O33078

FOREST RESOURCE INFORMATION SYSTEM

Quarterly Report

for the period

1 January 1978 to 31 March 1978

Prepared for

NATIONAL AERONAUTICS and SPACE ADMINISTRATION

Johnson Space Center
Earth Observations Division
Houston, Texas 77058

Contract: NAS9-15325
Technical Monitor: R.E. Joosten/SF5

Submitted by:

The Laboratory for Applications of Remote Sensing
Purdue University
West Lafayette, Indiana 47906

Principal Investigator: R.P. Mroczynski

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16. Abstract

This report documents activities which occured between 1 January and 31 March 1978. This quarter marks the beginning of the Demonstration phase of FRIS. A significant number of Technology Transfer activities occured in relation to the classification and mapping unit activities. Vendor selection and the benchmark evaluation tasks have also made significant progress. The first FRIS Landsat data was classified.

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FRIS PROJECT SUMMARY

The Forest Resource Information System Project (FRIS) is a cooperative effort between the National Aeronautics and Space Administration (NASA) and St. Regis Paper Co.(STR). Purdue University's Laboratory for Applications of Remote Sensing (LARS), under contract to NASA, will supply technical support to the project.

FRIS is an Application System Verification and Transfer (ASVT) Project funded by NASA. The project is interdisciplinary in nature involving experties from both the public and private sectors. FRIS also represents the first ASVT to involve a large broad base forest industry (STR) in a cooperative with the government and the academic communities.

Purpose

The goal of FRIS is to demonstrate the feasibility of using computer-aided analysis of Landsat Multispectral Scanner Data to broaden and improve the existing STR Forest data base. The successful demonstration of this technology during the first half of the project will lead to the establishment by STR of an independently controled operational forest resource information system in which Landsat data is expected to make a significant contribution. FRIS can be viewed by the user community as a model of NASA's involvement in practical application and effective use of space technology.

Additionally, FRIS will serve to demonstrate the capability of Landsat MSS data and machine-assisted analysis technology to private industry by:

- Determining economic potentials,
- Providing visibility and documentation, and
- The ability to provide timely information and thus serve management needs,

The ultimate long term successfullness of FRIS be measured through future development of remote sensing technology within the forest products industry.

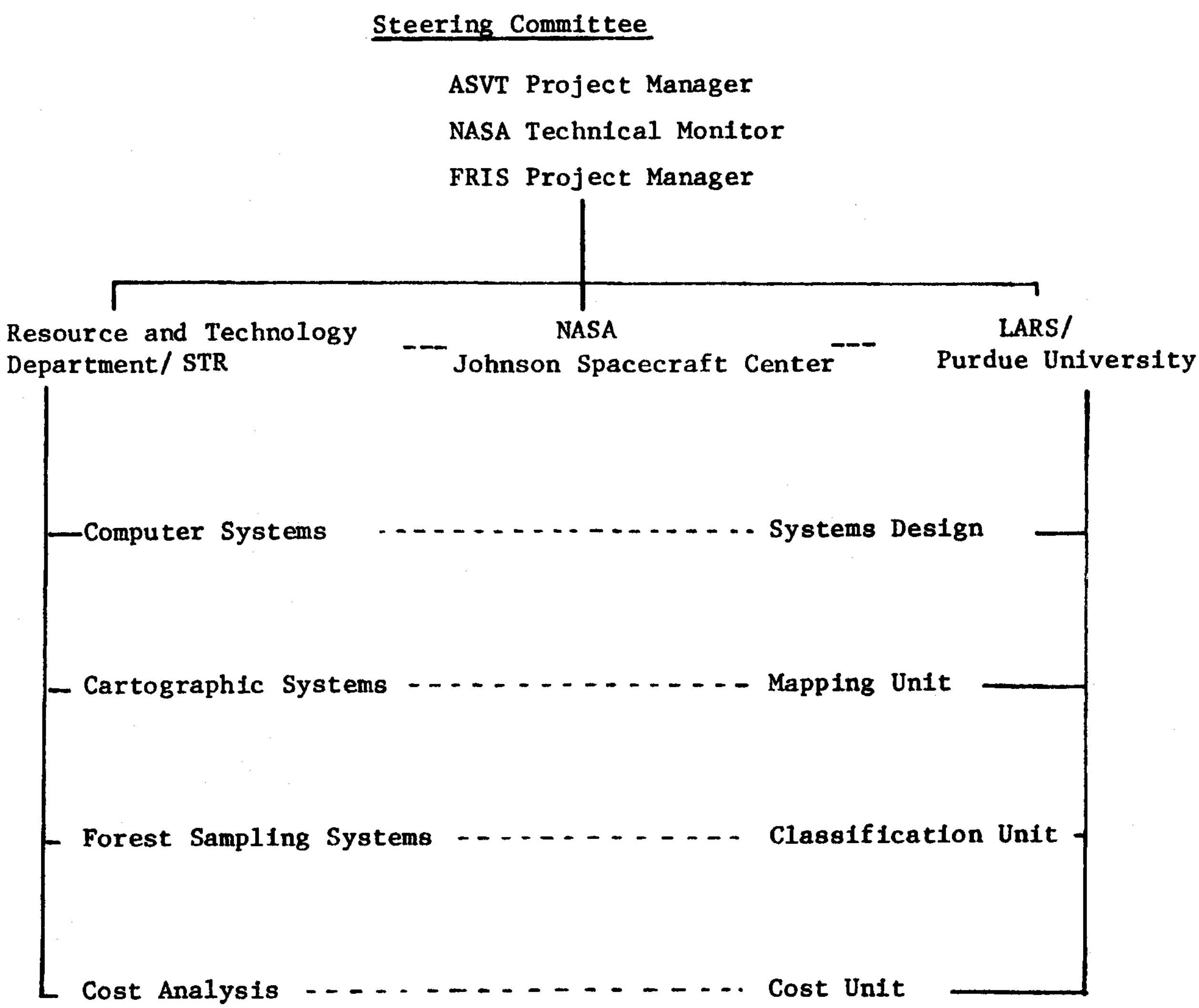
Scope

FRIS is funded as a modular or phasedproject with an anticipated duration of three years. The original project concepts were developed in 1973, and a formal project plan was submitted to NASA by STR in 1976. The project offically began in October 1977 after the signing of a cooperative agreement between NASA and STR; and after the completion of contractual arrangements with Purdue University.

Organization

The organization of FRIS is depicted in the chart that follows. Since FRIS is a cooperative involving three independent agencies, a steering committee consisting of a project manager from each institution was formed to provide for overall guidance and coordination. Operationally, both STR and LARS have project managers and project staff to insure for the timely completion of activities within the project. The NASA technical coordinator monitors project activities and provides a liasion between the STR and LARS staffs. The solid lines on the chart indicate the flow of management responsibility. The dash lines reflect the technical and scientific interchanges between operating units.

FRIS Organization



1.0 Introduction

The materials presented in the report, document activities from the second FRIS project quarter. This quarter, from 1 January to 31 March 1978, marks the beginning of Phase II or the FRIS Demonstration. The working objective for this Phase of the Project is:

> To provide St. Regis Paper Company, through a demonstration of computer-aided Landsat analysis, information concerning the economic feasibility and practical applicability of remote sensing technology for forest inventory.

Activities during this Phase will occur under one of five Working Units. These are:

1. Classifications and Evaluation
2. Mapping and Digitizing
3. System Design
4. Cost Evaluations
5. Management

A significant level of effort was extended by all Work Units during this quarter toward the Phase objective. Especially noteworthy activities were:

- A specifically taylored remote sensing training session was given to STR staff.
- The first FRIS test area data was classified by STR staff.
- Significant modifications were made to improve LARS digitizing capabilities. These changes occured through joint efforts by both STR and LARS project staffs.

Detailed discussions of these and other project activities which occured during this quarter appear in the sections which follow.

2.1 Classification and Evaluation

2.1.1 Classifications

Four test areas, figure 1, will be classified and evaluated as part of the FRIS Demonstration. The four areas are identified as follows:

Test Area 1	Southeastern Georgia
Test Area 2	Southeastern Mississippi
Test Area 3	West Central Georgia
Test Area 4	Western Florida

The most intensive classification work, including tests of different classifiers, will occur on Test Area 1 (TA-1). TA-1 has been identified as the Prime Test Site, and will include various data base information channels and an anniversary Landsat data set. For these reasons and because a complete set of reference data was available (OA maps, Inventory Updates and air photos) TA-1 was selected for preliminary analysis.

The TA-1 analysis was designed to fulfill two purposes:

1) Outline the classification approach; help define expected spectral/information class groups; and
2) Provide hands-on training for STR staff.

Ultimately, the approach which would be followed throughout the demonstration would be defined by STR during this classification session. LARS staff provided technical support and training during this process.

Figure 2 is a color infrared composit from Landsat Scene Id: 2816-15042. This block of data contained the area selected by STR staff for classification.

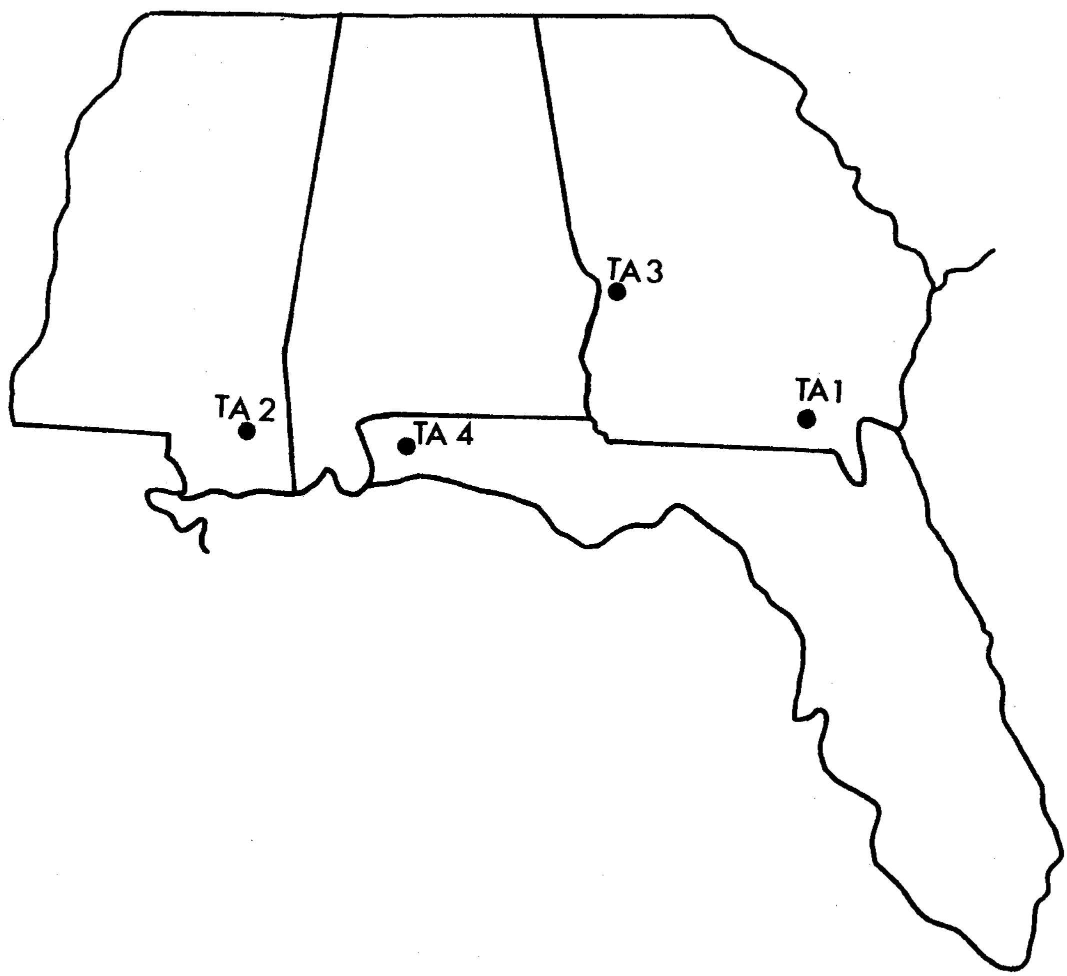


Figure 1. Approximate location of the four FRIS Test Areas.

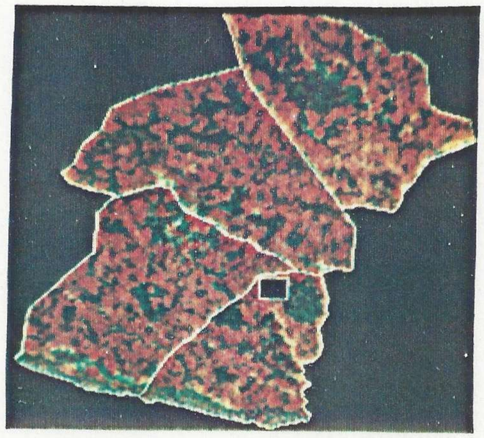


Figure 2. Example of Spring Landsat data in a four AU training set.

Various cover types, including:

Planted and Seeded Slash Pine.

Slash-Cypress.

Sweet bay, blackgum, Maple.

Non-stocked and regeneration areas.

occur in the data. An area of 500 lines and 700 columns was selected for classification and cursory evaluation. A small area was used since our primary intentions were for procedures development and training. A multi-cluster block training approach, figure 3 (from Fleming & Hoffer) was used to develop the classifications.

From the test area six blocks of data were selected to be clustered individually. Each block contained about 3000 data points. The blocks were positioned within the area to insure that all cover types present would be included in at least one block in sufficient numbers to define the cover type adequately. For the purpose of defining a statistical training set, a class must have a minimum of 40 data points.

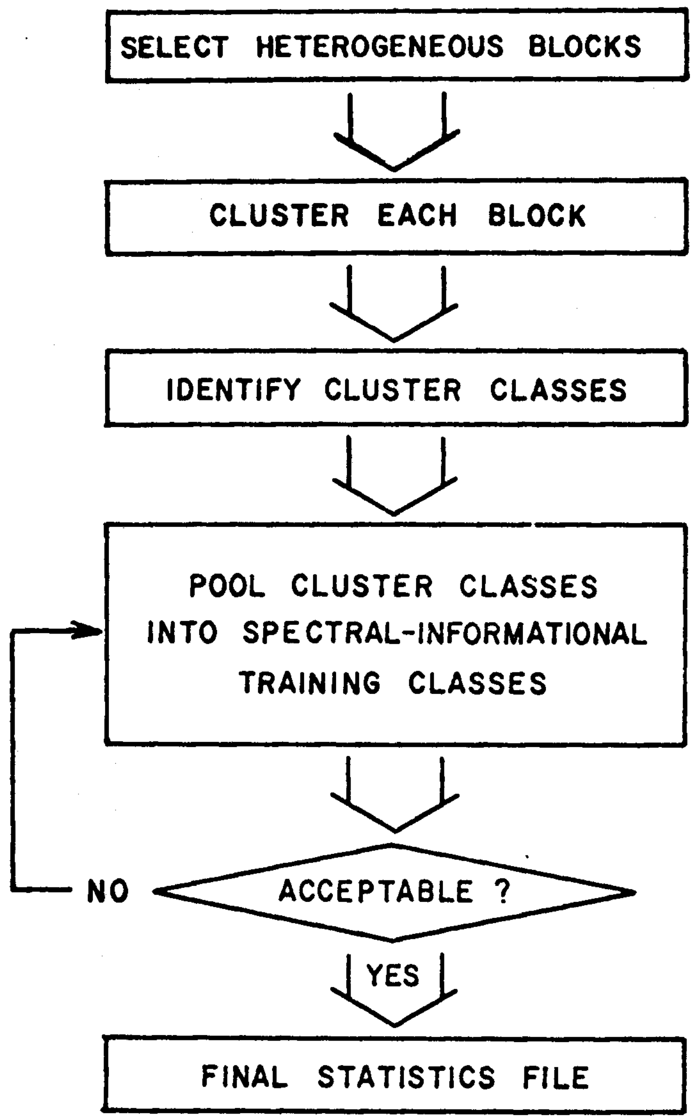


Figure 3. Flowchart of multi-cluster blocks analysis sequence (from Fleming and Hoffer).

Classes defined by the clustering program are identified as to information structure by the analyst. The analyst compares the cluster map output from each block with the type maps and color infrared air photo of that area. Any classes that cannot be related to known cover types are deleted. Usually these unidentified classes are mixed data points, i.e.; combinations of information classes. These mixed pixels often represent transitions between cover types.

After the classes within each of the clustered blocks of data have been labeled, the statistics are combined with those from one or two other blocks to form a new set of training classes.

Since many cover types will occur in several blocks, the classes are tested to find those which are statistically similar and can be pooled. This process reduces the total number of classes and at the same time identifies spectrally different subclasses within information classes, i.e.; cover types.

This procedure was repeated until only one set of training statistics remains. This set was used to classify the entire test site. At this point various output products, such as the example in figure 4 can be produced.

The classification approach will be documented and utilized for classifying all FRIS data.

2.1.2 Benchmark Evaluations

The greatest advantage of the information derived from Landsat lies in its synoptic coverage. Information on the entire holdings of the Southern Timberlands Division can be obtained on a "snapshot" basis. That is, the data is collected in a very short period of time and can give a complete

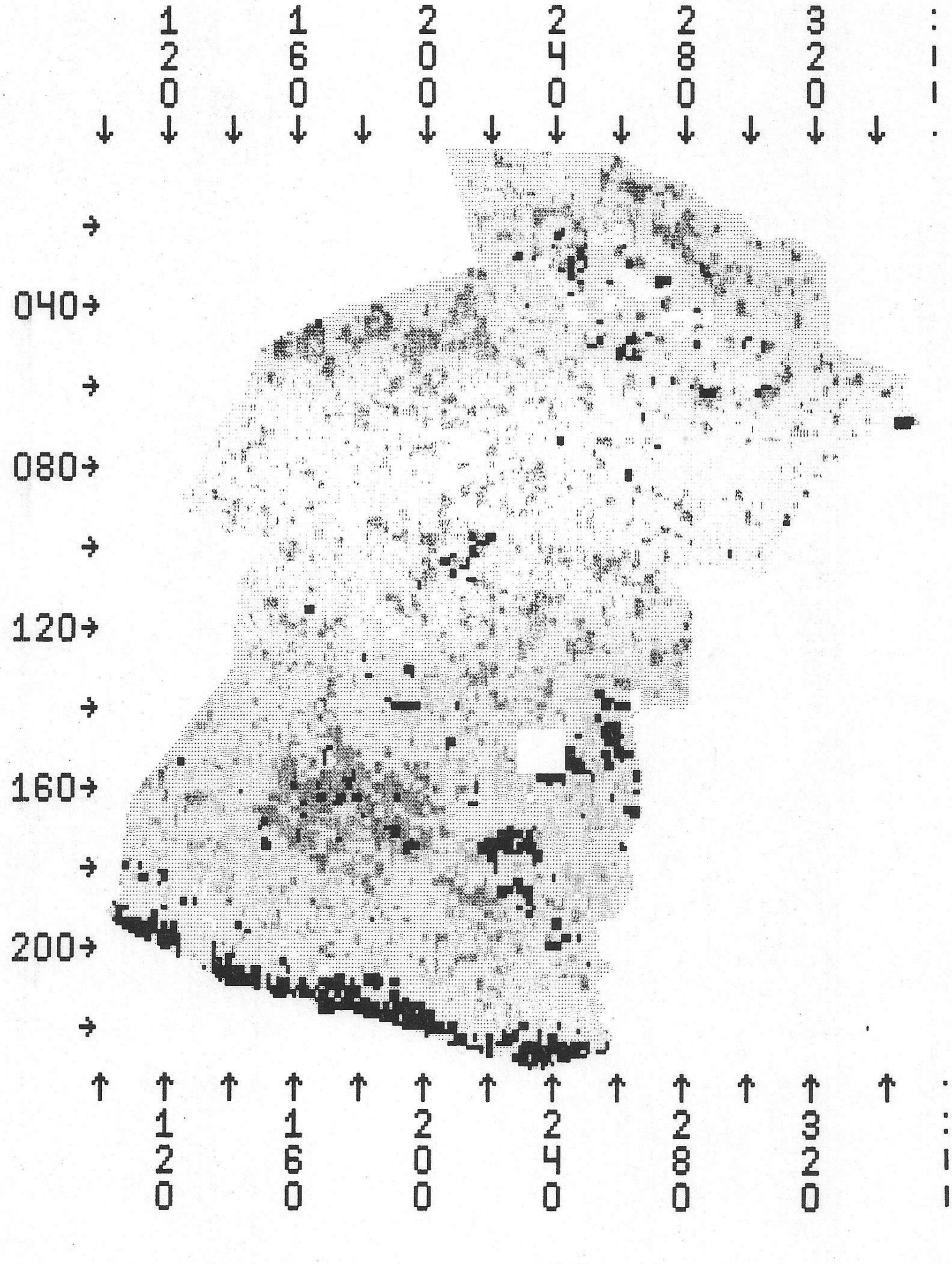


Figure 4. Classification map of a four AU test area produced on a Varian electrostatic printer/plotter. The darkest areas represents hardwoods. The lighter areas represent various spectral classes of pines.

view of the Division's resource position at a given point in time. In addition, these "snapshots" are available every 18 days, and so have the potential to provide on-going monitoring of the Division's status.

This type of information, Division-wide, essentially at the same time, is not available at all in the current St. Regis inventory system. This new additional kind of information has great potential for improving the quality, timeliness, completeness of the information produced by the inventory system while reducing some of the costs involved. These improvements must be evaluated in light of the incremental benefit they bring to users of the forest resource inventory system.

Since Landsat will provide a type of data not previously available in the inventory system, the standard it must be measured against is not just the quality of information currently in the system. The quality of information derived from Landsat must be established, and then the additional benefit of the data assessed. The first can be done quantitatively, but the second will involve some judgment on the part of the users of the inventory system as to their potential use of the increased and repetitive coverage of Landsat.

The specific contributions which Landsat data can make, and which must be evaluated are to:

- acreage verification
- monitoring of change on STD holdings
- improvement of sampling schemes involving aerial photography and ground observations, and
- development of a computer aided, geographically referenced information base which can cost effectively supply the information required by all users of the inventory system.

The purpose of this sub-unit activity is the definition and evaluation of benchmarks for the above contributions.

2.1.2.1 Landsat Data Quality Measurements:

The evaluations of the information derived from Landsat must begin with a discussion of the properties required by the inventory system. These properties involve:

- the cartographic integrity of the Landsat data,
- the accuracy of the classification derived from the Landsat data, and
- the accuracy and precision of estimates derived from that information.

Cartographic Integrity

The property considered here relates to the precision with which information in the data base can be related to a point on the ground. The Landsat data, as it is received from the satellite, is both skewed and rotated away from north. To enter it into the data base and use it with the currently available information, it must be deskewed, rotated, geometrically corrected, and rescaled to match the existing maps and inventories. In this process, some questions arise regarding how close the spectral measurement was made to the point it represents on a map. A measurement of this closeness is made during the process of registration through the use of checkpoints. These are points whose locations in the Landsat data (X_i,Y_i) and the ground (U_i,V_i) are known. The average root mean square error (RMS) or

$$\overline{RMSE} = \frac{1}{K} \sum_{i=1}^{k} [(X_i-U_i)^2 + (U_i - V_i)^2]^{\frac{1}{2}}$$

is calculated for these points and gives an overall measurement of the quality of the registration for that data set. The registration may be improved by the use of additional checkpoints, but the quality of Landsat data, in terms of noise and bad data lines, can limit the quality of the registration.

In this project, an average RMS error of less than one half pixel will be attained for the Landsat registration (McGillem and Svedlow). This will insure that, on the average, the position in the data base of any Landsat data element will not be more than 40 meters from the place on the ground it was taken from.

Classification Accuracy

After the Landsat data is analyzed, and each data element is placed into a class, the accuracy with which the classification was done must be assessed. Essentially test points whose true class is known are examined, and the agreement between the true class and the classification labels is measured. That is we examine $e_{ij} = n_{ij}/n_j \quad i,j = 1\ldots,k$

where k = number of classes,

n_{ij} = number of test points from class j which have been classified into class i,

and n_j = number of test points in class j. This estimates Pr $(X \epsilon \hat{w}_i | X \epsilon w_j)$, the probability that X is classified into class i given that X is in class j. The matrix $\{e_{ij}\}$ is called the classification error matrix. Two measures of the accuracy of the classification for all classes are commonly used; the overall classification accuracy, PCC_0,

$$PCC_0 = \sum_{i=1}^{k} n_{ij} / \sum_{i=1}^{k} n_i$$

and the average classification accuracy, PCC_A,

$$PCC_A = \sum_{i=1}^{k} e_{ii}/k$$

These measures are not necessarily, of themselves, good measures of classification accuracy. Care must be taken in several areas to insure a proper evaluation. Generally, the set of test points which forms the basis for these measurements must be randomly selected, representative of the entire area classified, and large enough to provide a good estimate. The data points in the test sample must be locatable in both the ground observations and in the spectral data, so that the class to which a test point belongs is truly known.

Since the identity of the test pixels must be known, the test sample is restricted to those areas where a class can be assigned to the test pixel. This leads to three possible bases for the evaluation of classification accuracy over the STD holdings, the Permanent Growth Samples, the Operating Area Inventory, and the Annual Inventory Updating.

The Permanent Growth Sample (PGS) plots are a systematic sample over the entire St. Regis ownership, comprised of 3000 one-fifth acre plots. Each plot's location on the ground is well established and the species composition is known. The same plots and trees have been remeasured every five years, giving long term volumetric information on each plot.

These advantages are matched by some limitations. A plot of one-fifth acre cannot be seen in the Landsat-1-2, or -3 data as the resolution of the scanner is approximately one acre. Thus the PGS plots must be assumed to represent a large area surrounding them or aerial photography must be examined to enlarge the plots to a size as large or larger than a Landsat resolution element.

Another limitation is the number of plots. With only 3000 plots spread over 1.7 million acres, the estimate of accuracy over the entire area will have relatively large variability. Estimates of accuracy over portions of the St. Regis ownership will have even larger variability. The PGS plots could be used as a "first cut" estimate of the classification accuracy, but cannot be considered the only measure.

The temporary plots used for the Operating Area Inventory (OAI) have only one advantage; more samples are taken than in the Permanent Growth Sample. The plots are not relocatable; so their ground location is not well established. The OAI is comprised of variable radius plots, so the sizes of the plots are not really known. This causes additional problems when attempting to obtain plots which are larger than a Landsat resolution element. The temporary plots of the OAI do not appear to be suitable for a reference standard at this time.

The Annual Inventory Updating specifies the changes made in the operating area boundaries over all St. Regis Land in the past year. In this sense it is the most current information available over all the St. Regis holdings. Since the entire area is covered, a very large sample can be taken. It will be convenient to use when digitized boundaries are available.

Two major limitations exist with this basis for evaluation. In order to use the Operating Area boundaries an assumption must be made to evaluate accuracy that all pixels in an OA are the same category for classification purposes. This may not be acceptable in all cases. Second, the OA's vary in size, and some with very small area, such as ponds, may not appear in the test sample.

Area Estimation Procedures

The first estimates to be derived from the Landsat data will be estimates of the acreage in each of the covertypes of interest in all the holdings of the Southern Timberlands Division. In addition to the value of the overall estimate, this information will provide a check on the acreages given in the Annual Inventory Updating. After the area estimates have been made, it may be possible to also make volumetric estimates. The details for this have not been worked out.

Three procedures for area estimation have been developed. Two are based on the Operating Area boundaries, and one on the Permanent Growth Samples.

The first procedure based on the operating area boundaries is very simple. First, the number of pixels inside an operating area classified into each class are tabulated. This value will be converted to acreages by multiplying by the ratio of the total acreage in the OA to the total number of pixels tabulated. This is an easy method to use and can give data on all information classes in an operating area, administrative unit, or ownership. There are two limitations to this procedure: the estimate is biased due to classification error, and an assumption must be made that classes occur on the edges in the same proportion as in the center of an operating area, administrative unit, or other management area.

The second procedure eliminates these problems, but introduces its own disadvantages. The second procedure, known as a "stratified areal estimate", begins by taking a random sample of test pixels through the classified area and identified them from the operating area of each lies in. A set of weights α_{ij}, the proportion of test points that area from information class i classified in class j. The estimate of the proportion of the total area in class i is:

$$p_i = \frac{1}{N} \sum_{j=1}^{k} \alpha_{ij} N_j$$

where N_j is the number of pixels classified in class j and N is the total number of points classified. The estimate is unbiased if there is a large number of test samples and no error in the identification in the test samples. The disadvantages are not major; first, at least one test point in every class is needed. Second, to obtain optimum sampling properties, it must be assumed that the test samples are allocated proportional to the class' occurance in the scene.

A third procedure for area estimation is based on the Permanent Growth Sample plots. The PGS form a random sample over the entire Southern Timberland Division holdings. The "stratified areal estimate" procedure can be applied to this sample. The sample has already been taken and the species composition of each plot is known for each plot. There are relatively few plots so there may be some problems in estimation since a class may be missed in the random sample. A future possibility for this procedure is the estimation of volumetric data by a related procedure.

2.2 Mapping and Digitizing Unit

2.2.1 Pilot Digitization Area

The mapping units activities are directed toward the preparation of a geographic data base for Test Area 1. Additionally, there is a sub-objective to digitize a pilor are (four AU's and accompanying OA's) as a barometer against which to access outside vendor capabilities. The pilot area figure 5, is fairly complex and representative of available source documents for the test area. In addition to digitizing this map, considerable time and effort was expended during this period in modifying existing digitizing software.

Historically, digitizing was accomplished with mechanical digitizing tables. These devices are heavily oriented toward human effort and by their nature have very low throughput. The new generation of electronic digitizing tables provide greater throughput with a minimum of human effort. Storage of the point data may be either on cards or on a computer disk file. Future systems may be with virtually no human interaction until after the digitizing and recording of that information has taken place.

For digitizing the FRIS data base a hybrid approach will be utilized. The hybrid conceptually combines a semi-automated menu to define the boundary characteristics of numerous arch and arch segments which together compose the AU and OA boundaries. As a result use is being made of the organization found in digitizing archs and segments combined with the extensive and much more advanced menu from the semi-automated area menu concept. The combination of these methods means that the digitizing could progress quickly because human input of ancillary data through a typewriter terminal is minimized thereby maximizing line digitization rates. These advances to the digitizing effort are noteable because they are the result of a joint STR/LARS effort which is aimed at improving the user-oriented capabilities required by the digitizing task.

Some modifications that have been implemented to contribute to a more user oriented system environment consist of the menus and their location

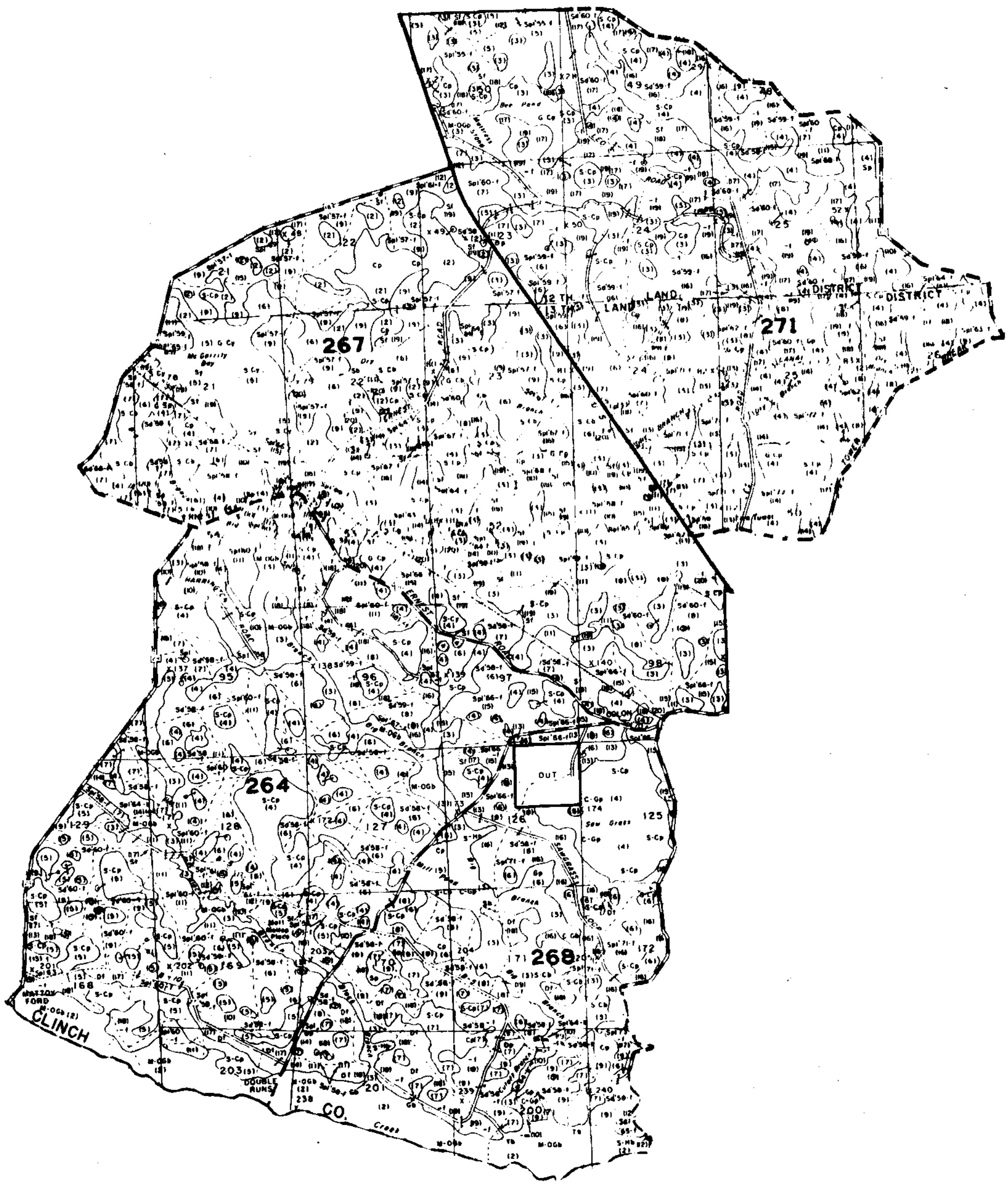


Figure 5. Example of the level of detail necessary to digitize.

to the source document. Similiarity a new CRT location has been chosen closer to the digitizer. This allows the person to minotor his progress, as a result he does not have to stop his work in order to determine the status of the digitizing in regards to the mini-computer. Another modification being considered would allow the CRT and typewriter terminal to display information at the same time.

A new menu includes a complete command structure as well as the number identification structure. As a result, the initialization of the various types of digitizing can be done more effectively and again cause less interruptions during digitizing. Software modifications are being contemplated to allow for correction or redoing an arch or arch segment.

One suggestion that has great possiblity is the ability to bring points on-line at a faster rate. Currently the complexity of the data is such that a number of points being generated and the level of the threshold generating points is very low numerically. As a result the number of points being generated is very high for the computer to absorb in a given period of time. However, for a given length of arc the number of points is very small, on the order of five per second or one-tenth of an inch per second. Obviously in one second a human will overshoot the maximum distance and lose points. The addition of a hardware floating point unit to the system will help improve the mini-computer response to the digitizer and therefore improve point flow and speed. Other hardware additions are contemplated that would allow a boundary replot to occur shortly after the digitizing session. The memory addition will allow larger buffers and larger programs to be written for processing the data at the mini-computer level before it has to go on to the main frame for more extensive processing.

2.2.2 Vendor Selection

An important aspect of this demonstration phase of FRIS is the development and manipulation of an ancillary data set with the Landsat classifications. LARS has developed the capability and has experience in manipulating milti-channeled data bases with Landsat data. There are a number of data base systems available commercially that may adequately achieve desireable results. To assess these commercial capabilities and compare costs to our current system, a task to identify and define vendor capabilities was initiated.

Consideration of the requirements for vendor evaluation led to the decision to require gridding and reformatting to some standard (preferably LARSYS) format. This requirement would result in evaluation of the maximum capability available in the industry and would establish a benchmark maximum capability against which to evaluate vendors. Steps to be requested of vendors are then:

1. A standard duplicate copy of an administrative unit base map containing four AU's will be sent to vendors. The AU areas will be clearly marked on the map and the operating area (OA) boundaries within the AU's will be made as clear as possible.

2. A requirements document will accompany the map and contain at least the following:

    1. General requirements definition which is to convert the boundaries of all AU's and OA's to digital form recorded on magnetic tape. The specific requirements:

    A. Boundaries of the four Administrative Units are to be traced by a digitizing device and the coordinates of points along the boundaries recorded. The accuracy of the recorded points must be such that the location error be less than the mapping accuracy of the map product. This is nominally 1/50 inch. The maps have a scale of 1:15480 thus the ground tolerance is on the order of 26 feet.

B. The boundaries of the Operating Areas (there are about 20 in each AU) will be traced and digitized as in (A.). The interiors of each area identified by number codes and these codes must be recorded and identified with the associated boundary data.

C. A digital gridding procedure will then be employed to produce two digital image data sets. One will represent the AU's and the other the OA's. All grid cell points within a particular polygon (whether it be AU or OA) will contain the number defining that area. The data set will be coded in eight bit binary words (called a byte) and recorded in a line by line format, one tape record per line. The LARSYS 3.1 format is preferred (document attached).

D. Control points are to be digitized and recorded as separately identified records. Control points can be map corners, road interactions and other features accurately identifiable by latitude-longitude coordinates or on aerial/space imagery. At least four control points must be identified.

2. A blank magnetic computer tape will be provided to store the digitized map data.

Vendor selection will follow response to the distribution of a request for quotation by the Purdue Purchasing Department.

2.3 Systems Design

The ultimate goal of this task is to help STR define a remote sensing system capable of addressing STR resource information needs. Initial activities have been in the areas of:

1) Information requirements definition, and

2) Preliminary remote terminal design considerations.

The information requirements task is in the formative stages and will be supported in more detail during the next quarterly period. Preliminary steps were taken during this quarter to identify a possible remote terminal facility for STD. The following identifies the usual remote terminal installation, and therefore valuable background information for tayloring a specific installation for STD.

Typically, the remote terminal user at LARS initially accesses the earth resources data processing system on the Purdue/LARS IBM 370/148 computer via a typewriter terminal. This can be either a teleprinter terminal or a CRT display terminal. The output of this processing is printed on a line printer, punched on cards, and/or stored on a disk file or tape. Batch terminals with card readers, printers and card punches are available for lease or purchase, and most remote terminals to LARS have one of the DAT 100 batch terminals; a few have IBM 2780 terminals. In addition, users may need access to a keypunch, although online editting of control input at the terminal is available. Higher quality maps and graphs can be obtained from such devices as printer/plotters; LARS has a Varian electrostatis printer/plotter for such output. For applications involving the overlaying of various boundaries on the data, a digitizer would be most helpful at LARS. This capability is interfaced with a PDP 11/34 minicomputer. To connect these devices to the mainframe, modems and telephone lines are required.

In the following sections, some of the devices which LARS has used, and costs estimates are discussed. Space requirements and diagrams are included for two levels of a remote terminal configuration. As the system requirements and constraints for FRIS are identified, a remote terminal installation will be recommended and planned.

2.3.1 Equipment Considerations

A. Typewriter terminals

Typewriter terminals provide on-line access to the Purdue/LARS computing faciltiy. The user can enter commands to verify the status of files, create input control files, specify printer and punch output destinations, and begin execution of desired programs. Printer output can be directed to these terminals, but since they generally operate at 30 characters per second, any sizeable ouptut could easily take several hours to print. LARS can support a variety of terminals at different speeds and with different character codes. The following terminals have been or will be used at LARS. The first two have CRT screens and the last three print user inputs and computer outputs on papers.

Lear-Siegler ADM3A (CRT)	$895 purchase
Infoton's VISTAR/GTX (CRT)	$990 purchase
DECwriter II (LA-36)	$1695 purchase
Texas Instruments Silent 700, Model 745	$1995 purchase

- This terminal comes with an acoustic coupler for dial-up access to the computer

Intertec Superterm $2245 purchase

- This terminal has user programmable characters and can be set to print 8 lines, which is good for getting map-like outputs on the terminal.

DATA 100/IBM 2780 Batch Terminals

DATA 100 Batch Terminals are located at the most of the current Purdue/LARS remote terminal sites. They are configured to emulate an IBM 2780, and have card reading units, printers and card punches, which can be ordered to operate at a variety of speeds. If disk and tape files can be used for output, the card punch is not necessary; we have one remote site which is operating without a card punch. Current prices on the DATA 100 terminals are as follows:

DATA 100 Model 76-104f			
300 line per minute printer		$175/month	
Card reader			
300 cards per minute		$174/month	
Card Punch		$402/month	
Statis Eliminator		$ 15/month	
	TOTAL	$904/month	without punch
		$1306/month	with punch

IBM 029 Keypunch

A keypunch is required if input control files or data are to be entered via the card reader. Many companies already have these available from other applications. These can be leased for about $81 per month from IBM.

Modems

A modem is required at each location to interface between the digital signal from the terminal equipment or computer and the analog signals of the telephone line. If more than one terminal is being operated over the same phone line, the modems also combine the signals from the phone line into the two or more signals at the other end of the line. There are a number of modem manufacturers; the ones we have used at most are the Codex modems. The speed and options selected for the modem depend on the speed and number of terminals connected to the modem. The DATA 100 terminal is operated at 4800 bps for most of our remote locations and the Codes LSI 4800 data modem can support the DATA 100 at 4800 bps and also two typewriter terminals at up to 15 characters per second. The codes LSI 7200 modem can support the DATA 100 and up to 8 typewriter terminals at 30 characters per second. Many other combinations are possible. One year lease prices are quoted below:

2 Codex LSI 4800 Data modems with Dual Secondary Channels	$340/month
2 Codex LSI 7200 data modems with 4-channel data Multiplexer	$420/month
2 Codex LSI 9600 data modems with 4-channel Data Multiplexer	$490/month

Phone Lines

Phone lines are used to carry the user commands and data to the computer, and output from the computer to the user over long distances. Several levels of conditioning are available depending on the speed and quality of signal required. C2 conditioning is often needed, so we obtained an estimate for a 4-wire AT&T type 3002 line with C2 conditioning, which was quoted at $1465/month.

Digitizer

Purdue/LARS has interfaced a Talos Systems Model 660B digitizer (44 x 60 inch active area) with its PDP 11/34 minicomputer. This is used to digitize various types of boundaries from maps for overlaying on digital data. The purchase price of this equipment was around $9,900.

Varian Electrostatic Printer/Plotter

The Varian Model 4211 electrostatic printer/plotter at LARS is also interfaced with the PDP 11/34 minicomputer. It can produce grayscale maps of varying scales and line graphs. These grayscale maps of data or classification results are visually superior to the alphanumeric maps from a line printer. The cost of this equipment was about $12,000.

PDP 11/34

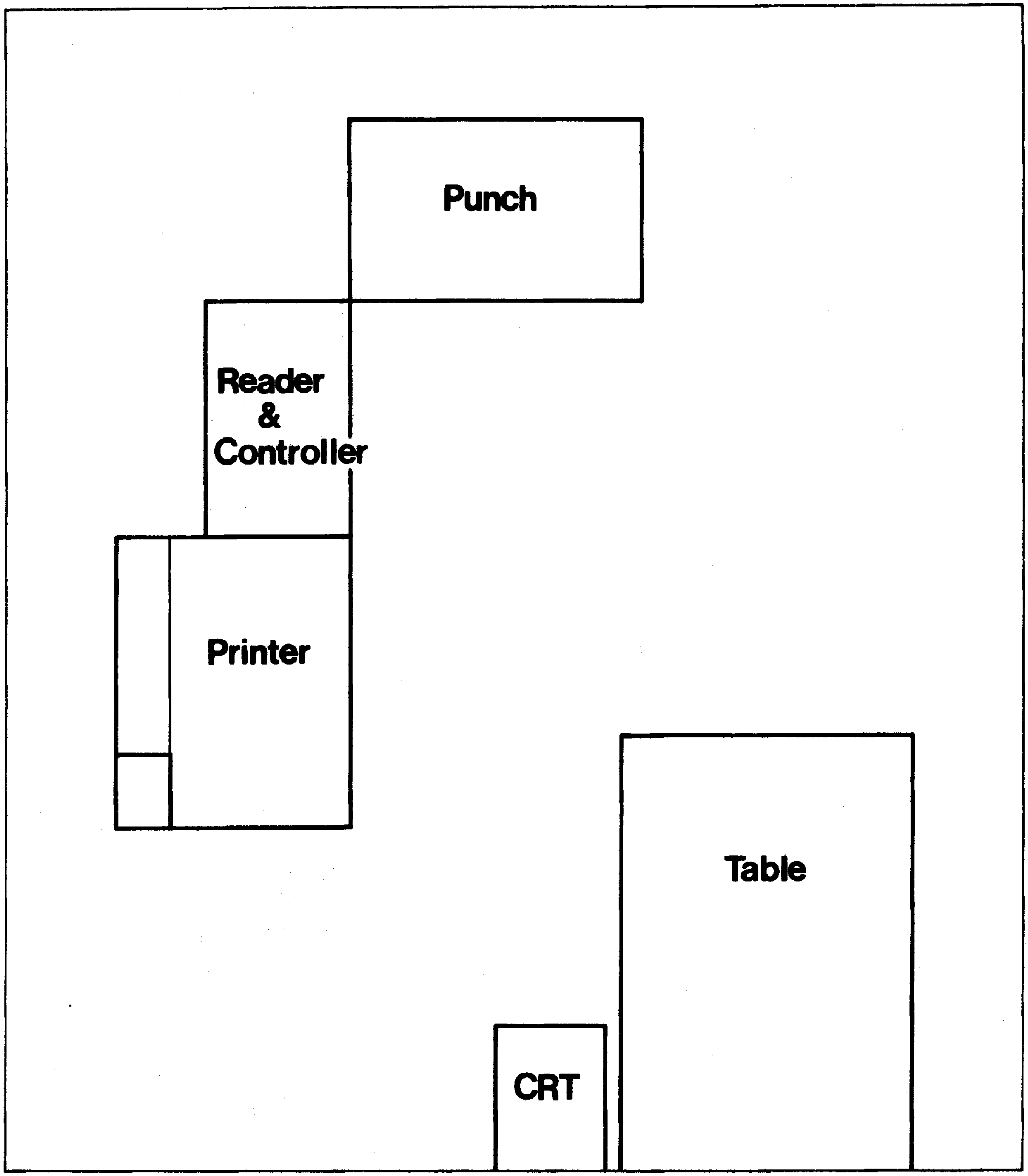
The PDP 11/34 minicomputer is used to support both the Varian printer/plotter and the digitizer. This provides an "intelligent" work station away from the main computer and helps obtain reasonable data rates for the plotter output. It also stores digitizer data for transmission to the main computer. Its cost was approximately $43,000.

2.3.2 Space Requirements

An example of a medium-sized remote terminal configuration with a CRT terminal, a DATA 100 card reader/printer/and punch terminal and a work table is illustrated in Figure 6. This particular arrangement requires a 14 foot by 16 foot area. A floor plan for the mini-computer with the Varian printer/plotter and digitizer is found in Figure 7. It is important to remember that each piece of equipment requires an electrical outlet, and depending on the equipment selected, a number of separate circuts will be required.

2.4 Cost Evaluations

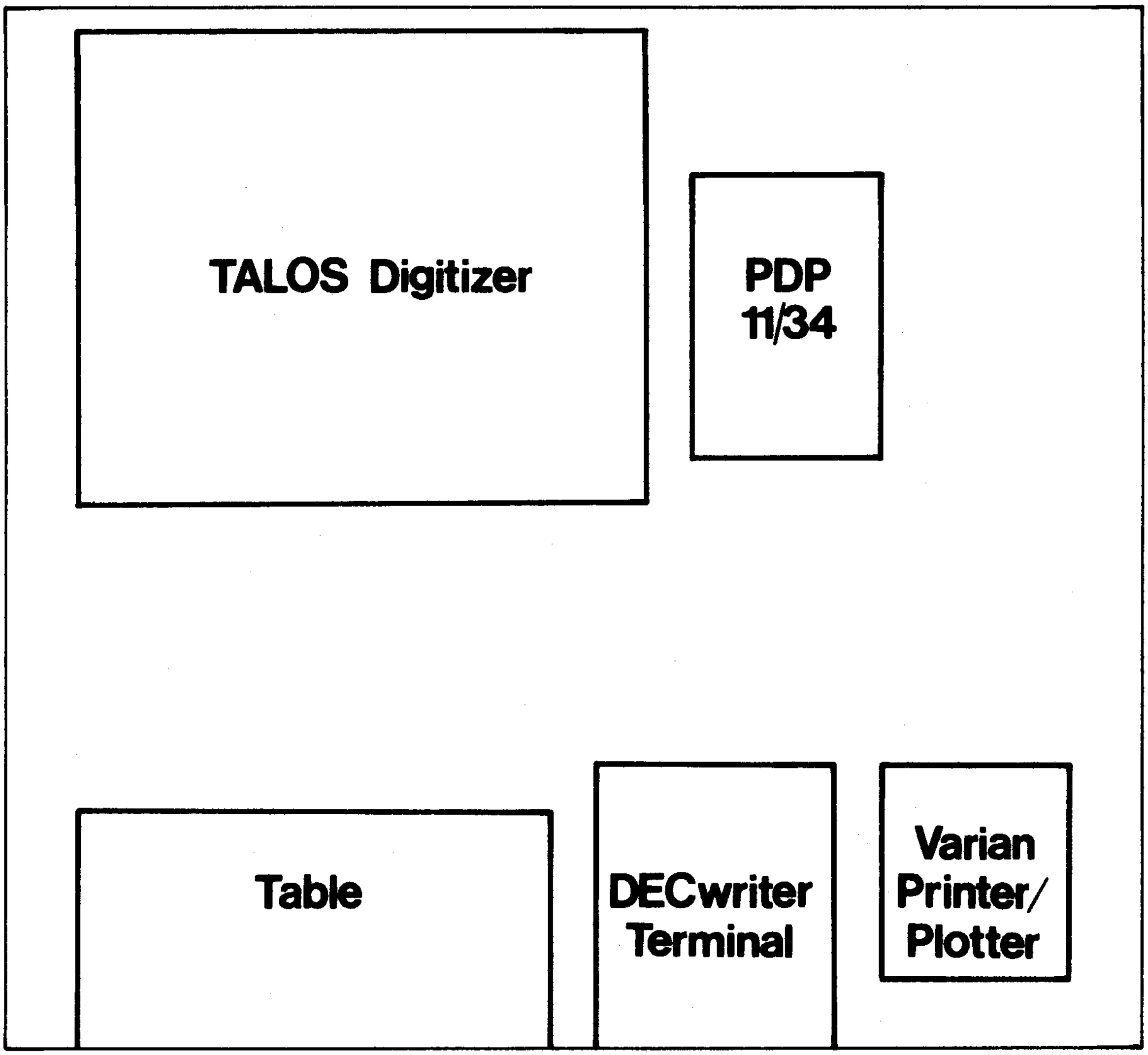
Cost of the technology to the user will be an important barometer to aid in assessing the extent to which the technology will be transferred. In these beginning stages of the project our emphasis, therefore, will be aimed at accounting the technology costs. A list of items to be considered in generating costs are listed below:



Scale
1" = 2 feet

Figure 6

A Remote Terminal Layout
(14 foot x 16 foot room)



Scale: 1" = 2 feet

Figure 7

Layout of a Minicomputer Workstation
(11 foot x 12 foot room)

I. Costs associated with creating and maintaining an on going FRIS

A. Cost of Establishment

1. Hardware needs
2. Software needs
3. Facilities
4. New personnel
5. Data Base Creation

B. Cost of Operation

1. Data Acquisition
2. Reformatting
3. Pre processing
4. Training the Classifier
5. Classification
6. Output product generator
   a. Statistical data for STD-MIS
   b. Maps

C. Cost of Maintenance

1. Hardware
2. Software
3. Data Base

II. Profit Improvement Motivations and/or Potential Cost Reduction

A. Multi-level Sampling

B. Map System Automation

C. New land acquisitions

D. Landowner assistance programs

E. Efficiency in up-dating

F. Timelines of Data

Evaluation of the impact of these costs will occur as the project matures. Throughout Phase II we will be collecting and evaluating data related to these items. As an aid in evaluating the importance of various cost elements we have undertaken the task of collecting pertinent reference materials related to cost analysis and/or remote sensing. A partial listing of references appears below:

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McGuigan, J.R. and R.C. Moyer. 1975. MANAGERIAL ECONOMICS: PRIVATE AND PUBLIC SECTOR DECISION ANALYSIS. The Dryden Press, Hinsdale, Illinois. 619 pp.

Miller, W.L. 1974. The Economic Impact of Remote Sensing Data as the Source of Nonpoint Pollution Monitoring and Control. Laboratory for Applications of Remote Sensing Information Note 041674, 11 pp.

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2.5 Technology Transfer

The ultimate measure of the success of Landsat to provide useful information to FRIS will be the implementation of computer assisted analysis capabilities by STR. Therefore, one of the most important aspects of LARS involvement in FRIS is developing the ability of STR staff to utilize the technology. The transfer of this technology is a dynamic process which began in STR with the birth of the concept in the early 70's. LARS active involvement in technology transfer began in October 1977. The technology transfer activity escalated during the first quarter of Phase II and are anticipated to continue at an intensive pace throughout the remainder of the project.

Specific activities over the past period included:

A. A formal 2½-day training session at Jacksonville.

B. Hands-on involvement for

1) Classification, and

2) digitizing.

A formal training course on the fundamentals of remote sensing was conducted in Jacksonville, in early February, 1978. Nine STR and five LARS staff participated in this 2½-day activity. An outline of the course topics follows:

- Spectral characteristics of earth surface features.
- The electromagnetic spectrum and instrumentation.
- Fundamentals of pattern recognition.
- Case study workshop (supervised approach).
- Theory and concepts of pattern recognition.
- Thematic mapper characteristics.

- Case study workshop (multi-cluster blocks approach).

The formal short course and workshop was followed by a hands-on training session at LARS. Four STR staff worked with their respective counterparts at LARS in classifications and digitizing. The hands-on training is a more intense, one-on-one activity where theory and concepts are supported by experience. Furthermore, the flow of knowledge during these sessions goes two ways. Both STR and LARS staff have gained from the exposure. Both formal and informal technology transfer activities will continue in the future.

3.0 Summary

The ultimate conclusion that will be drawn at the termination of the Phase II Demonstration relates to the feasibility of using Landsat data as an "operational" forest management tool. All activities during this 15-month phase are directed toward this end. There are, however, a number of positive "pre-conclusions" that can be stated even this early in the project. A summary of these activities appears below:

- A positive working rapport has developed between the FRIS staffs at STR and LARS.

Although this may appear to be an intangible, it is an important asset when considering the physical separation of the project staffs.

- Preliminary FRIS classification of four AU's appear very promising. Both winter and spring data has been classified.
- Progress has been made on the benchmark evaluations documentation. The entire FRIS staff has come to a level of understanding with regards to the evaluation criteria.
- Vendors for the out-of-house digitizing activity have been selected.
- The in-house digitizing activity has been improved through suggestions of STR staff.
- Guidelines for the cost accounting activity of Phase II are being developed.
- The FRIS information needs are being evaluated in light of remote sensing capabilities.
- A number of Technology Transfer activities were conducted during this quarter.

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