne remote sensing problem is considered.

112674 Montgomery, O., and Baumgardner, M. The Effects of the Physical and Chemical Properties of Soils on the Spectral Reflectance of Soils. The objectives of this study are twofold: 1) To evaluate quantitatively the effects of organic matter, free iron oxides, texture, moisture content and cation exchange capacity on the spectral reflectance of soils, and 2) to develop and test techniques for differentiating soil orders by computer analysis of multispectral data. By collecting 71 soil samples of benchmark soils from the different climactic regions within the U.S., and using the extended wavelength field spectroradiometer (Exotech Model 20B) to obtain reflectance values and curves for each sample, average curves were constructed for each soil order (excluding Oxisols and Histosols). Multiple regression analyses were performed, using the spectral data as the dependent variables and physical-chemical properties as independent variables. Results suggest that multispectral analysis may be a valuable tool for delineating and quantifying differences between soils.

022175 McGillem, C. Interpolation of ERTS-I Multispectral Scanner Data. Whenever continuous function such as a scene are represented by discrete samples, problems arise in estimating the original values between the samples. The paper discusses several methods for interpolating data to reproduce a continuous function. The techniques are applies to ERTS MSS data from the Washington D.C. and Gary, Indiana areas.

022575 Anuta, P. and Mobasseri, B. ERTS Multispectral Image Transformations for Geological Lineament Enhancement. In process. Sponsored by NASA under Contract Number NAS-9-14016.

031775 Thie, J., Tarnocai, C., Mills, G., and Kristof, S. A Rapid Resource Inventory for Canada's North by Means of Satellite and Airborne Remote Sensing. There is an urgent need in Canada for northern baseline data for resource policy and planning purposes. To evaluate the impact of airborne and satellite remote sensing for Northern Inventories three areas were studied in boreal, arctic and sub-arctic environments. ERTS satellite imagery was found to be very effective for a rapid mapping of bio-physical units and can provide an excellent basis for integration of water and land-based classifications. An operational system for a rapid, broad brush inventory is proposed for Canada, costing in the order of two to four dollars per square mile.

031875 Tarnocai, C., and Kristof, S. Computer-Aided Classification of Land and Water Bodies Using ERTS Data - Mackenzie Delta Area, N.W.T. Terrestrial and aquatic environments on Richards Island (Mackenzie River Delta) were classified by a computer implemented pattern recognition technique using ERTS data. A clustering sampling procedure applied to a portion of the area divided the data into groups of sample points of similar spectral characteristics. These cluster groups were used as reference or training samples in the classification of each data point on Richards Island into one of 22 spectral classes (14 terrestrial and 8 aquatic). The description of the cluster classes and the evaluation of the classification accuracy were based on data collected at the ground truth sites. The maximum overall classification accuracy was 88 percent.

050575 Cary, T. K., and Lindenlaub, J. C. A Case Study Using LARSYS for Analysis of LANDSAT Data. This material was designed to be a component of the LARSYS Educational Package, teaching new users the sequence of steps comprising an analysis. For each step of the sequence, concepts and theory are presented, and example using LANDSAT data is shown and discussed, and instructions are included directing the student to perform an analysis of another LANDSAT data set.

050975 Kettig, R. L. and Landgrebe, D. A. Computer Classification of Remotely Sensed Multispectral Image Data by Extraction and Classification of Homogeneous Objects. A method of classification of digitized multispectral images is developed and experimentally evaluated on actual earth resources data collected by aircraft and satellite. The method is designed to exploit the characteristic dependence between adjacent states of nature that is neglected by the more conventional simple-symmetric decision rule. The principle reason for doing this is to improve the accuracy of the classification, but it is shown that the speed of the classification can also be increased.

051975 Lindenlaub, J., Davis, S., and Morrison, D. Bringing Remote Sensing Technology to the User Community. This paper discusses the procedures and services available for educating and training potential users of remote sensing technology and describes approaches for achieving an in-house capability for the analysis of remotely sensed data using numerical techniques based on pattern recognition principles. The hierarchy of educational steps includes self-study of the literature, attending conferences and symposia, participating in intensive short courses and in residence program. Remote terminal computer networks and the implementation of analysis software are presented as ways to obtain an in-house capability for numerical analysis. Cost estimates are provided where appropriate.

052175 Svedlow, M., McGillem, C. D., Anuta, P. E. Experimental Examination of Similarity Measures and Preprocessing Methods Used for Image Registration. In press. Three image correlation methods and five enhancement methods are evaluated against LANDSAT data from several sites in the U.S. Conclusions are drawn as to the correlator and enhancement method giving best overall performance.

052275 Chu, N., McGillem, C. D., Anuta, P. E. Analysis of the Effects of Interpolation and Enhancement of LANDSAT-I Data on Classification and Area Estimation Accuracy. In press. Unaltered and enhanced LANDSAT data from Illinois and Indiana were analyzed for classification accuracy and area measurement accuracy improvement.

052375 Landgrebe, D. A. and LARS Staff. A Study of the Utilization of ERTS-I Data from the Wabash River Basin - Final Report. Nine projects were defined for the study; five ERTS data applications experiments and four supporting technology tasks. 1., The Identification and Area Estimation of Crops experiment tested the usefulness of ERTS data for crop survey and produced results indicating that crop statistics could be obtained from ERTS data. 2., Soil Associations Mapping. Results showed that strong relationships exist between ERTS data derived maps and conventional soil maps. 3., Urban Land Use Analysis experiment results indicate potential for accurate gross land use mapping from ERTS data. 4., Water Resources mapping demonstrated the feasibility of mapping water bodies from ERTS data. 5., Earth Surface Features Identification demonstrated feasibility for deriving large area land use data from ERTS. The four supporting technology tasks provided technique development, reformatting and temporal overlay, atmospheric modeling, and scene-processed ERTS data evaluation.

052775 Biehl, L. L. and Silva, L. F. Machine Aided Multispectral Analysis Utilizing SKYLAB Thermal Data for Land Use Mapping. Eight channel SKYLAB multispectral scanner data obtained in January, 1974, was used in a level two land-use analysis of Allen County, Indiana. The data set which includes one visible channel, four near infrared channels, and one far infrared channel was from the X-5 detector array of the S-192 experiment in the Earth Resources Experiment Package on board the SKYLAB space station. The results indicate that a good quality far infrared (thermal) channel is very valuable for land use mapping during the winter months.

052875 Baker, J. R., and Mikhail, E. M. Geometric Analysis and Restitution of Digital Multispectral Scanner Data Arrays. This thesis contains the results of an investigation performed in order to define causes of geometric defects within digital multispectral scanner (MSS) data arrays, to analyze the nature of the resulting geometric errors, and to investigate restitution methods to correct or reduce such geometric errors.

The introduction of geometric transformation relationships for scanned data, from which collinearity equations for MSS may be derived, serves as the basis of parametric methods of analysis and restitution of MSS digital data arrays. The linearization of these collinearity equations is presented, including consideration of the functional assumptions made in order to model the stochastic changes in the exterior orientation of the sensor down the flight line.

A proposed system for the geometric analysis and restitution of MSS digital data arrays is introduced. This procedure is used to test the methods of analysis and restitution, utilizing actual MSS data arrays from two aircraft flights. The results of these tests indicate that the collinearity equations can yield acceptable results when utilized for the analysis and restitution of such arrays.

052975 Davis, S. M. The FOCUS Series 1975: A Collection of Single-Concept Remote Sensing Educational Materials. The FOCUS Series has been developed to present basic remote sensing concepts in a simple, concise way. Issues currently available are collected here so that more people may know of their existance.

061275 Swain, P. H., Wu, C. L., Landgrebe, D. A. and Hauska, H. Layered Classification Techniques for Remote Sensing Applications. Layered classification offers several advantages over the very familiar single-stage approach. The single-stage method of pattern classification utilizes all available features in a single test which assigns the "unknown" to a category according to a specific decision strategy (such as the maximum likelihood strategy). The layered classifier classifies the "unknown" through a sequence of tests, each of which may be dependent on the outcome of previous tests. Although the layered classifier was originally investigated as a means of improving classification accuracy and efficiency, it has become apparent that in the context of remote sensing data analysis, other advantages also accrue due to many of the special characteristics of both the data and the applications pursued. This paper outlines the layered classifier method and discusses several of the diverse applications to which this approach is well suited.

061875 Parson, C. L., Jr., and Jurica, G. M. Correction of Earth Resources Technology Satellite Multi-Spectral Scanner Data for the Effect of the Atmosphere. A physically-based series of computer programs is used to numerically compute the intensity of the scattered upward-traveling radiation at the top of a plane-parallel in homogeneous atmosphere containing specified vertical distributions of ozone and water vapor concentration and aerosol number density. The study indicates that of all the meterorological parameters affecting the propagation of electromagnetic radiation, water vapor concentration is one of the most variable and most important, particularly in the 0.80-1.10 μm MSS band. It is concluded that a spectrally-variable transmission correction is required to optimize classification of features using automatic pattern recognition techniques.

062775 Phillips, T., Grams, H., Lindenlaub, J., Schwingendorf, S., Swain, P., Simmons, W. Remote Terminal Final Report: Purdue University The Laboratory for Applications of Remote Sensing at Purdue University has developed an earth resources data processing system which is being used by both LARS personnel and remote terminal users in part to evaluate the value of the system for training, technology transfer, and data processing. The results of Purdue's participation in this project are documented in this report. The facility has been used at seven separate sites and demonstrated to be a cost effective system for training personnel and technology transfer as well as meeting many data processing needs.

III. TALKS AND PUBLICATIONS

Anuta, P.E., Use of Multispectral Difference Data for Urban Change Detection. Earth Environment and Resources Conference Presentation, Philadelphia, Pennsylvania, September 11, 1974.

Bauer, M.E., Potential of Remote Sensing for Crop Inventories. Talk presented to National Grain Trade Council, annual meeting, Lake Geneva, Wisconsin, September 19, 1974.

Baumgardner, Marion F., Lectures, Seminars and Symposia in Europe on Applications of Remote Sensing.

International Institute for Aerial Survey and Earth Sciences in Enschede, The Netherlands, November, 1974.

First International Congress on Ecology, The Hague, Netherlands, September, 1974.

College of Engineering Leicester University, Leicester, England, October, 1974.

Geography Department University College of Wales, Aberystwyth, Wales, October 1974.

Agronomic Research Station BASF, Linburgerhof, West Germany, December, 1974.

Geography Institute, Heidelburg University, Heidelburg, West Germany, December, 1974.

Ministry of Agriculture Government of Sudan, Khartoum, Sudan, December, 1974.

International Development Research Center, Ottawa, Canada, January, 1975.

Soil Science Institute Friedrich Wilhelms University, Bonn, West Germany, January, 1975.

Institute of Soil Biochemistry Agricultural Experiment Station, Braunschweig, West Germany, February, 1975.

American Embassy, The Hague, February, 1975.

Institute for Plant Nutrition, Technical University, Hannover, West Germany, February, 1975.

Institute of Soil Science and Plant Nutrition, Christian Albrechts University, Kiel, West Germany, February, 1975.

Institute of Applied Geology, Free University of Berlin, West Berlin, Germany, February, 1975.

Faculty of Agriculture University of Novi Sad, Novi Sad, Yugoslavia, April, 1975.

Soil Science Institute, Belgrade University, Belgrade, Yugoslavia, April, 1975.

National Council of Science and Technology Government of Rumania, Bucharest, Rumania, April, 1975 (4 lectures).

Bulgarian Academy of Agriculture, Sofia, Bulgaria, May, 1975 (2 lectures).

National Institute of Agricultural Research, Ministry of Agriculture, Madrid, Spain, June, 1975 (4 lectures).

Ministry of Agriculture, Hashemite Kingdom of Jordan, Amman, Jordan, June, 1975 (3 lectures).

Bartolucci, L., R. Hoffer, and S. Luther, Performance Evaluation of a Layered Classification Technique for Water Resources Applications. Presented at the Purdue Symposium on Machine Processing of Remotely Sensed Data, June 3-5, 1975.

Biehl, L.L. and L.F. Silva, Machine Aided Multispectral Analysis Utilizing Skylab Thermal Data for Land Use Mapping. Symposium, Machine Processing of Remotely Sensed Data. Purdue University, West Lafayette, IN (IEEE Catalog No. 74 CH 1009-0-C). June 1975.

Davis, B.J. and P.H. Swain, An Automated and Repeatable Data Analysis Procedure for Remote Sensing Applications, Proc. Ninth International Symposium on Remote Sensing of the Environment, Ann Arbor, Michigan, April, 1974.

Ellefsen, R., L. Gaydos, P. Swain, J. Wray, New Techniques in Mapping Urban Land Use and Monitoring Change for Selected U.S. Metropolitan Areas: An Experiment Employing Computer-Assisted Analysis of ERTS-1 MSS Data, presented at the Commission VII Symposium, International Society of Photogrammetry, Banff, Alberta, Canada, October, 1974.

Fleming, M., J. Berkebile and R. Hoffer, Computer-Aided Analysis of LANDSAT-1 MSS Data: A Comparison of Three Approaches Including "Modified Clustering" Approach, presented at the Purdue Symposium on Machine Processing of Remotely Sensed Data, June 3-5, 1975.

Gorsuch, J.W., C.F. Walker, and R.A. Weismiller, Computer Analysis of Satellite Data to Produce Row Crop Area Estimates by Bare Soil Classification, in process.

Hauska, H., B. Follested, and D. Levandowski, Computer-Aided Geologic Mapping Using LANDSAT-1 Data, A Feasible Task? Symposium, Machine Processing of Remotely Sensed Data. Purdue University, West Lafayette, IN (IEEE Catalog No. 74 CH 1009-0-C), June, 1975.

Hauska, H. and P.H. Swain, The Decision Tree Classifier: Design and Potential. Proc. Purdue Symposium on Machine Processing of Remotely Sensed Data, June, 1975.

Hoffer, R.M., and L. Bartolucci, Fishing for Catfish from 5000 Feet; or, The Utilization of Calibrated Thermal Infrared Scanner Systems for Studying the Impact of Thermal Effluent from Power Plants on Fish Populations. Invited paper presented at the Fall Convention of the American Society of Photogrammetry, Washington, D.C. September 10-13, 1974.

Hoffer, R.M., M.D. Fleming and P.V. Krebs, Use of Computer-Aided Analysis Techniques for Cover Type Mapping in Areas of Mountainous Terrain. Invited paper presented at the 14th International Congress of Surveyors, Washington, D.C. September 1974. Also LARS Information Note 091274.

Hoffer, R.M., New Horizons in Natural Resource Surveys. Invited paper presented at the 8th Annual Conference of American Technical Education Association, Ann Arbor, Michigan, October 4, 1974.

Hoffer, R.M. and J.B. Peterson, Inventorying of Land Use and Water Resources Invited paper presented for the United Nations Developmental Program. New York, New York, December 11-13, 1974.

Hoffer, R.M., Digital Processing of Remote Sensor Data for Land Use Mapping. Invited paper at the Symposium on the Cartiographic-Remote Sensing Interface in Land Use Data Acquisition and Presentation, State University of New York at Albany, March 15, 1975.

Kettig, R.L. and D.A. Landgrebe, Classification of Multispectral Image Data by Extraction and Classification of Homogeneous Objects. Symposium, Machine Processing of Remotely Sensed Data. Purdue University, West Lafayette, IN (IEEE Catalog No. 74 CH 1009-0-C), June, 1975.

Kristof, S.J. and M.F. Baumgardner, Changes of Multispectral Soils Patterns with Increasing Crop Canopy. From Agronomy Journal Vol 67, May-June 1975, p. 317-321.

Landgrebe, D.A.
System Parameters Fundamental to the Extraction of Earth Resources Information, Invited Seminar Presented to the NASA/HQ Staff, Washington, D.C. July 30, 1974.

Invited testimony before the U. S. Senate Subcommittee on Aeronautical and Space Sciences, August 8, 1974.

"View and Assessing the Earth Surface and Environmental Factors from Space," Environmental Quality Seminar presented September 19, 1974, Purdue University.

Lecture for Short Course, USAID International Course on Remote Sensing, EROS Data Center, Sioux Falls, South Dakota, October 10, 1974.

Presentation to the Indiana Planning Association. Indiana State Office Building, Indianapolis, Indiana, October 15, 1974.

Machine Processing of Remotely Sensed Data, Presentation to the President's Council, Seminar on "World Food Problems and Issues," Purdue University, Stewart Center, November 1, 1974.

Earth Resources Image Data Processing, Presented paper at Institute for Graphic Communication Conference, The Future For Computer Image Analysis, held November, 3-5, 1974, Ipswich, Massachusetts.

Machine Processing of Remotely Sensed Data, Remote Sensing Applied to Energy - Related Problems Symposium, Miami, Florida December 2-4, 1974.

On the transfer of Pattern Recognition Technology to the User Community, IEEE Computer Society Workshop, March 2-5, 1975, Pacific Grove, California.

Image Processing, Coding, and Transmission, Lecture for Short Course, Wintek, Inc., West Lafayette, Indiana, May, 1975.

Organized and chaired Information and Services Session (25 papers) and User's Services Interactive Session (panel) at NASA Earth Resources Survey Symposium, Houston, Texas, June 8-12, 1975.

McGillem, C.D., T.E. Riemer and G. Mobasseri, Resolution Enhancement of ERTS Imagery. Symposium, Machine Processing of Remotely Sensed Data. Purdue University, West Lafayette, IN (IEEE Catalog No. 74 CH 1009-0-C). June 1975.

McGillem, C.C., and M. Svedlow, Image Registration Error Variance As A Measure of Overlay Quality. Symposium, Machine Processing of Remotely Sensed Data, Purdue University, West Lafayette, IN (IEEE Catalog No. 74 CH 1009-0-C), June 1975.

Riemer, T.E., and C.D. McGillem, Ghost Suppression in Image Restoration Filtering. Proceedings of International Conference on Communications, San Francisco, June 16-18, 1975.

Silva, L.F., (with L.L. Biehl), Evaluation of Skylab Data for Land Use Mapping. Advances in the Astronautical Sciences, Vol. 31, 1974. Presented at the 20th Annual Meeting of the American Astronautical Society, Los Angeles, California, August, 1974.

Swain, P.H., 'Automatic" Analysis of Multispectral Remote Sensing Data -- Problems and Prospects. Invited presentation at the Electronic Industries Association Workshop on Near Future Prospects for Image Pattern Recognition, Silver Spring, MD, November, 1974.

Weismiller, R.A. and M.F. Baumgardner, Land Use Inventory of the Great Lakes Basin by Computer Analysis of Satellite Data. 1974 Earth Environment and Resources Conference, September, 1974, Philadelphia, Pa.

Weismiller, R.A., F.E. Goodrick, J.A. Henderson, Jr., and J.W. Gorsuch, Land Use Classification of Satellite Data by Computer Implemented Pattern Recognition Techniques, American Society of Agronomy Meetings, Chicago, IL, November, 1974.