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# QUARTERLY REPORT

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16. Abstract


This report provides tentative and preliminary results and summarizes progress for the current quarter on the four tasks of the subject contract which are:

2.1 Ag Scene Understanding
2.2 Processing Techniques Development
2.3 Crop Production Statistics
2.4 Computer Processing Support


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083077 ECHO User's Guide by J. L. Kast, P. H. Swain, B. J. Davis, and P. W. Spencer.

Over the past several years, the ECHO classifiers have been developed to incorporate spatial as well as spectral information into the classifier decision criteria. This document contains a comprehensive description of the functional organization of the supervised and the non-supervised ECHO processes, the manner in which they are invoked and controlled. It is written primarily for individuals who intend to make use of the ECHO classifiers, although it is also of value to those wanting to understand or implement the ECHO algorithms.

051578 The Development of a Spectral/Spatial Classifier for Earth Observational Data by D. A. Landgrebe.

Over the last several years a classifier for earth observational image data has been under development which is intended to achieve improved performance by utilizing spatial characteristics of the data as an adjunct to multispectral ones. This paper provides an overview of the conception, development, evaluation, and documentation of this spectral/spatial classifier. The research program leading to this classifier is described, the algorithms of the current implementation called ECHO are outlined, and results on its performance are summarized. These results show it to have improved accuracy, with greater computation efficiency, and only slightly increased operator complexity.

061578 A Parametric Multiclass Bayes Estimator for the Multispectral Scanner Spatial Model Performance Evaluation by B. G. Mobasseri, C. D. McGillem, and P. E. Anuta.

Analytical models are developed to enable evaluation of multispectral scanner performance without a physical realization of a real system. The scanner IFOV and noise characteristics are represented by statistical models. Probability of correct classification is estimated via numerical solution using Gaussian distribution functions.

061778 Analytical Techniques for the Study of Some Parameters of Multispectral Scanner Systems for Remote Sensing by E. R. Wiswell and G. R. Cooper.

Analytical techniques for selecting wavelength bands are needed for design of future scanner systems for remote sensing. Information theory techniques and statistical models of crop spectra were used to develop a band selection approach. Average mutual information is shown to be a useful concept for the study of multispectral scanner systems.

# 1. AGRICULTURAL SCENE UNDERSTANDING

## A. Analysis of Spectral Data for Physical Understanding

### 1. Introduction

The spectral and agronomic measurements which have been acquired during the three years of the LACIE Field Measurements program are being analyzed to provide a quantitative understanding of the relationship of reflectance to the biological and physical characteristics of crops and soils.

The knowledge which will be gained from these analyses of how important agronomic and physical factors affect reflectance is necessary for the optimal use of current Landsat MSS technology as well as for design and development of future remote sensing systems. Methods developed for analysis can be applied to the Multicrop supporting field research task. Knowledge of the relationships of agronomic variables to one another and to spectral reflectance and the effects of sun and view angles on reflecance can be used to design better research for wheat, corn, and soybeans.

### II. Objectives

The overall objective of this task is to design and perform analyses of spectral data to increase our understanding of the reflectance properties of agricultural crops and how these properties depend upon specific agronomic and other physical variables. The results of these analyses will be interpreted to determine the spectral-temporal features of particular crops or crop conditions and to develop predictive relationships between the crop identity, agronomic variables, physical variables, and the reflectance spectra.

The specific objectives of the analyses are:

- Determine the relationship of canopy variables such as leaf area index, biomass, and percent soil cover to multispectral reflectance.

- Determine effects of cultural and environmental factors on the spectral response of wheat.
- Determine the effect of physical factors such as solar elevation, azimuth angle, view angle, and view direction on reflectance spectra.
- Identify optimal times and wavelengths for discriminating wheat from small grains and other confusion crops.

## III. Approach

The spectral data being analyzed include truck-mounted spectrometer data acquired at the agriculture experiment stations (AES) and helicopter-mounted spectrometer data acquired at the intensive test sites (ITS) during 1976 and 1977. Landsat-band radiometer data acquired at the Williston AES in 1977 are also being analyzed. Agronomic and meteorological data acquired at the experiment stations and intensive test sites are also being used.

The general approach has been to analyze band means for the Landsat MSS and proposed reflective thematic mapper bands. In addition, the spectral data have been analyzed using several transformations of reflectance values including greenness, brightness, ratios, and the vegetation index.

The approach began with plotting the reflectance spectra to verify data quality and to qualitatively assess the information contained in the data. Regression and correlation are being used to relate biological and physical parameters such as leaf area index, biomass, percent soil cover, height, maturity stage, and solar angles to spectral response. Analysis of variance and discriminant analysis are being used to evaluate the separability of wheat from other cover types and to determine effects of experimental treatments on spectral response.

## IV. Accomplishments this Quarter

The progress which has been made through this past quarter is shown in the milestone chart attached. Some analyses have been delayed due to commitments to the summer field research program.

Study of the effects of experimental treatments and the relationship of crop canopy variables to reflectance has been completed on the 1975 and 1976 Williston AES data. A technical report of this investigation has been completed, except for final editing; a summary is included in this quarterly report. Further investigations with the 1977 data have begun. Work has progressed on analysis of the sun angle-view angle experiment, but there are no completed results to report at this time. An investigation of crop discriminability using the North Dakota ITS data has been completed and is summarized in this report.

a. Relation of Crop Canopy Variables to the Multispectral Reflectance of Spring Wheat

Reflectance spectra over the wavelength range 0.4-2.5 μm were acquired during each of the major development stages of spring wheat canopies at Williston, North Dakota, using a truck-mounted spectrometer. Treatments in the experiment included planting date, nitrogen fertilization, cultivar, and soil moisture. Agronomic characterization of the wheat canopies included measurements of maturity stage, plant height, fresh and dry biomass, leaf area index, and percent soil cover. An example of the spectral and agronomic data is shown in Figures 1A-1 and 2.

Leaf area index, percent soil cover, and plant water content had high linear correlations with reflectance in most wavelength bands (Table 1A-1) and reflectance was sensitive to changes in these variables throughout the growing season. Reflectance in single wavelength bands was sensitive to changes in fresh and dry biomass only during the vegetative phases of development.

The 0.76-0.90 μm wavelength band had a high correlation with each crop canopy variable early in the growing season indicating a sensitivity to small amounts of biomass. However, due to the large influence of bare soil, other wavelength bands did not account for much of the variation in the crop canopy variables early in the growing season.

In each wavelength region, the correlation of the thematic mapper band with crop canopy variables was greater than that of the corresponding Landsat MSS band (Table 1A-1). Prediction equations developed to explain the variation in crop canopy variables showed that the 2.08-2.35 μm wavelength band was the single most important band explaining the variation in fresh biomass, dry biomass, and plant water. The near infrared band (0.76-0.90 μm) explained the most variation in leaf area index and percent soil cover (Table 1A-2). This result shows the importance of collecting spectral information in the near and middle infrared wavelength regions.

The $R^2$ values for comparisons of measured and predicted canopy variables ranged from 0.81 to 0.93 when three or more spectral bands were included (Table 1A-2), indicating the potential for using remotely sensed spectral measurements to characterize the status of crops (Figure 1A-3).

Analyses showed that reflectance measurements from the best four thematic mapper bands could estimate crop canopy variables better than all four Landsat MSS bands (Table 1A-3). The improved predictions are attributed to the narrower and more optimal placement of the thematic mapper bands in relation to the spectral characteristics of vegetation.

Transformations of red and infrared wavelength bands were not found to explain any aditional variation in the data when used in combination with the best bands, although individual transformations did have slightly higher correlations with some crop canopy variables than the single wavelength bands.

The strong relationship between spectral reflectance and different crop canopy variables throughout the growing season illustrates the potential to monitor crop growth and development. Additional research is needed to investigate the amount of variation induced by different agronomic treatment factors on spectral reflectance and to determine whether these treatment factors are spectrally separable (Figure 1A-4). The prediction equations developed need to be based on several years of data, then used to estimate independent data sets. Transformations should also be investigated in greater detail for their abilities to normalize reflectance for effects of sun angle and canopy differences.

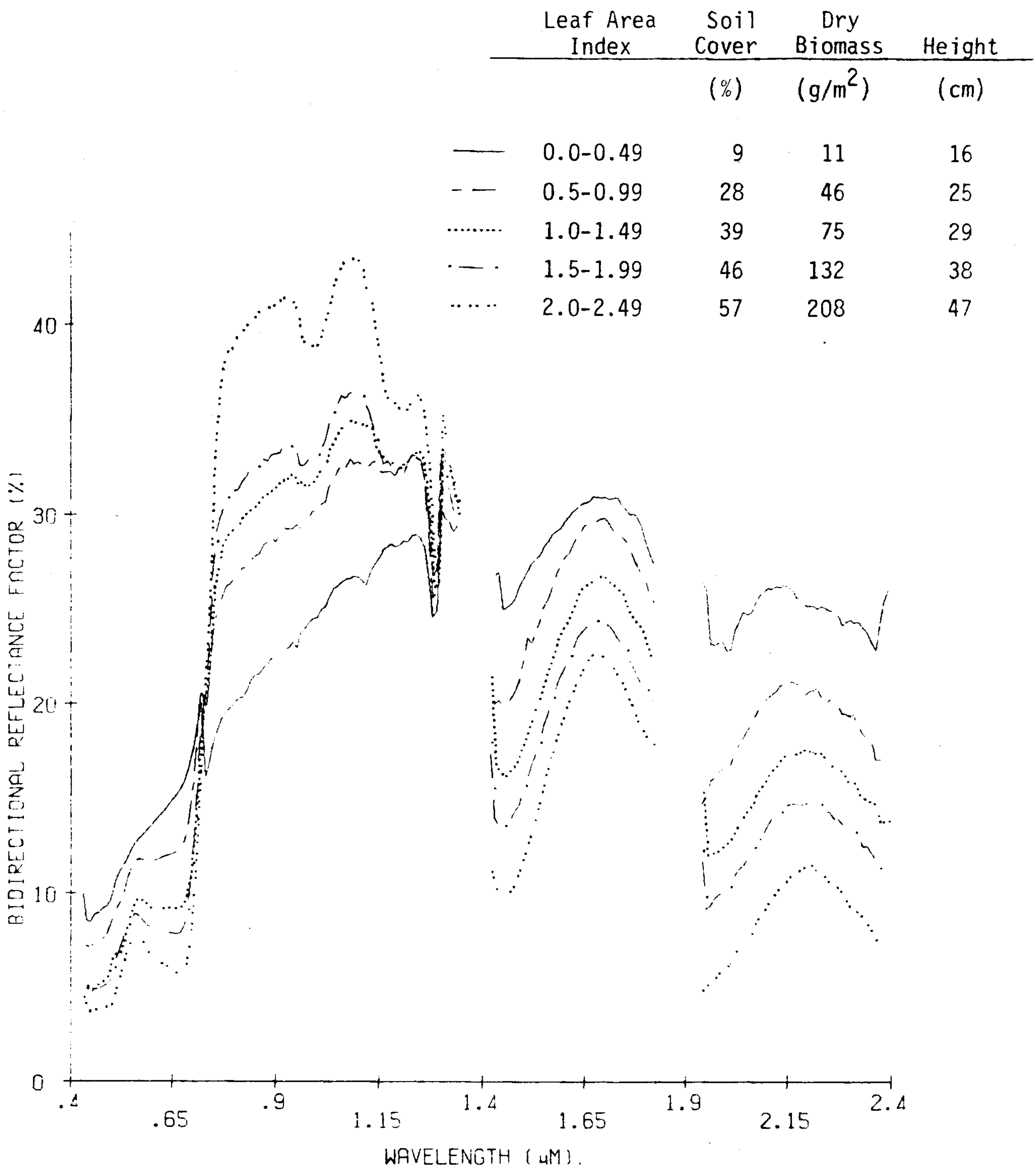



Figure 1A-1. Effect of leaf area index, percent soil cover, dry biomass, and plant height on the spectral reflectance of spring wheat during the period between tillering and the beginning of heading when the maximum green leaf area was reached.

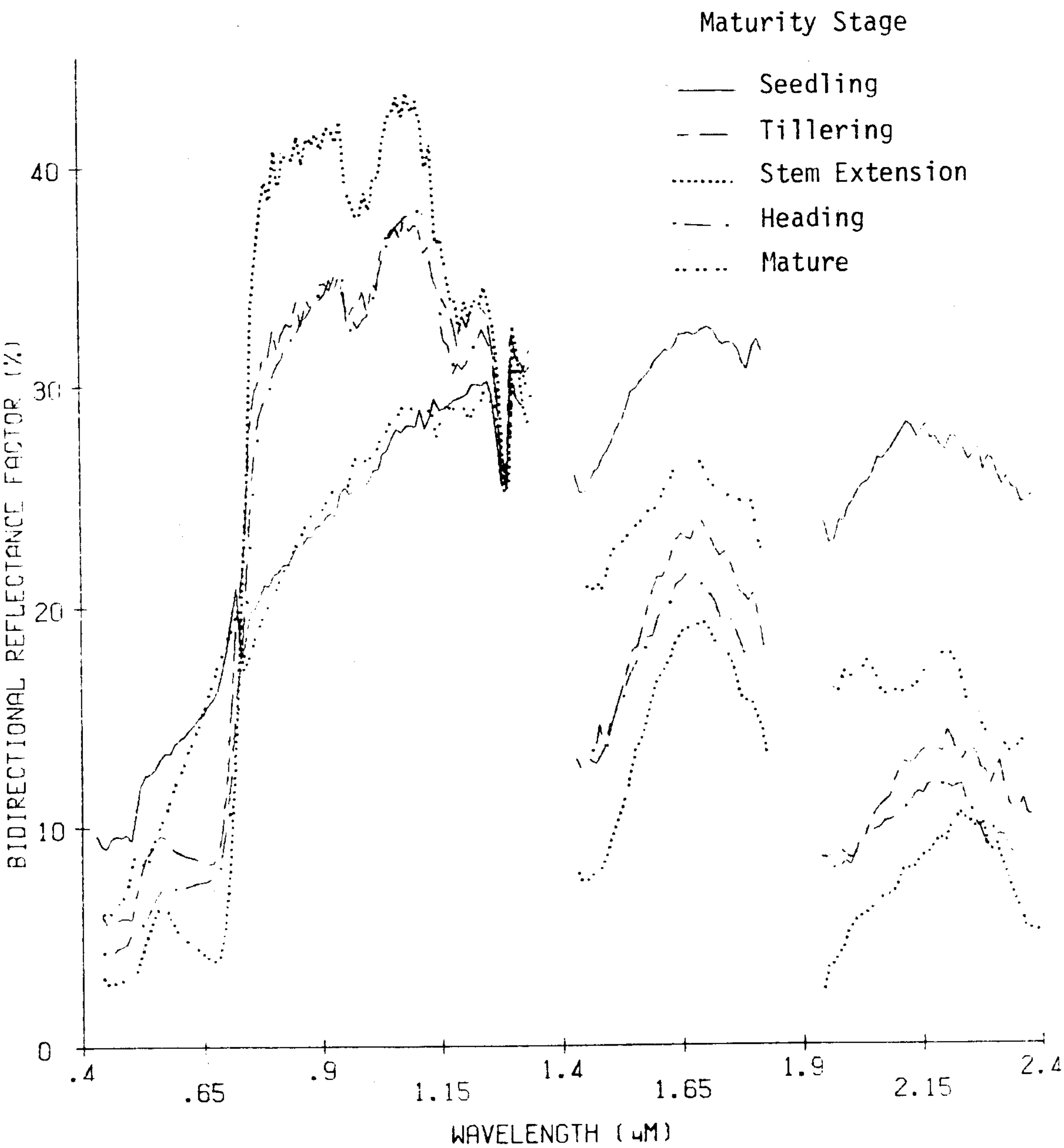



Figure 1A-2. Effect of maturity stage on the spectral reflectance of spring wheat canopies.

Table 1A-1. The linear correlations (r) of the proposed thematic mapper and Landsat MSS wavelength bands with percent soil cover, leaf area index, fresh and dry biomass, and plant water content.

| Wavelength Band (μm) | Percent Soil Cover | Leaf Area Index | Fresh Biomass | Dry Biomass | Plant Water Content |
|---|---|---|---|---|---|
| Thematic Mapper | | | | | |
| 0.45-0.52 | -0.82 | -0.79 | -0.75 | -0.69 | -0.76 |
| 0.52-0.60 | -0.82 | -0.78 | -0.81 | -0.77 | -0.82 |
| 0.63-0.69 | -0.91 | -0.86 | -0.80 | -0.73 | -0.81 |
| 0.76-0.90 | 0.93 | 0.92 | 0.76 | 0.67 | 0.79 |
| 1.55-1.75 | -0.85 | -0.80 | -0.83 | -0.79 | -0.84 |
| 2.08-2.35 | -0.91 | -0.85 | -0.86 | -0.81 | -0.86 |
| Landsat MSS | | | | | |
| 0.5-0.6 | -0.82 | -0.79 | -0.81 | -0.76 | -0.81 |
| 0.6-0.7 | -0.90 | -0.85 | -0.81 | -0.74 | -0.82 |
| 0.7-0.8 | 0.84 | 0.84 | 0.57 | 0.46 | 0.60 |
| 0.8-1.1 | 0.91 | 0.90 | 0.77 | 0.68 | 0.79 |

Table 1A-2. Selection of the best combinations of 1, 2,...6 wavelength bands for estimating percent soil cover, leaf area index, fresh biomass, dry biomass, and plant water content.

| Canopy Variable | No. Bands Entered | $R^2$ | $C_p$ | Bands Entered (μm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 0.45–0.52 | 0.52–0.60 | 0.63–0.69 | 0.76–0.90 | 1.55–1.75 | 2.08–2.35 |
| Percent Soil Cover | 1 | .86 | 132 | | | | X | | |
| | 2 | .92 | 16 | | | | X | | X |
| | 3 | .92 | 15 | X | | | X | | X |
| | 4 | .93 | 4 | X | X | | X | | X |
| | 5 | .93 | 5 | X | X | X | X | | X |
| | 6 | .93 | 7 | X | X | X | X | X | X |
| Leaf Area Index | 1 | .84 | 37 | | | | X | | |
| | 2 | .87 | 7 | | | | X | X | |
| | 3 | .88 | 2 | | | | X | X | X |
| | 4 | .88 | 4 | X | | | X | X | X |
| | 5 | .88 | 5 | X | X | | X | X | X |
| | 6 | .88 | 6 | X | X | X | X | X | X |
| Fresh Biomass | 1 | .73 | 239 | | | | | | X |
| | 2 | .76 | 211 | | X | | | | X |
| | 3 | .83 | 109 | | X | X | | | X |
| | 4 | .88 | 41 | | X | X | X | | X |
| | 5 | .90 | 12 | X | X | X | X | | X |
| | 6 | .93 | 7 | X | X | X | X | X | X |
| Dry Biomass | 1 | .65 | 252 | | | | | | X |
| | 2 | .67 | 229 | X | X | | | | |
| | 3 | .81 | 78 | | X | X | | | X |
| | 4 | .84 | 44 | | X | X | X | | X |
| | 5 | .87 | 20 | X | X | X | X | | X |
| | 6 | .88 | 7 | X | X | X | X | X | X |
| Plant Water Content | 1 | .75 | 201 | | | | | | X |
| | 2 | .77 | 175 | | X | | | | X |
| | 3 | .83 | 98 | X | X | | X | | |
| | 4 | .88 | 34 | | X | X | X | | X |
| | 5 | .90 | 9 | X | X | X | X | | X |
| | 6 | .90 | 7 | X | X | X | X | X | X |

Table 1A-3. The $R^2$ values for predictions of percent soil cover, leaf area index, fresh and dry biomass, and plant water content with four Landsat MSS bands, the best four thematic mapper bands, and the six thematic mapper bands.

| Wavelength Bands | Percent Soil Cover | Leaf Area Index | Fresh Biomass | Dry Biomass | Plant Water Content |
|---|---|---|---|---|---|
| Landsat MSS Bands | 0.91 | 0.86 | 0.86 | 0.84 | 0.85 |
| Best Four Thematic Mapper Bands | 0.93 | 0.88 | 0.88 | 0.84 | 0.88 |
| Six Thematic Mapper Bands | 0.93 | 0.88 | 0.91 | 0.88 | 0.90 |

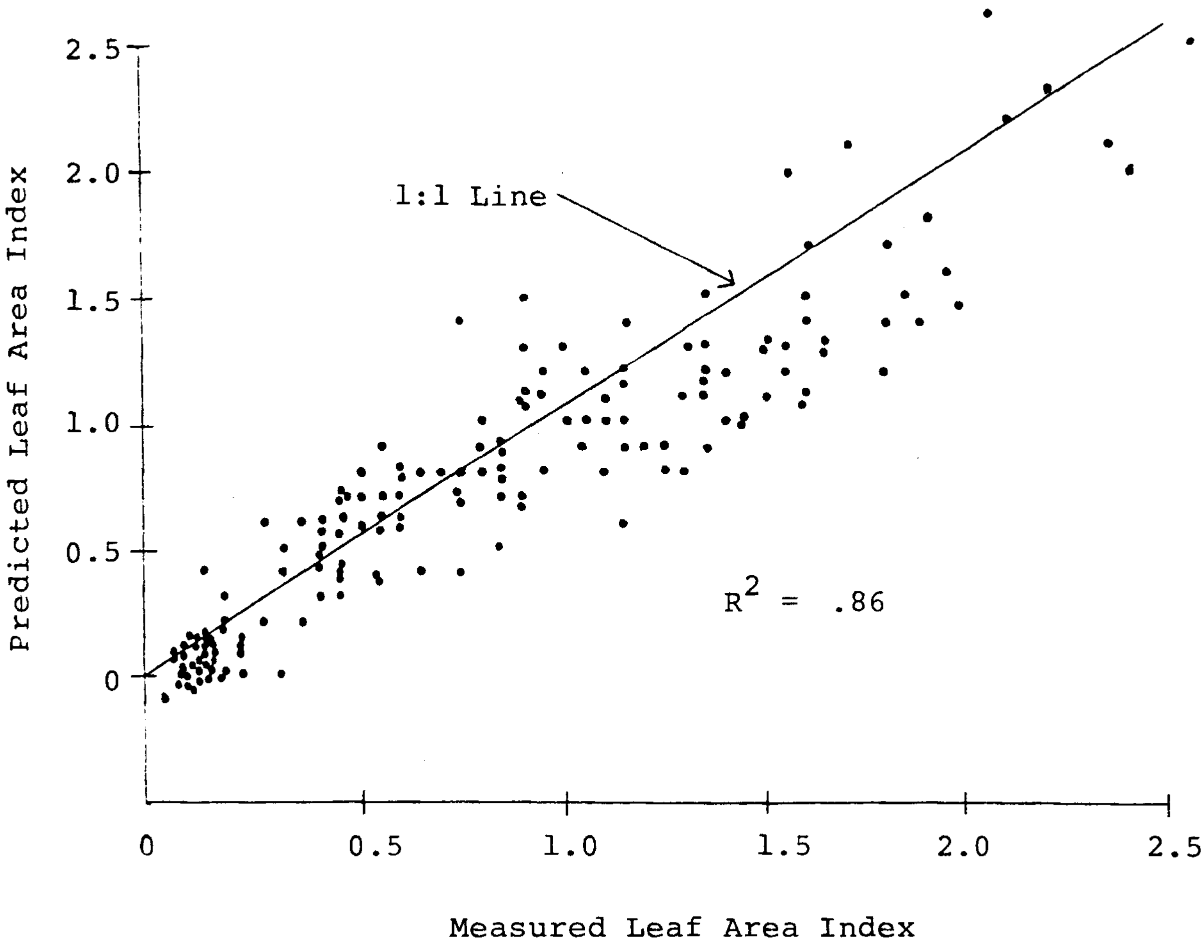



Figure 1A-3. Comparison of measured and predicted leaf area index of spring wheat. Predicted LAI = $-0.65 + 0.11X_1 - 0.13X_2 + 0.90X_3$, where $X_1$, $X_2$, and $X_3$ are the reflectances of the following wavelength bands: .76-.90, 1.55-1.75, and 2.08-2.35 μm.

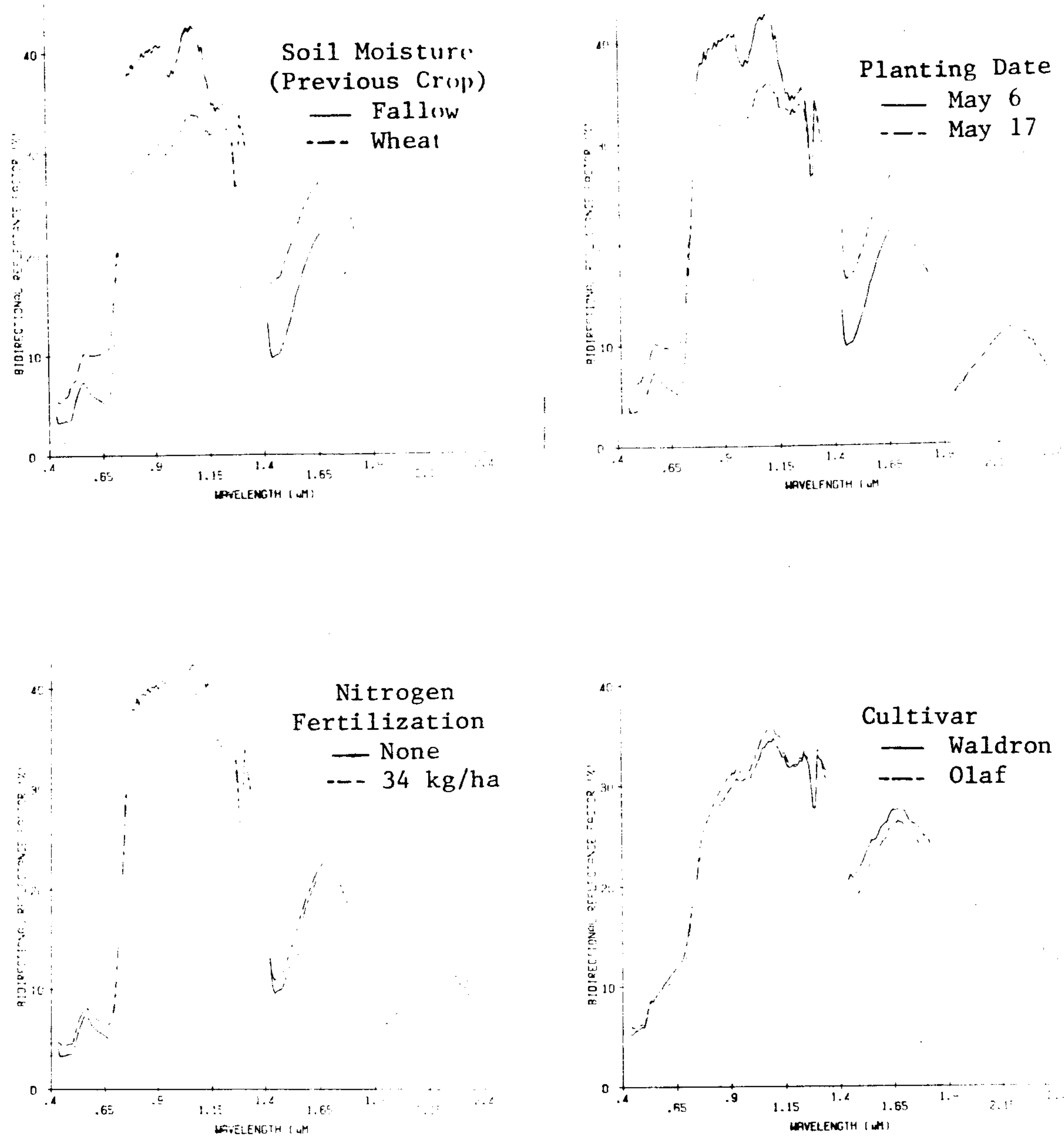



Figure 1A-4. Effects of agronomic treatments on the spectral reflectance of spring wheat. Spectra were measured on June 18 during the stem extension stage of development, except for the spectra of cultivars which were measured on July 16 after heading.

b. Crop Discriminability of 1976 North Dakota ITS Data

Unitemporal and multitemporal multivariate discriminant analyses were performed to investigate crop discriminability. Percent correct classification and percent commission errors were computed. In addition, the effect of sample size on discriminant analysis results was assessed. In all analyses, prior probabilities were selected proportional to sample size.

i. Training Sample Selection

There was some variation in the percent of wheat spectra correctly classified based on the size of the training set (Figure 1A-4). After June 25, there was good agreement in results among the three sample sizes 100, 50, and 25 percent of available spectra.

An additional unitemporal analysis was done using samples which were selected geographically; that is, a set of fields containing approximately 50 percent of the spectra was used for training and the spectra in the remaining fields were then classified. The percent of wheat spectra correctly classified varied between dates and between Landsat and thematic mapper bands as shown in Figure 1A-5. In general, the results using the thematic mapper bands were more consistent with the previous results for dates in the middle of the growing season than using the Landsat bands. Results for post-harvest dates (8/9 and 8/19), however, were worse for samples selected by fields than for random samples of available spectra.

ii. Comparisons of Discriminability and Confusion for Several Cover Types

In general, 99 percent of wheat spectra were correctly classified in the June 25 and later data for both the Landsat MSS and thematic mapper bands (Figure 1A-5). On the first three dates, the percent of wheat correctly identified was generally above 80. Spectra of fallow fields were almost equally well identified on each date, but 50 percent of the spectra of pasture were confused with fallow after July 20 when using either the Landsat MSS or thematic mapper bands.

Through all the single date analyses, pasture was confused with wheat and fallow in both Landsat MSS and thematic mapper bands with the percent of pasture spectra correctly classified decreasing with sample size for samples based on random selection. Pasture had fewer available spectra for training than the other cover types, resulting in a smaller a priori probability, but equalization of prior probabilities did not improve classification performance for pasture.

When cumulative spectral information from several dates was used, high classification accuracies were achieved. The percentage of wheat spectra correctly classified ranged from 97 to 100 for both Landsat and thematic mapper bands. The confusion of pasture with other cover types was not encountered.

An investigation was then carried out to find a reduced set of dates which, when combined, would give results comparable to using the full data set. The combinations of dates used were selected to include important growth stages. Again, using multitemporal information, the confusion of pasture with other cover types is not encountered and all cover types are identified with high accuracy (Table 1A-6).

iii. Utility of Transformations for Crop Identification

Similar unitemporal analyses using the brightness and greenness components of reflectance were also conducted. The results of these analyses did not show an improvement in classfication of wheat spectra over the use of two Landsat bands.

Table 1A-4. Percent correct classification of spring wheat, fallow, and pasture using the proposed thematic mapper bands (Williams Co. ITS, 1976).

| Combination of Dates | Percent Correct | | |
|---|---|---|---|
| | Wheat | Pasture | Fallow |
| 6/17, 7/6, 7/28 | 99.3 | 92.2 | 99.4 |
| 5/28, 6/25, 7/28 | 98.8 | 88.0 | 98.8 |
| 5/28, 6/25, 7/20, 8/9 | 99.5 | 100.0 | 99.4 |
| 6/17, 6/25, 7/6, 7/28 | 100.0 | 95.6 | 100.0 |

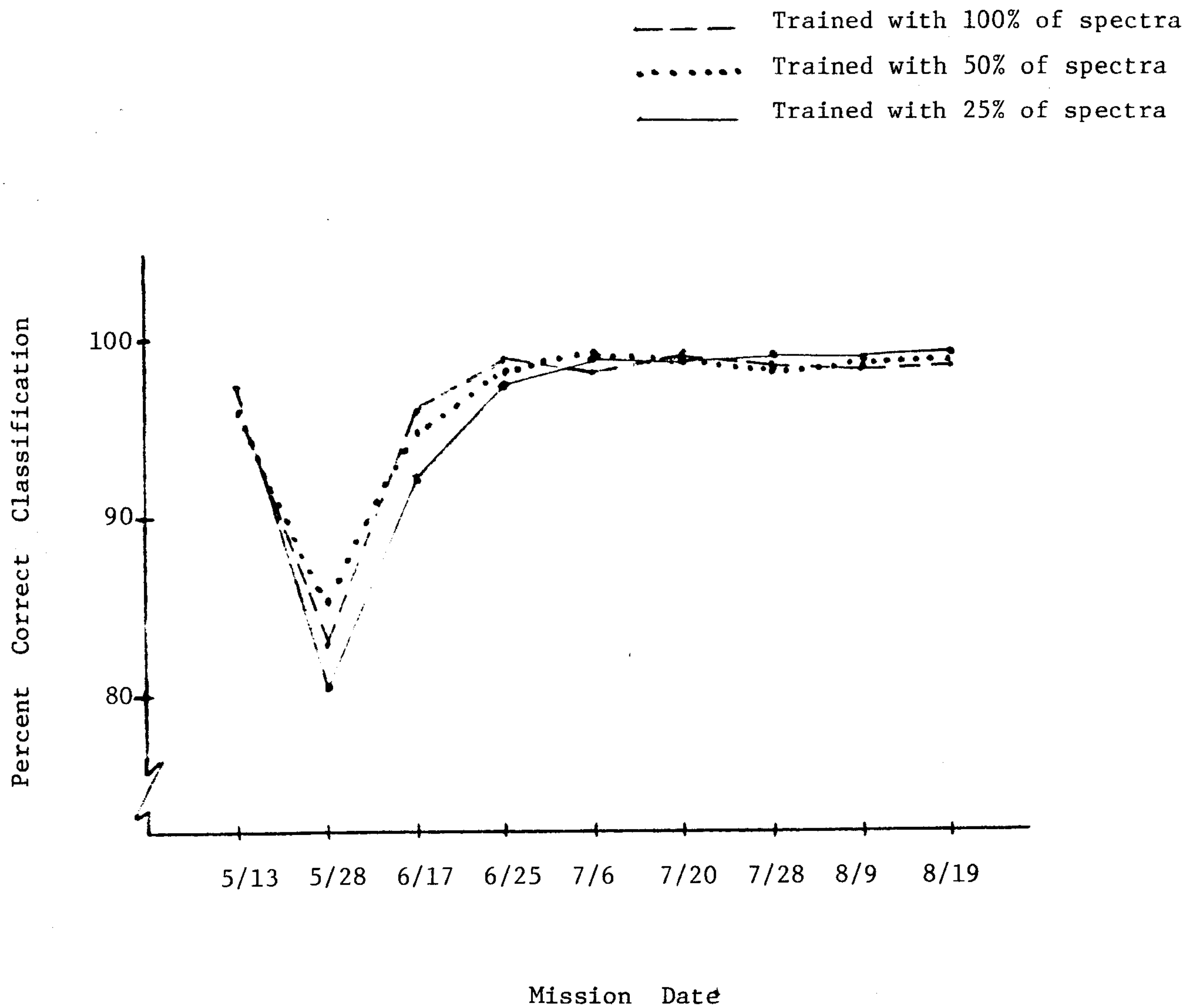



Figure 1A-5. Percent correct classification by the thematic mapper bands of wheat on different missions using several training methods.

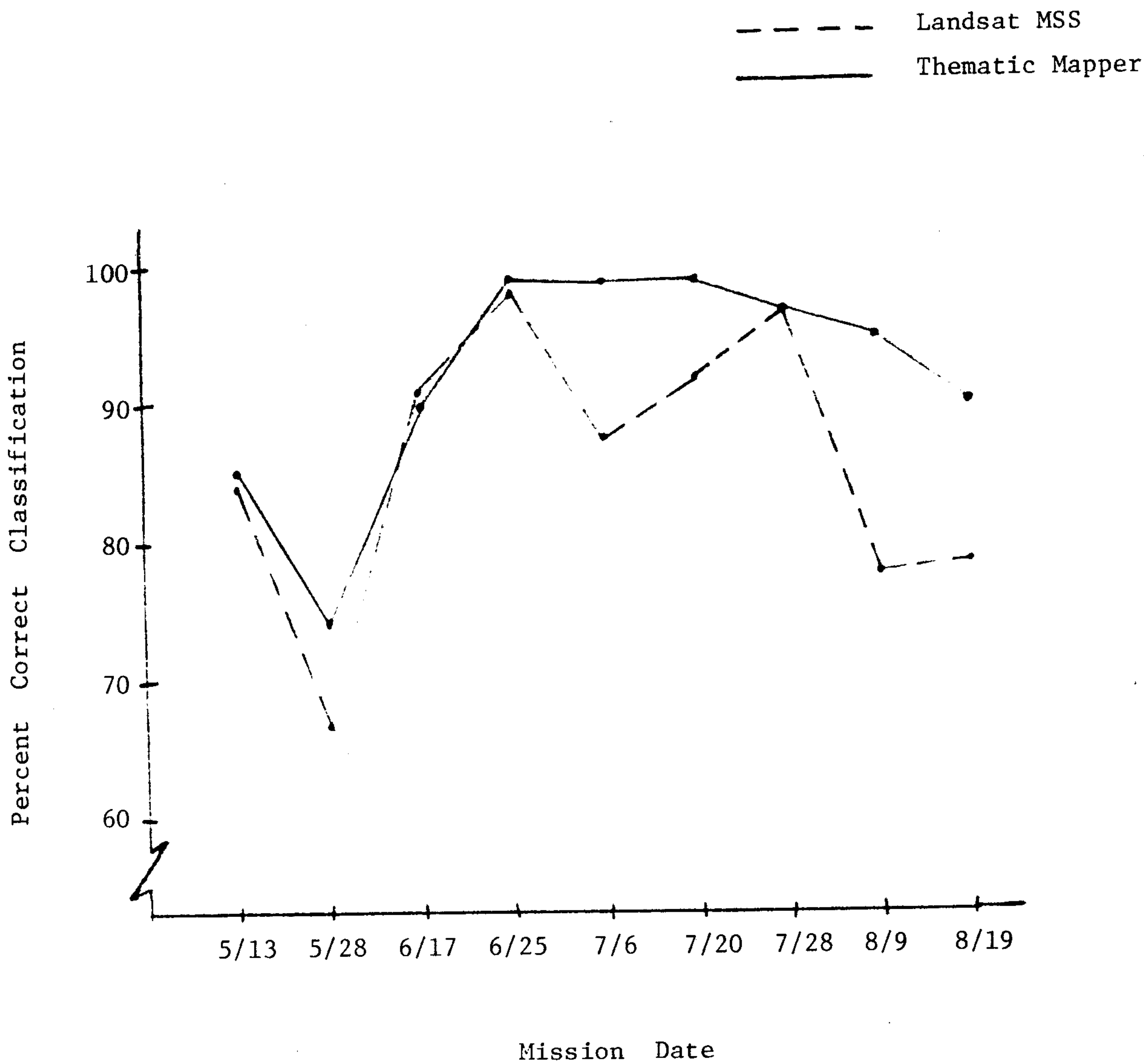
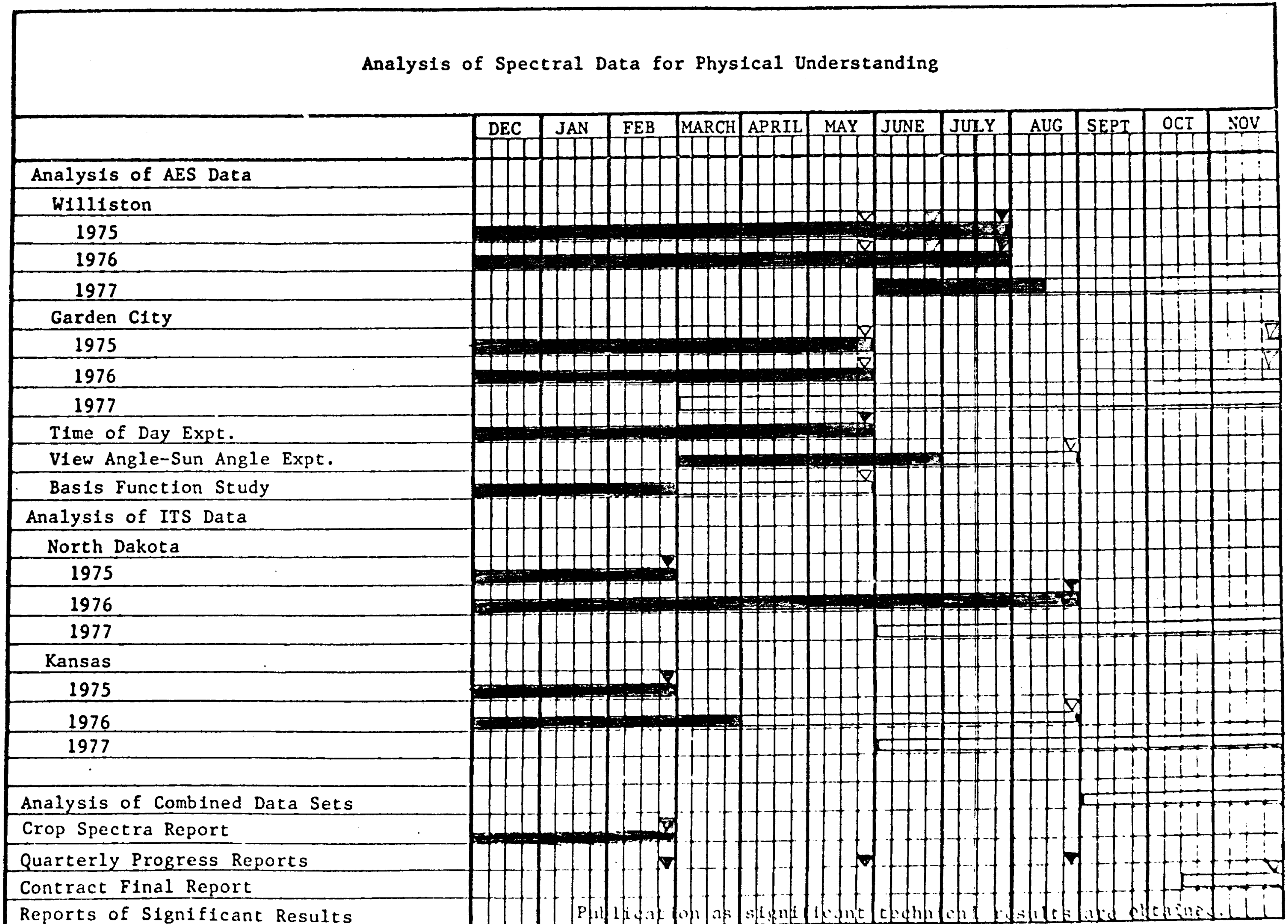



Figure 1A-6. Percent correct classification of wheat on different missions using 50 percent of available fields for training.

V. Plans for Next Quarter

Studies of the relationship of canopy variables and reflectance will continue with the Garden City AES and 1977 Williston AES data. Multiyear studies to evaluate prediction potential of agronomic variables will be conducted. Effects of experimental treatments will be assessed using data from both experiment stations. The results of the diurnal variation in reflectance study will be used in the North Dakota study.

Detailed Implementation Schedule



B. Field Measurements Data Management

I. Introduction

The objective of this task is to complete the reformatting, verification and correlation of the data acquired during the 1975, 1976, and 1977 crop years at the three LACIE Field Measurements intensive test sites and continue the operation of the data library (prepare catalogs and distribute data). The objective was changed in late spring to also include the processing and verification of the field data acquired at the Purdue University Agronomy Farm during 1978.

Activities during this quarter towards fulfillment of the objective include distribution of data to Goddard Space Flight Center and General Electric, redesign of a part of the LACIE Field Measurements Data Library Catalog, and initial preparation of the 1978 data for processing.

II. Data Processing and Reformatting

a. Purdue/LARS Exotech 20C Field Spectrometer Data. The digitizing and keypunching of the 1978 data collected at the Purdue University Agronomy Farm during June, July and August was begun.

b. NASA/JSC Field Spectrometer System (FSS). The reprocessed FSS intercomparison data were received from NASA/JSC and will be used in the calibration-correlation analyses.

c. Landsat and Aircraft Multispectral Scanner Data. No Landsat or aircraft data were received during this quarter.

## III. Maintenance of Data Library and Data Distribution

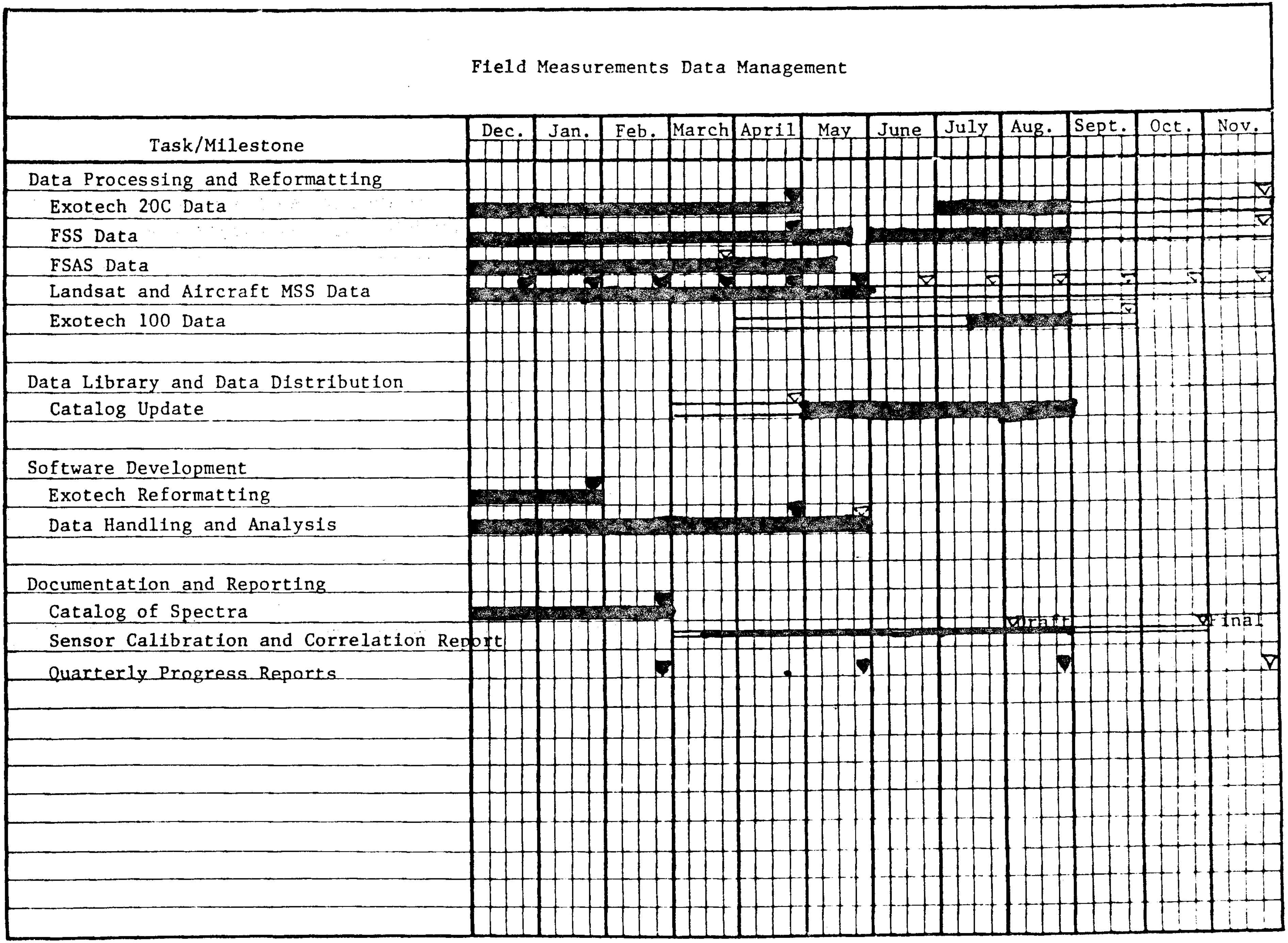
The LACIE Field Measurements Data Library Catalog is being revised and updated. The revision affects the Index section for the spectrometer data. Instead of listing the date, flightlines, and flightline start times for the FSS data in the index for each test site, the date, field number, number of observations per field per date and mission start and stop times will be given. In the truck-mounted spectrometer data and tripod mounted radiometer data the date, plot number, number of observations per plot per date and start-stop times for each day will be given for each experiment instead of only the date, experiment name, and number of observations per experiment. Also, the correlation of field number and crop type for each intensive test site will be added to the appendix. These revisions should help users who are not familiar with the LACIE Field Measurements Project to select data for analysis.

The 1976-77 FSS data collected at the Finney County, Kansas intensive test site were distributed to Dr. John Barker of NASA/Goddard. Also, the 1977 Exotech 20C data collected at the Williston, North Dakota Experiment Station and the 1976-77 FSS data collected at the Hand County, South Dakota intensive test site were distributed to Dr. David Wood of NASA/Goddard and Dr. John Conrad of General Electric. The only item needed to complete the present Goddard/General Electric request is the 1977 yield data for the Hand County, South Dakota intensive test site which has not been received at LARS yet.

## IV. Next Quarter

During the next quarter, it is expected that the revisions and updating of the catalog will be completed. Also, a technical report will be completed summarizing the calibration and correlation of the LACIE Field Measurements spectral data.

Figure 1. Implementation Schedule



## C. Determining the Climatic and Genetic Effects on the Relationships Between Multispectral Reflectance and Physical/Chemical Properties of Soil

### I. Introduction

This quarter has seen the completion of the preparatory phase for analysis of soil samples with the Exotech Model 20C spectroradiometer. Of the original list of 254 Benchmark soils requested, the Soil Conservation Service has collected and forwarded 238 duplicate soil samples complete with detailed sampling site information. All of these soil samples have been dried, sieved and stored in suitably cataloged cardboard containers for analysis of physical, chemical, engineering, and spectroradiometric properties.

An identification record containing complete soil taxonomic information along with other site characteristics and a unique soil sampling number has been prepared for each of the 238 Benchmark soils on hand. A breakdown of the soils by climatic region (Table 1C-1) differs slightly from that reported during the first quarter because of intramontaine climatic variations from the mapped climate types.

### II. Major Accomplishments

In addition to the completion of the soil preparation phase, laboratory analyses of chemical, physical and engineering properties have proceeded at a rate such that completion of the tests should occur early in the final quarter. Late arrival of many of the soil samples has delayed initiation of spectroradiometric measurements; however, all preparatory work has been completed and spectral readings will soon be carried out in nine 36-hour time blocks.

The EXOSYS data logging procedure for establishing a header record of soils information has been completed and tested. Items included in the soils header record and their position on computer punch cards are shown in Figure 1C-1. All available soils information is being added to this data record as test results become available.

a. Randomization scheme for Exotech data collection

An equipotential moisture condition will be established for spectrophotometric analysis of the sieved soil samples. Two asbestos tension tables have been constructed so that 56 soil samples can be equilibrated at one-tenth bar soil moisture tension in one 36-hour time frame. Because of the limitation of running only 56 soil samples at one set-up, nine blocks of 56 samples each were created. The 56 samples in each block were chosen so that each climatic region would be represented by a proportionate number of samples based on its cell size (Table 1C-2). Duplicate soil samples of a given Benchmark soil were treated as separate observations, thus the total number of observations in each climate cell is double the number in Table 1C-1. After randomly selecting the assigned number of soil samples from within each climatic region, the 54 resultant samples along with two check samples were again randomized to determine the run order and position of the sample on the tension table.

Each block contains two randomly assigned check samples consisting of subsamples of a silt loam soil sampled in one location. The check samples will serve to measure any variability within a given set-up as well as variability between different time blocks.

III. Technical Problems Encountered

Heavy field work schedules prevented the collection of soil samples by Soil Conservation Service personnel in Montana, Iowa, Connecticut, North Carolina, and Florida until mid-summer 1978. This necessitated the continuation of soil sample preparation through August 1978.

Construction and testing of the asbestos tension tables has been delayed because of conflicting work loads involving field collection of spectral data.

IV. Activities for Next Quarter

Soil sample spectral measurements will be completed early in the quarter and ancillary test data will be included in the header record so that statistical analysis can begin. Verification of data and correlation analysis will be completed in order to relate spectral measurements to the chemical, physical and engineering properties of the soils studied.

Table 1C-1. Summary of Benchmark Soils On-Hand

| | Climatic Region | Number of Benchmark Soil Series |
|---|---|---|
| 1 | Perhumic Mesic | 6 |
| 2 | Humid Frigid | 18 |
| 3 | Humid Mesic | 37 |
| 4 | Humid Thermic | 28 |
| 5 | Humid Hyperthermic | 6 |
| 6 | Subhumid Frigid | 21 |
| 7 | Subhumid Mesic | 23 |
| 8 | Subhumid Thermic | 18 |
| 9 | Subhumid Hyperthermic | 2 |
| 10 | Semiarid Frigid | 9 |
| 11 | Semiarid Mesic | 24 |
| 12 | Semiarid Thermic | 10 |
| 13 | Semiarid Hyperthermic | 5 |
| 14 | Arid Frigid | 2 |
| 15 | Arid Mesic | 16 |
| 16 | Arid Thermic | 12 |
| 17 | Arid Hyperthermic | 1 |
| | | 237 total |

Table 1C-2. Assignment of Soil Samples to Time Blocks for Spectroradiometric Measurements. Number of Samples Per Climatic Region.

| Climatic Region | Block (days) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX |
| 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 0 |
| 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 3 | 8 | 8 | 9 | 9 | 8 | 8 | 8 | 8 | 8 |
| 4 | 5 | 5 | 5 | 6 | 6 | 7 | 6 | 7 | 9 |
| 5 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 2 |
| 7 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 |
| 8 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 9 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| 10 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 11 | 5 | 5 | 6 | 6 | 6 | 5 | 6 | 5 | 4 |
| 12 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 13 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 14 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 15 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 0 |
| 16 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 0 |
| 17 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 54 | 54 | 54 | 54 | 54 | 54 | 54 | 54 | 44 |

Note: Two check samples are assigned to each block.

Figure 1C-1. EXOSYS Soil Record Sheets for Header Record Data Logging.

## PURDUE/LARS SOILS RECORD SHEET NO. 1

Location | Dates of Corresponding Instrument Data | 1 | Dates Soils Data Collected | Investigator

| Obser. Code | Treatment Level Of Factor No. 1 2 3 4 5 6 | Parent Material | Soil Taxonomy Classification: Order | Suborder | Great Group | Particle Size Class | Contrasting Particle Size | Mineralogy | Other Modifiers | Temperature Reg. | Moisture Zone | Drainage Class | Slope Class | Erosion Phase | Physiographic Position | Soil Taxonomy Subgroup Name | Soil Series Name | Soil Survey Sample Number (coded for year, state, county) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

## PURDUE/LARS SOILS RECORD SHEET NO. 2

| Obser. Code | Horizon | Soil Testing Lab Number | Organic Carbon (%) | Water pH | Buffer pH | Extractable Bases (me/100g) Ca | Mg | Na | K | Extractable Acidity | CEC Sum | Base Saturation (%) | $Fe_2O_3$ (%) | $Al_2O_3$ (%) | $MnO_2$ (%) | $SiO_2$ (%) | Available P Kg/ha | Available K Kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

## PURDUE/LARS SOILS RECORD SHEET NO. 3

| Obser. Code | Soil Moisture Tension (Bars) | Water Content (%) | Bulk Density g/cm³ | Munsell Color Moist: Hue | Value | /Chroma | Textural Class (Material <2mm) | USDA Particle Size Distribution (mm) (Percent of <2mm Fraction): Total Sand (2-.05) | Total Silt (.05-.002) | Total Clay (<.002) | Sand V.Coarse (2-1) | Sand Coarse (1-.5) | Sand Medium (.5-.25) | Sand Fine (.25-.10) | Sand V.Fine (.10-.05) | Silt Coarse (.05-.02) | Silt Fine (.02-.002) | Electrical Conductivity mmhos/cm | Erosion Factor K | Wind Erodibility Group |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

Figure 1C-1. (Continued)

## PURDUE/LARS SOIL RECORD SHEET NO. 4

| Obser. Code | Engineering Lab Number | Sample Portion <.425/<2mm | DUP | Engineering Tests (based on <.425 mm Fraction): Liquid Limit | Plastic Limit | Plasticity Index | Activity | Liquidity Index | Shrinkage Limit | Shrinkage Ratio | Volumetric Shrinkage | Linear Shrinkage | Compression Index | ASTM Particle Size Distribution: Med. Sand (2–.425) | Fine Sand (.425–.075) | Fines (<.075) | Specific Gravity g/cm³ | AASHO Soil Classification | Unified Soil Classification | Experimentors Parameters (real numbers) #1 | #2 | #3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | |

## PURDUE/LARS SOILS RECORD SHEET NO. 5

| Obser. Code | Soil Elevation (meters) | DUP | Experimentor's Parameters (real numbers) #4 | #5 | #6 | #7 | #8 | #9 | #10 | #11 | #12 | #13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |

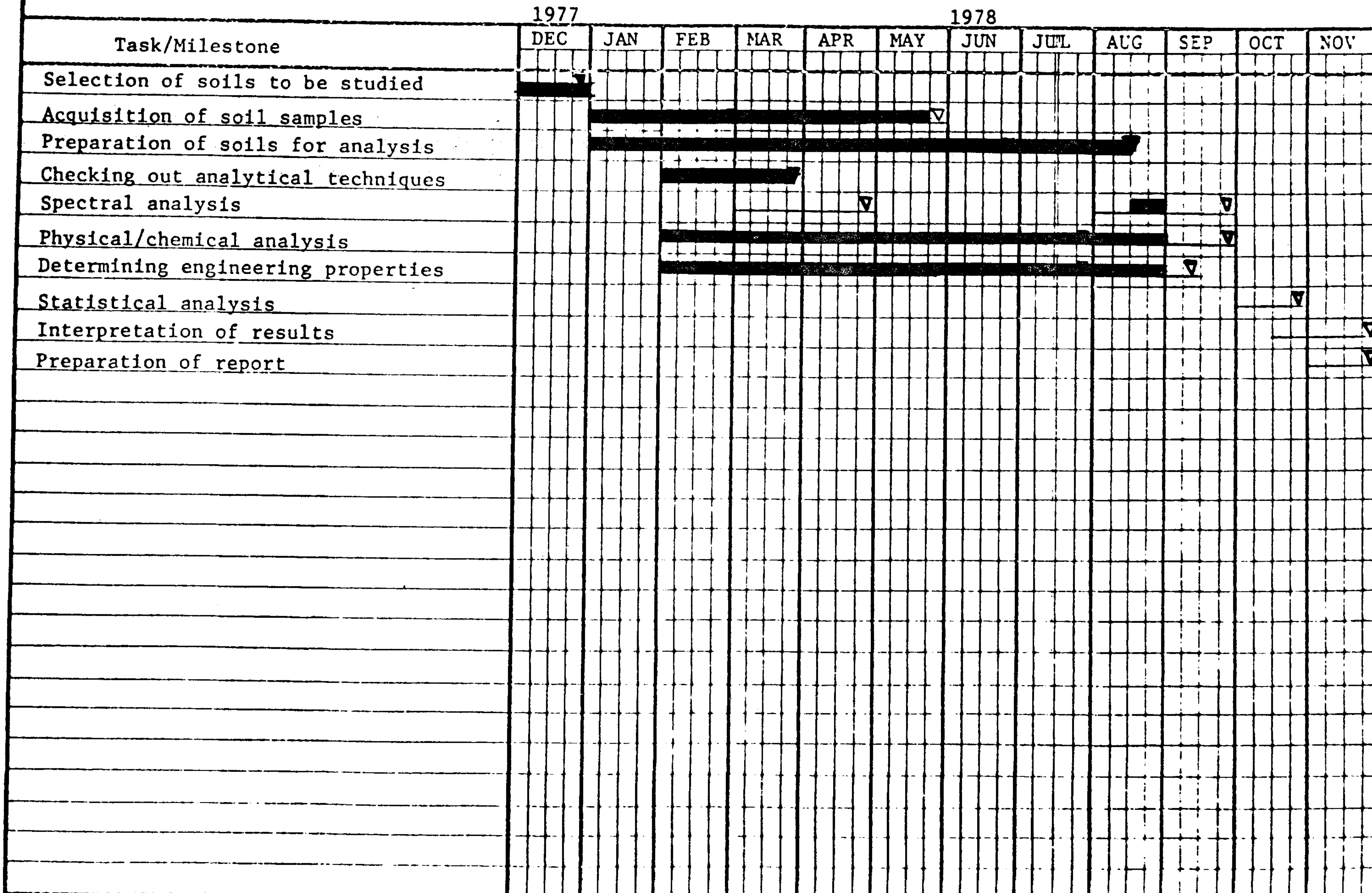
## PURDUE/LARS SOILS RECORD SHEET NO. 6

| Obser. Code | Natural Vegetation or Crop | Surface Condition or Tillage-Planting System | Comments |
|---|---|---|---|
| | | | |

## PURDUE/LARS SOILS RECORD SHEET NO. 7

| Obser. Code | Comments (cont.) | DUP | Comments (cont.) |
|---|---|---|---|
| | | | |

# 1C. Determining the Climatic and Genetic Effects on the Relationships between Multispectral Reflectance and Physical/Chemical Properties of Soil



# 2. PROCESSING TECHNIQUES DEVELOPMENT

## A. Application of Statistical Pattern Recognition to Image Interpretation.

### I. Introduction

The objective of this task is to apply statistical pattern recognition techniques for the purpose of upgrading the reliability and objectivity with which analyst interpreters (AI's) can label wheat samples. It is intended to determine the extent to which the sample labeling process is amenable to machine implementation.

Efforts this quarter continued to be applied to the accumulation of LIST performance data through application of the LIST method to LACIE imagery. Statistical analysis was applied to the results obtained to date, and a critique of the LIST questionaire was developed by the data analysts at LARS. The assembly of the CITARS data to support future Multicrop studies by JSC was also pursued.

A revised implementation plan for this task, solicited by JSC to reflect the growing importance of Multicrop efforts, was reviewed during the last quarterly meeting at JSC in June, 1978. At that time it was concluded that, due to budgetary constraints, LARS would not extend its wheat labeling studies to corn and soybeans. However, LARS would support the Multicrop effort by preparing multispectral and reference data from CITARS in the form of PFC products and multiacquisition tapes in Universal format.

A major staff change at LARS affecting this task took place in June with the departure of Barbara J. Davis. This has necessitated a reallocation of responsibility among existing and new personnel assigned to the task; every effort is being made to minimize the impact of these changes on anticipated progress.

### II. Major Accomplishments

#### a. LACIE Data Set Assembly

The supporting data rquired to analyze the LACIE Blind Sites outside of Kansas have been compiled. There are two gaps in the data. Because of data quality problems, EROS Data Center was unable to supply full-frame color imagery for segments 1652 (ND), 1927 (ND), and 1677 (SD). Also still missing are ERIM-generated digitized ground truth data for 1977 Kansas segment 1861, 1977 North Dakota segments 1633, 1637, 1652, 1661, and 1897, 1977 South Dakota segments 1677, 1681, 1800 and 1811, and 1977 Minnesota segment 1825. The data now on hand are sufficient for all planned labeling, but the missing ground truth data are required for evaluating the labeling results.

b. LIST Analysis of Blind Site Data

Staffing changes cited above precluded completion of the labeling analysis of the Kansas Blind Sites. Two of three analysts have completed labeling all seven segments, and their results and the associated ground truth have been digitized for evaluation. The third analyst has completed four of the seven segments.

Some work has also been completed on the North Dakota segments. Segment 1660 appears to have severe misregistration problems and has been deleted from all further work.

To support the North Dakota LIST analyses, typical temporal trajectory plots for North Dakota wheat were required. These plots have not been made available by JSC, necessitating their in-house generation at LARS. Since many different crop environments may occur within a state, it was decided to sample two strata from Kansas and two from North Dakota. Blind site data were selected from segments with adequate cloud-free acquisitions throughout the growing season. Cluster analysis was used to identify spectral subclasses, and the mean green numbers and brightness values were plotted.

Table 2A-1 lists the segments used to develop the trajectory plots and the plots are sketched in Figure 2A-1. Our experience has shown that the variability of wheat pixel trajectory plots is considerable. Although the LIST questions ask for comparisions of actual greenness and brightness values at pixels against "typical" trajectories, such specific comparisions are rarely helpful in the labeling process. Rather it is the general shape of the wheat temporal trajectory which is useful. In fact, this is considered by our AI's to be the most valuable information currently available for performing the labeling process. In this same sense, we would characterize

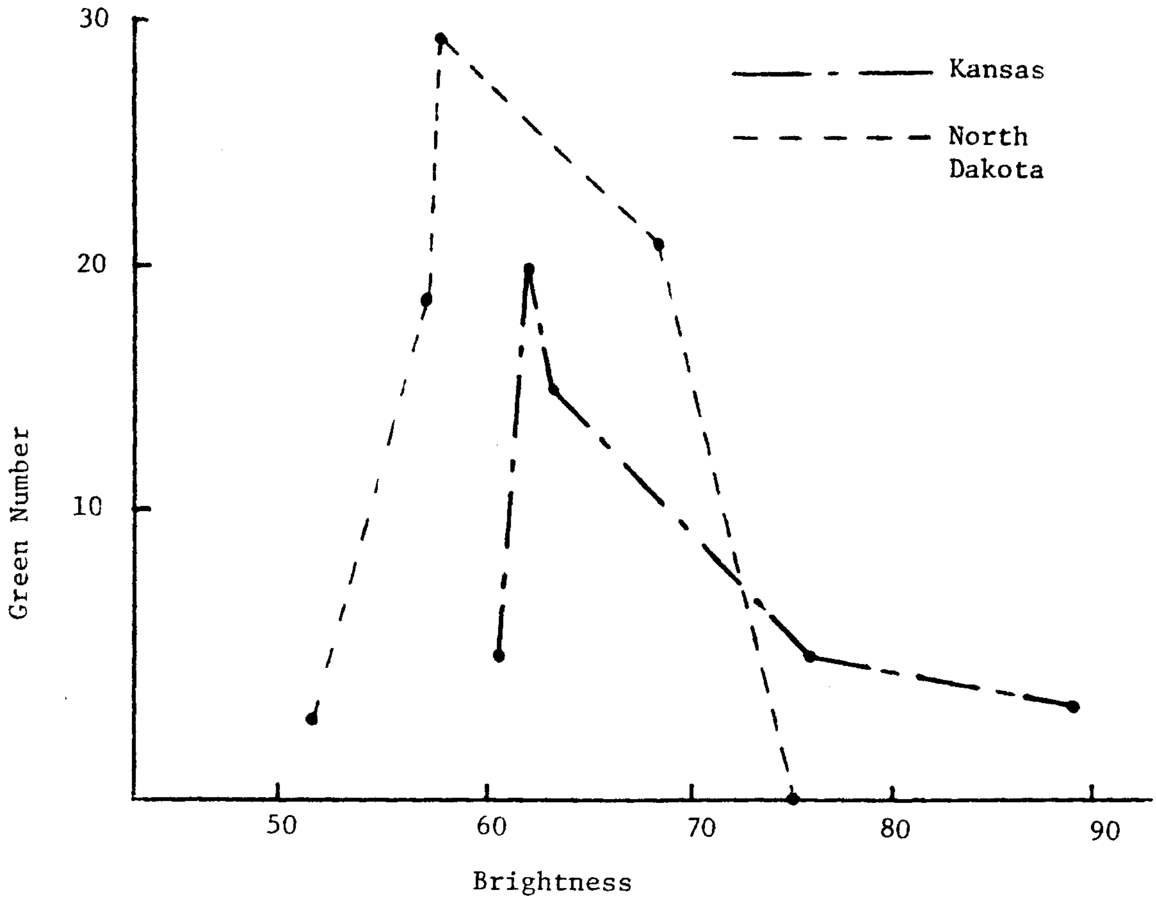



Figure 2A-1 Typical trajectory plots for winter wheat in Kansas and North Dakota.

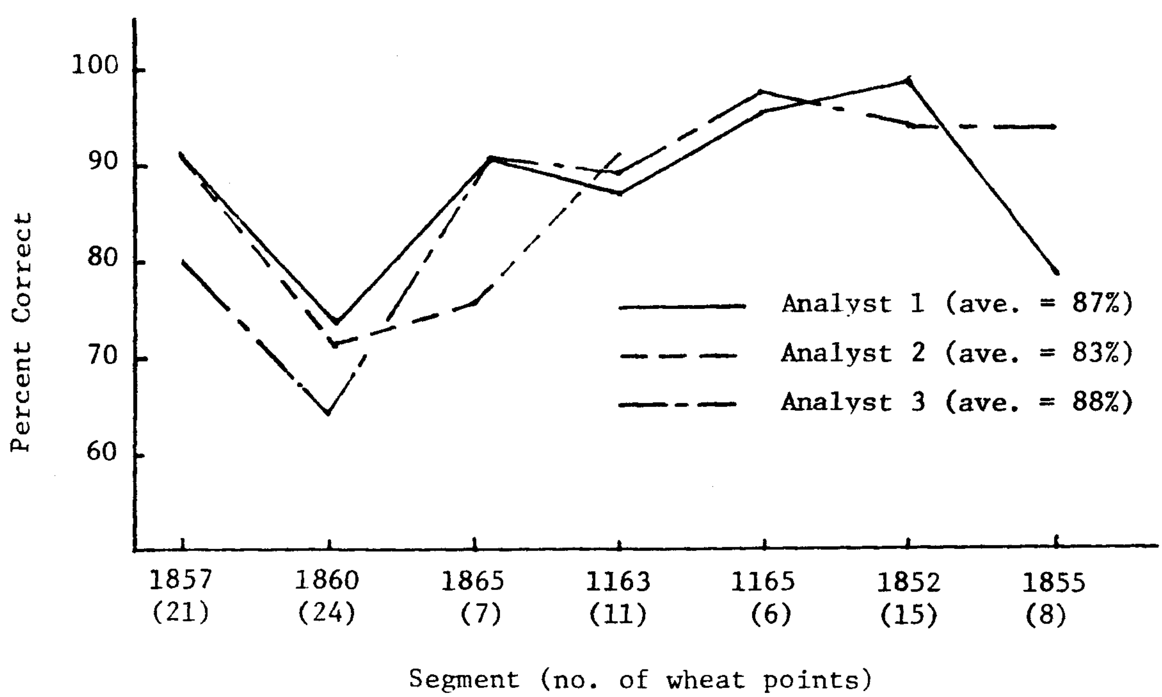



Figure 2A-2 Labeling accuracy for Kansas segments.

the Kansas and North Dakota plots in Figure 2A-1 as "similar", even though they differ considerably in absolute terms.

Table 2A-1. Blind sites used to develop typical trajectory plots for winter wheat.

Kansas Blind Sites

| 1036 (Grant Co.), | 1065 (Haskell Co.) |
|---|---|
| Acquisition Date | Robertson Biostage |
| October 23, 1973 | 2 (Emergence) |
| May 9, 1973 | 3 (Jointing) |
| May 27, 1973 | 4 (Heading) |
| June 16, 1973 | 5 (Soft Dough) |
| July 3, 1973 | 6 (Hard Dough) |

North Dakota Blind Sites

| 1618 (Grand Forks Co.), | 1642 (Cass Co.) |
|---|---|
| Acquisition Date | Robertson Biostage |
| May 25, 1976 | 2 (Emergence) |
| June 11, 1976 | 3 (Jointing) |
| June 31, 1976 | 4 (Heading) |
| July 18, 1976 | 5 (Soft Dough) |
| August 23, 1976 | 7 (Harvest) |

c. LIST Performance Assessment

Labeling results to date for the Kansas segments are plotted in Figure 2A-2. The general trend of these results suggests that which segment is being analyzed has a more pronounced effect on the results than the analyst producing the results. There is further evidence to support this conclusion. Table 2A-2 characterizes the major sources of error for the four segments processed by all three analysts.

Table 2A-2 Major Contributions to Labeling Error

| Segment \ Analyst | 1 | 2 | 3 |
|---|---|---|---|
| 1857 | Wheat low<br>Fallow high | Wheat low<br>Fallow high | Fallow high |
| 1860 | Wheat high<br>Fallow low | Wheat/non-small grains confusion | Wheat low |
| 1865 | Small grains high | Small grains high | Small grains high |
| 1163 | Wheat/non small grains confusion<br>Fallow high | Wheat low<br>Fallow high | Wheat high<br>Edges high<br>Fallow low |

For the most part, although the types of errors vary from segment to segment, all analysts tended to make the same type of error on a given segment. Still further substantiation of the "segment effect" was provided by an analysis of variance of the results of the four completed segments. The details of the analysis of variance will be reported when the Kansas blind site analyses have been completed.

d. Evaluation and Refinement of the LIST Questionnaire

With the LIST analysis of the Kansas data largely completed, the analyst interpreters at LARS were asked to comment on the general procedure and the LIST questionnaire in particular. We summarize here the more significant responses.

It is not surprising to find that the LIST process is quite tedious due to the quantity of data handling involved and the number of questions to be answered. It is clear that automation of the process to the extent possible is warranted, even if to maximize the effectiveness of the AI. rather than to reduce or eliminate his role in the actual labeling decision. To maintain a high level of motivation, the analyst should understand the role of every question in the list, and should be provided as much feedback as possible with respect to performance. To our knowledge, sufficient attention has not been paid to these aspects so far. Also, the specific data products and/or responses to previous questions to be used to answer each question should be clearly described. Otherwise, the analyst may overlook an important piece of evidence, and analyst-to-analyst variability will be increased.

In the present LIST questionnaire, the analysts are directed to skip a number of questions if a pixel is temporally misregistered. However, a labeling decision is still sought. Our analysts feel strongly that these pixels should be deleted from consideration altogether, because for these pixels the important trajectory information is unavailable. Certainly the reliability and utility of data under such circumstances is doubtful.

The "Kraus product" PFC imagery is intended to provide "normalized" color imagery so that acquisition-to-acquisition comparisons of imagery can be made more meaningfully. According to our analysts, this end has not been achieved. More specifically, it does not appear that the "redness" of a field in the Krauss product can be taken as a direct indication of the vegetative state or quality of the field. The analysts feel that the "Product 1" imagery is still the most interpretable and information-bearing.

The "natural" way to use the LIST questionnaire is to analyze one pixel at a time, working completely through the questionnaire for each pixel. This could be called "dot-serial analysis." It has been suggested by our analysts, however, that a "dot-parallel" approach may be more effective, answering one or a small number of questions for every dot. The latter approach reduces the tedium due to paper shuffling (less handling of analyst aids), is faster, and may lead to more accurate results because it is easier to incorporate contextual information (comparison of dots) into into the labeling process.

Finally, every question in a procedure such as this should be checked for operational "answerability," since it is possible for questions which appear to be fairly straightforward to be virtually impossible to answer in practice. Example:

Q43. If more than one non-small grain spectral signature is observed, do the proportions of the signatures correspond to the historical non-small grain percentages?

Yes: Non-small grains - STOP
Indeterminate
No: Go to 44

The analyst is called on to perform two quantitative operations, neither of which is trivial and neither of which he is well-equipped to carry out. He is asked to estimate the proportions of the segment occurring as various spectral signatures (at least some probably occurring in fairly small percentages scattered over the segment), but he is likely to feel that a pixel count to obtain such an estimate is unwarranted and too time-consuming. And he is asked to determine whether these estimated percentages "correspond" to historical data, but no guidance is given as to how closely or in what manner the percentages must match to motivate a particular choice of answer.

Similar comments pertain to questions 45-51, where the analyst makes a final attempt to discriminate wheat from other small grains.

The impact on the analyst interpreter of "unaswerable" questions such as the above can be devastating. At minimum he will be frustrated by his own inability to provide a meaningful answer to the question, an answer he can feel confident about. At worst, the presence of such questions will raise doubts in his mind about the extent to which the questionnaire was operationally tested by the "experts" who devised it, and may call into question in his mind the utility of the entire process. In any case, if the labeling process depends in any significant way on such questions, the reliability of the results will certainly be reduced.

A more detailed compilation of the analyst comments will be provided in a separate report during the next quarter.

III. Technical Problems Encountered

a. Data Acquisition

1. ERIM-generated digitized ground truth data for the 1977 crop year segments 1633, 1637, 1663, 1652, 1677, 1681, 1800, 1811, 1825, 1861, and 1897 have not been received from JSC. 2. Full-frame Landsat imagery is not available for segment (date) 1652 (7-16-77), 1677 (8-1877), or 1927 (8-17-77).

b. LIST Analysis of Blind Site Data

We have assessed and summarized the problems encountered in applying the LIST method:

1. Interpretation keys have never been made available by LEC/JSC (question no. 34).
2. Data are not available on 3-days-prior precipitation (question no. 18).
3. Data have not been automatically screened for DO and DU prior to analysis (questions no. 26,27).
4. We have been unable to locate specific documentation for correction of green numbers to 60° north latitude (question no. 36).
5. With available spectral aids (see item 1 above), it does not appear possible to make the distinction between wheat and other small grains based on the present LIST questions 45-51.
6. Typical trajectory plots for winter wheat are too general to use for precise numerical comparison of trajectory plots of pixels to be labeled. However, the general shape of the plot is considered to provide useful information.

None of the foregoing problems are considered serious relative to progress of this task.

c. Assembly of CITARS Data

1. Some difficulty has been encountered in determining the precise method by which JSC determined gains and biases for a PFC tape. The methods initially documented by JSC have apparently been modified, and the modification is not yet fully understood at LARS. Thus the single-acquisition PFC tapes of the CITARS data have yet to be transmitted to JSC.

2. The Universal tape format for multiacquisition data is not fully defined. LARS has not yet obtained adequate documentation of the format assumed by JSC and has been unable to produce a Universal format multi-acquisition tape of the CITARS data which is readable by the EODLARYSYS software.

These problems need to be resolved to produce the desired data products. LARS will continue to pursue them.

The major difficulty this quarter has been administrative rather than technical, namely the staffing changes brought about by the departure of the project manager. All aspects of the work have been somewhat slowed by this, but the greatest impact has been on the modeling, analysis and revision of the LIST process.

IV. Activities for the Fourth Quarter

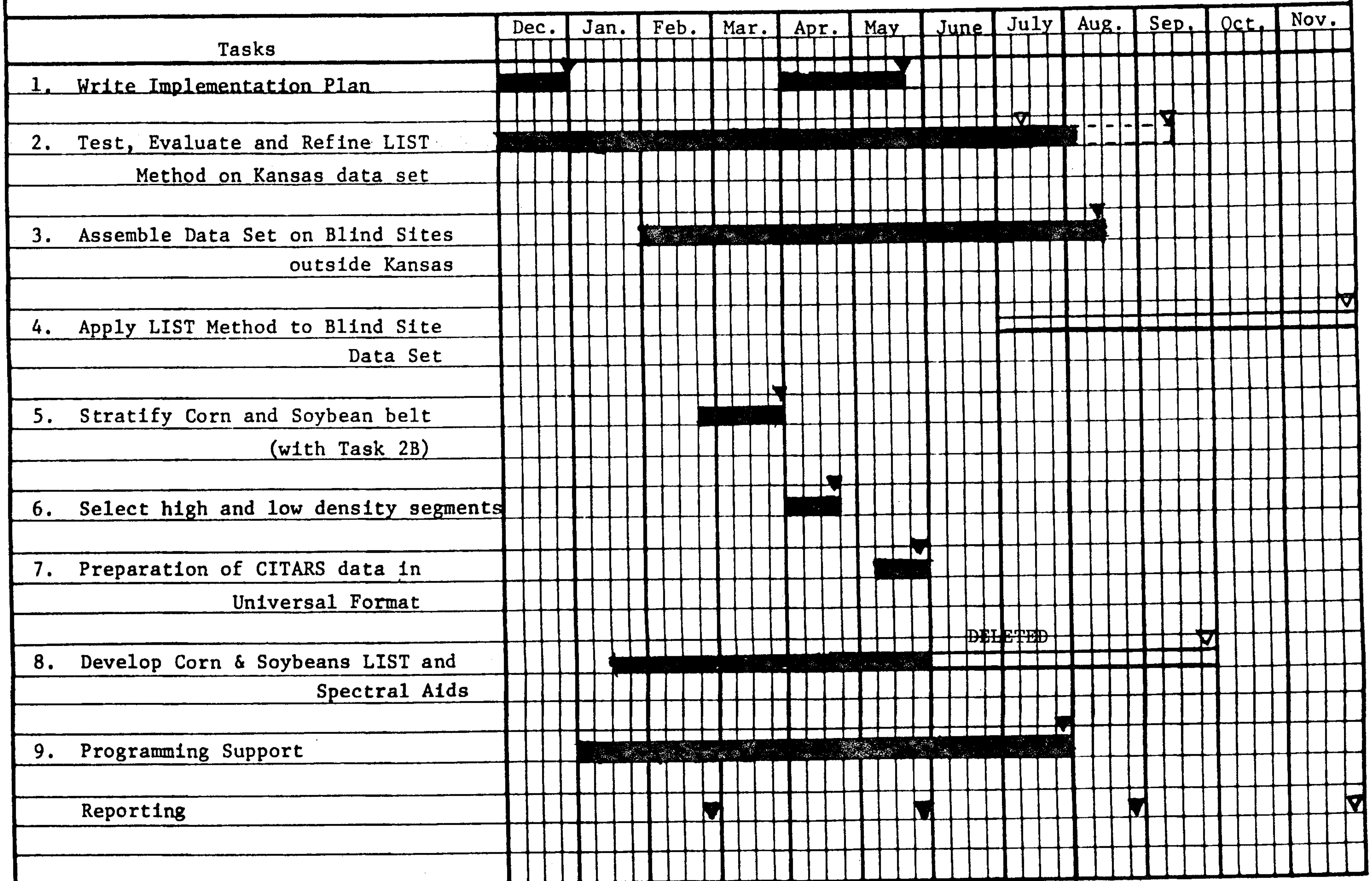
During the next quarter, all data analysis by LIST will be completed, documented, and evaluated. Detailed assessment of the strengths and weaknesses of the process as it now stands will be used to propose a revised and more effective questionnaire.

Statistical modeling of the LIST process will be pursued and, hopefully, a general design and evaluation scheme will be proposed.

CITARS data assembly will be completed, pending resolution of the difficulties cited above, and the data will be available at JSC and on the LARS computer system.

The final report on this task will be prepared and delivered to JSC.

Figure 2A- 3 Implementation Schedule (revised to reflect impact of Multicrop effort)



## B1. Application and Evaluation of Landsat Training, Classification, and Area Estimation Procedures for Crop Inventory

### I. Introduction

This task supports the classification and sampling and aggregation components of the multicrop research effort. A preliminary study using currently available data is evaluating the procedures used in LACIE for wheat area estimation when applied to corn and soybeans and recommending changes in the procedure for the new classification problem. When the 1978 multicrop Landsat and reference data become available, recent developments in scene stratification, training sample selection, classification algorithms, and area estimation methods will be considered in the development of an inventory system for corn and soybeans.

During this quarter, the primary activities of this task concerned evaluation of the LACIE Procedure 1(P-1). Data acquisition was underway although no new data has been received at LARS. Data needs of JSC and UCB were addressed.

### II. Objectives

This task is the first part of a two year effort to advance the development of large area crop inventory systems for multicrop regions by applying and evaluating recently developed techniques. The investigation is divided into two phases: a preliminary study and a major study.

The primary objectives during year one are:

(1) To develop the experiment design and approach and define data requirements for the major study.

(2) To conduct a preliminary study using currently available data to evaluate P-1 for a corn/soybeans/"other" crop identification problem and investigate changes to improve the performance of P-1 on corn and soybeans.

The objectives of the major study include studying methods for training area selection and integration and evaluation of training, classification, and area estimation procedures. Specific objectives of the major study can be found in the implementation plan or in the previous quarterly report.

## III. Approach

In the preliminary study, data on corn and soybeans acquired for the CITARS project are being used. Grids falling in areas with reference data (ground observed or photointerpreted crop types) were digitized and the pixels were associated with "ground truth" labels. This aspect of the approach permits evaluation of the analysis procedure rather than the image interpretation accuracy. Each CITARS segment is being analyzed as four 5 x 5 mile blocks.

In the assessment of LACIE P-1, default parameters are being used. These settings are not optimal for the corn/soybeans/"other" crop identification problem due to differences in the spectral distribution of the crops of interest from that of wheat, presence of more confusion crops, differences in crop calendar, and other factors. A sequential decision procedure or response surface design will be used to study improvements in accuracy due to parameter changes.

## IV. Accomplishments this Quarter

During this quarter, the primary activities of this task were concerned with the preliminary study, in particular, the evaluation of P-1. Data acquisition for the major study was initiated by USDA and NASA, but no 1978 data has been received by LARS to date. Each aspect of the task is discussed along with progress made and difficulties encountered.

### a. Acquaintance of Personnel with Procedure 1

New personnel on the project were introduced to P-1 and all analysts continued familiarization with the system through use of the programs.

b. Generation of Dot Files

Dot grids have been digitized from CITARS overlays of ground truth or photointerpreted areas. The coordinates of these dots have been converted to dot file format and associated with their ground truth labels. Similarly, coordinates of designated other (DO) and designated unidentifiable (DU) fields have been digitized. This task has been time-consuming, but is now almost complete for all segments and acquisitions.

c. P-1 Batch Machine and Exec Routine

These aspects of the task are being addressed by personnel from Task 4 in support of JSC and LARS users. The 2 meg machine required for execution of the P-1 programs was found to substantially slow the computer system. P-1 programs were then generated in module form to require only a 768K virtual machine, thus having less impact on other computer users. The modules are LARS-generated so that it is imperative that we be informed of changes made to the programs by Lockheed so that this version can be kept up to date.

A priority batch machine has been set up to run P-1. Investigation is underway to permit results backup to tape from batch mode which is a needed capability. As computer funds for this project are scarce, we have requested a non-priority, night batch machine.

d. Debugging of P-1 Programs

Although a four channel, single acquisition run was completed several months ago, additional problems continue to be encountered. Each of these problems requires a program change by Lockheed which will take longer than the analysis task can wait. Hence, alternatives must be pursued.

DISPLAY does not handle DO and DU areas appropriately. Both DO and DU fields are excluded from the estimates. In order to match the LACIE procedure, two runs of DISPLAY must be made and the proportion estimates computed manually. This will increase the cost of each classification by about one minute of CPU time and one half hour of personnel time.

DO and DU areas were being ignored by ISOCLS. The problem was reported to Lockheed. LARS personnel traced the problem and found it to be caused by the fact that the words "other" and "unidentifiable" must begin in column 11 rather than column 11 or later as documented. Following this procedure, ISOCLS will produce a statistics deck which appears to have properly excluded the DO and DU areas, although the cluster map and associated table are still incorrect. Programming changes still need to be pursued to "clean up" the ISOCLS processor, but the changes are no longer time critical to our needs.

The use of continuation cards for field description cards does not work in the manner documented. Use of a continuation card causes immediate termination of any processor. To work around this, all DO and DU areas must be split and defined by sufficiently few vertices to fit on one card. The problem was traced by LARS personnel to an error in RDDATA and the appropriate correction has been made to LARS module system.

e. Recommendations for P-1 Programming Changes

Through use of the P-1 programs, several items have been noted which could be improved for easier analyst use or efficiency. The analyst needs to receive more descriptive error messages than are currently implemented. Errors often require programmers or a substantial amount of analyst time to identify. Better error messages would aid the analyst and increase personnel efficiency.

The analyst also needs better documentation for the P-1 software and procedures. Explanation of procedures and control card and output examples are sketchy; discussion of errors is non-existent. Better documentation would increase personnel efficiency by reducing the necessity of the "trial-and-error" procedure.

Program efficiency could be improved by saving the MSS data in core rather than reloading it from tape each time it is used.

Conditions sometimes exist which will cause difficulties later on in the analysis sequence. It would seem more logical to terminate the program or take remedial action when such a case arises rather than to attempt further execution. Two such situations have been identified. If there are fewer points in a cluster than the number of channels, the program should not proceed past ISOCLS but either give an error message and terminate or force a combine sequence until the criterion has been satisfied. Another situation which can arise is that no dots are assigned to one of the categories in LABEL. In this case, an error message should be printed immediately and processing terminated.

f. Recommendations for a Corn/Soybeans Crop Inventory System

The general methodology for crop inventories of corn and soybeans needs to be of somewhat different design than for wheat. In corn and soybeans production areas, the practice of double cropping, particularly soybeans following winter wheat, is becoming increasingly important. A methodology for classification of double cropped areas needs to be developed. Cloud cover is a greater problem in the Corn Belt than in the U.S. Great Plains; this has potential impact on the handling of DU areas. If only the area which is cloud-free on all four acquisitions is used for area estimation, insufficient pixels may be available to give accurate and precise estimates for the segment proportions. If DU areas exceed a certain percentage of land area in a segment, perhaps three cloud-free acquisitions could be used to classify some additional areas.

More specific alterations to Procedure 1 may also be required. A higher frequency dot grid may be required to obtain sufficient training dots which are not edge or boundary pixels. More than the LACIE minimum of 30 Type 1 and 40 Type 2 dots may be required to guarantee sufficient training for each of the three categories. A priori probabilities computed from the number of classes in each category may tend to bias results if the distribution of dots is not relatively representative of the true proportions of each category present in the scene. Cluster parameters including k-nearest neighbor and the number of iterations may need to be changed.

Evaluation of some of the above ideas and further recommendations will be forthcoming in the final report.

g. Data Needs of UCB and JSC

A request for CITARS ground truth was made by UCB on June 19. In response to this request, two types of data were supplied: (a) copies of MSS data overlays indicating field boundaries and (b) listings of section and quarter section boundaries and coordinates of field center pixels.

At the request of Keith Henderson during his visit to LARS, data used for the stratification work by LARS were supplied to JSC. On July 31, a tape was prepared containing USDA/SRS acreage, yield, and production data by county for all states in the U.S. Both single year data and five year averages were included for each cover type. All files provided had some data verifications performed. Also provided were a list of problems encountered with the data and actions taken, an explanation of the tape files, and line printer examples of the types of data provided.

V. Plans for Next Quarter

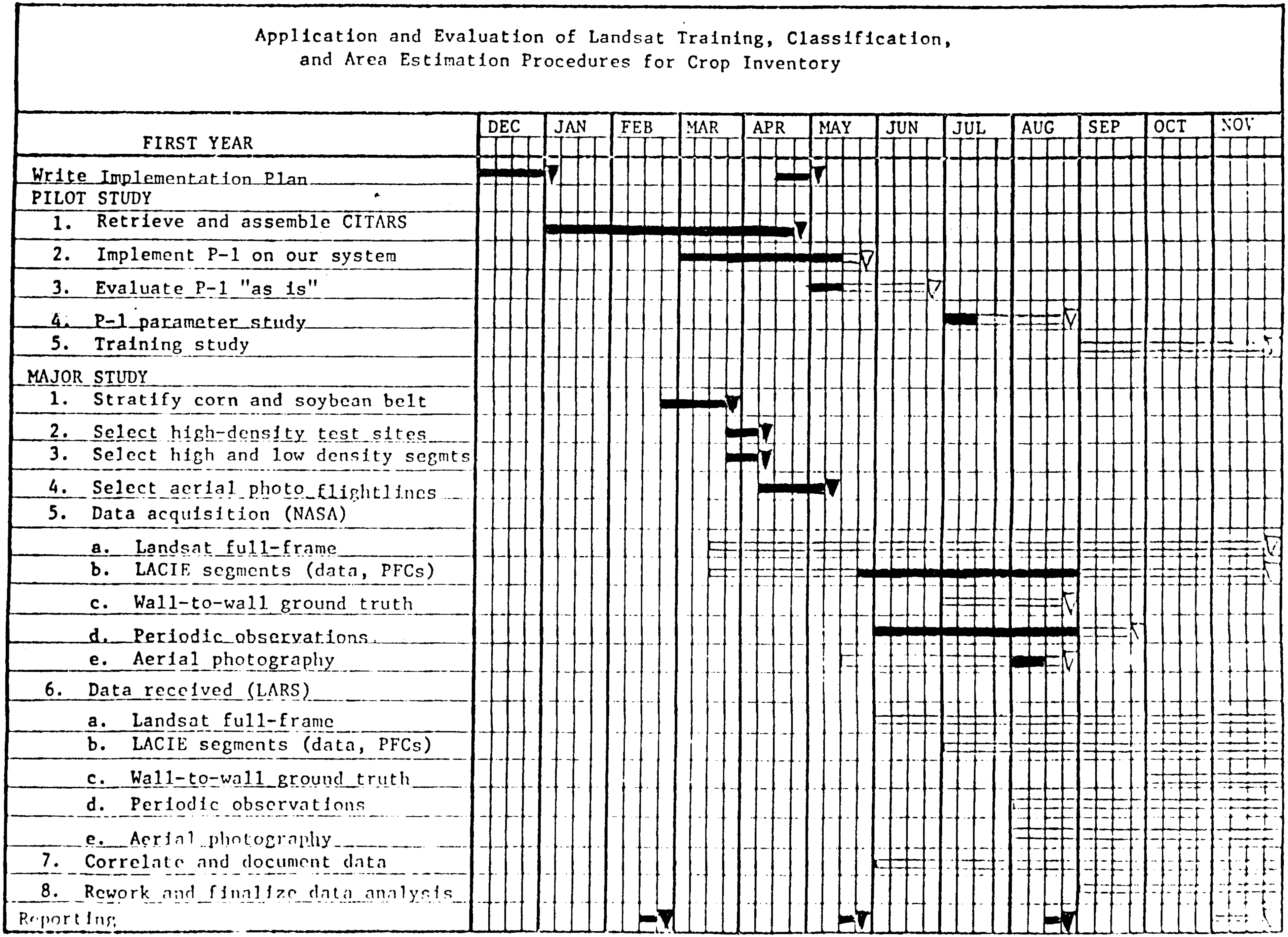
During the next quarter, evaluation of P-1 on the CITARS data and study of an improved crop inventory system for corn and soybeans will continue. If funds permit, reformatting and preparation of the data for the major study will begin when it is received.

VI. Critical Issues

Support of the LACIE P-1 programs by JSC needs to be continued and increased if possible. Problems which have already been identified require programming changes by Lockheed and any problems which may arise in the future will need support from Lockheed personnel.

Computer funding for this project has been a critical issue and is becoming increasingly critical since more time is spent debugging and since program errors result in decreased efficiency of analysis. When the implementation plan was revised, it was our understanding that sufficient funds to cover the increased emphasis on analysis were available from Task 4. This is not true now and, if no additional funding can be obtained, fewer of the planned analyses will be conducted. Anticipated budget cuts are: postponement of training studies, unitemporal analyses only on all segments except Fayette, and postponement of data reformatting.

Figure 1. Implementation Schedule.



## B2. Spectral Reflectance and Radiant Temperatures of Stressed and Non-stressed Corn and Soybeans.

### I. Introduction

As part of the Landsat/Crop Inventory task a supporting field research effort was initiated in the spring of 1978. It includes two components: (1) acquisition and analysis of spectral and agronomic measurements for corn and soybeans and (2) development of the specifications for a multispectral data acquisition system for field research.

### II. Objectives

The overall objectives of this field research task which include data acquisition and analysis are as follows:

1. To determine the reflectance characteristics of corn and soybeans as a function of maturity stage and amount of vegetation present.
2. To examine the effects of moisture and nutrient stresses on the reflectance and radiant temperatures of corn and soybeans.
3. To determine the effect of important cultural/management practices on the reflectance of soybeans.
4. To develop and assess various methods of incorporating spectal, meteorological, and ancillary data into models of crop condition assessment and yield prediction.

Activities this quarter towards fulfillment of the objective include collection of spectral, agronomic, and meterological data at the Purdue University Agronomy Farm for six experiments with two different spectrometer systems.

### III. Approach

Several specific experiments have been established at the Purdue Agronomy Farm to address the above objectives. The experiments, described in the implementation plan, are; corn moisture stress, nitrogen fertilization of corn, phosphorous and potassium fertilization of corn and soybeans, and cultural practices of soybeans. The experiments provide both normal and stressed conditions of corn and soybeans. Spectral, as well as agronomic and meteorological data are collected at approximately weekly intervals throughout the growing season.

Spectral measurements are being made with the Exotech 20C high resolution spectrometer system and the Exotech 100 Landsat-band radiometer. The Exotech 20C field system collect data every .01 micrometers from .4 to 2.4 micrometers. The Exotech 100 field system collects data in the four Landsat bands .5-.6, .6-.7, .7-.8, .8-1.1 micrometers. The spectral data are being calibrated using four foot square painted barium sulfate standards.

Augmenting the reflective measurements are radiant temperature measurements collected by PRT-5's and oblique and vertical photographs of the plots. The meteorological data includes air temperature, barometric pressure, relative humidity, wind speed and wind direction. A record of the irradiance is collected on pyranometer strip charts.

Detailed agronomic measurements of the crop canopies included leaf area index, fresh biomass, dry weights of leaves, stems, and ears (pods for soybeans), heights, maturity stage, percent of soil cover, and soil moisture. Leaf samples are being collected and dried for nutrient analysis.

The approach to each of the objectives is briefly summarized below. The first of the overall objectives of this task will be accomplished in the course of conducting specific experiments for Objectives 2 and 3. Spectra of normal (unstressed) corn and soybeans will be assembled and plotted to represent their reflectance as a function of maturity stage, biomass, leaf area index, height, and percent cover.

To accomplish the second objective different experiments, one on moisture stress and one on nutrient stress will be conducted. Plots of both experiments will be established on soils which are typical of many of the soils of the Corn Belt and on the Managed Soil Moisture System (MSMS). The MSMS facility is a series of plastic-lined plots equipped with pipes and pumps so that water and/or nutrient supply can be controlled and either type of stress can be imposed on the crop. Spectral reflectance, radiant temperatures, and agronomic characterizations (i.e., LAI, biomass, height, etc.) of the stressed and nonstressed canopies will be acquired once per day at 7 to 10 day intervals. On selected days during the season, reflectance, radiant temperature, and leaf water potential will be measured 4 to 8 times to monitor the diurnal changes in these parameters due to stress.

The third experiment would examine the effects of different plant types, planting densities (within row spacings), and row spacing on the reflectance of soybeans. Reflectance data from the Exotech 100 along with measurements of canopy variables (i.w., LAI, biomass, height, ground cover) will be used not only for characterizing the reflectance of soybeans but also for examining the physical basis for increased soybean production at narrow row spacings.

The fourth objective involves the assimilation of the data collected in these experiments into information which can be used in crop models to evaluate crop growth and to predict yields during the growing season. This objective represents one of the long range goals of this task and during the contract year will consist primarily of the conceptual development of crop yield models which will incorporate spectral, meteorological, and ancillary data.

The data acquired in this task and some previously acquired data (i.e., Exotech 20C data acquired in preliminary experiments on corn and soybeans during 1972 to 1974), will be assimilated into information during the data analysis phase. To achieve the objectives of this task statistical analyses will be performed starting early in the fall and extending through next summer. Various types of plots of the reflectance, radiant temperature, agronomic, and meteorological data will be made to verify data quality and to assess qualitatively the information contained in the data. Spectral data will be represented in several ways for analysis: band means for Landsat and the proposed thematic mapper bands; and transformations of the reflectance values such as IR/red ratio and greenness-brightness. Canopy radiant temperature data will be represented as absolute temperatures, as relative temperature differences (canopy temperature minus air temperature), and as accumulated relative differences in temperature during critical growth phases. Regression and correlation analyses will be used to relate biological and physical parameters of the canopies, such as leaf area index, biomass, height, leaf water potential, and maturity stage to measures of spectral response and radiant temperatures. Analyses of variance and covariance will be used to determine the threshold of detection and the separability of various levels of stress from each other.

## IV. Accomplishments this Quarter

Spectral measurements, along with agronomic and meteorological data, have been acquired on every day that weather conditions permitted. A summary of the data collection (number of observations per experiment) is shown in Tables 2B-1 and 2B-2.

The cool wet weather of the spring of 1978 delayed soil preparation and corn planting at the Agronomy Farm and necessitated some modifications in the experiments planned. The Russell soil on which the corn irrigation experiment was to be planted remained too wet for plowing until early June. On June 9 (a full month after the optimum planting data for corn) the first corn of this experiment was planted. This date was too late to include a series of later planting dates as indicated in the implementation plan. Instead a small experiment on the effects of soil surface moisture (wet vs dry) on the reflectance of corn canopies was initiated.

More frequent rains then normal during the summer also made establish ment of different levels of water stress nearly impossible. Short-term differences in soil moisture were established on several occasions and radiant temperature and water potential were measured.

Table 2B-1. Summary of data acquisition (number of observations) by the Exotech 20C data acquisition system.

| Dates | Corn Moisture Stress | Corn Canopy/Soil | Corn Phosphorous/ Potassium | Soybean Phosphorous/ Potassium | Corn Nitrogen |
|---|---|---|---|---|---|
| June 11-17 | 28 | - | 14 | - | - |
| June 18-24 | - | - | - | - | - |
| June 25-July 1 | 6 | - | - | 10 | 20 |
| July 2-8 | 6 | - | 48 | 56 | 33 |
| July 9-15 | 97 | - | 16 | 6 | 15 |
| July 16-22 | 8 | 16 | 16 | 29 | - |
| July 23-29 | - | - | 18 | - | 17 |
| July 30-August 5 | 8 | - | 29 | 25 | 17 |
| August 6-12 | 41 | - | - | - | - |
| August 13-19 | - | - | - | 5 | 16 |

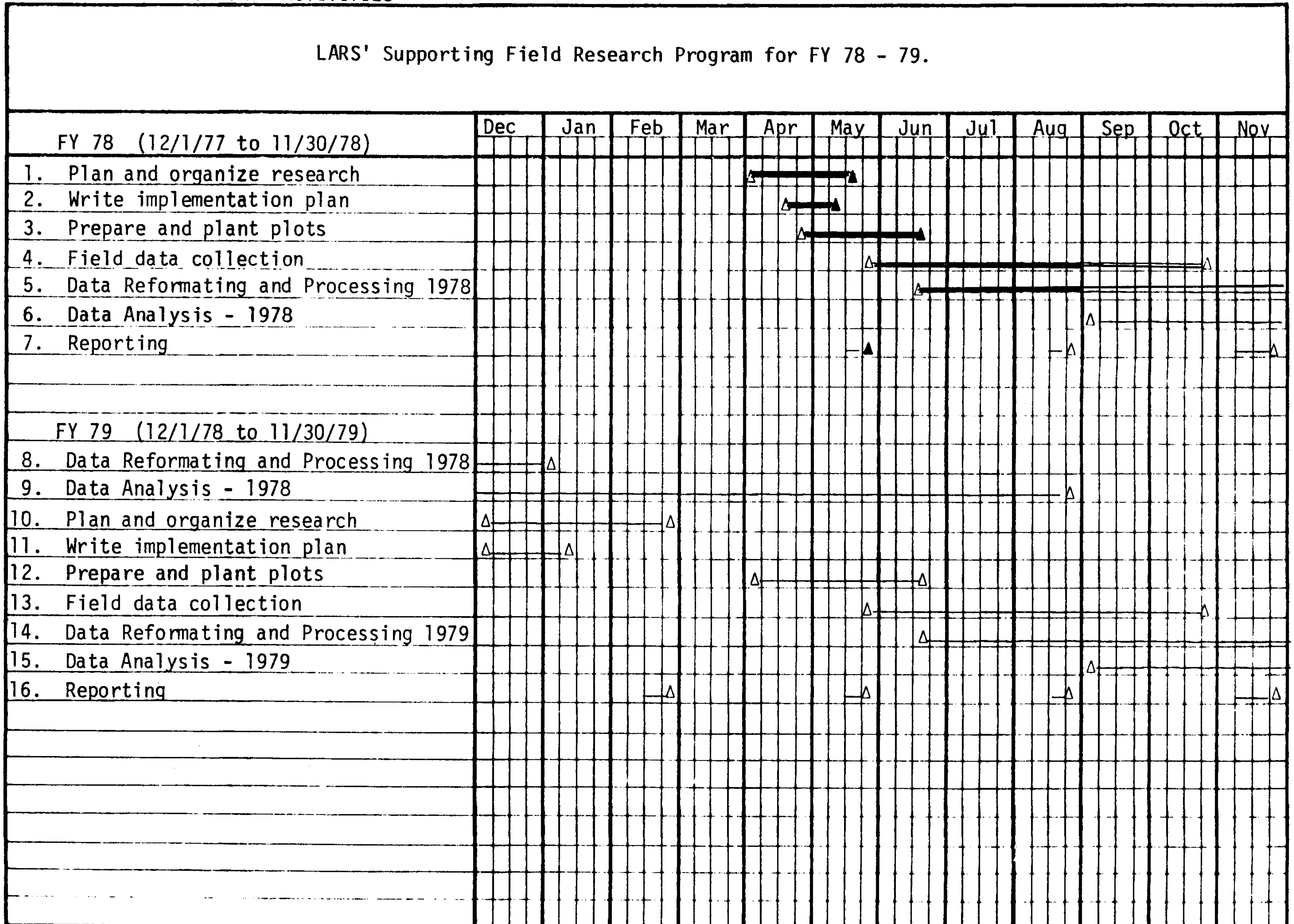
Table 2B-1. Summary of data acquisition (number of observations) by the Exotech 100 data acquisition system.

| Dates | Moisture Stress | Corn Phosphorous/ Potassium | Soybean Phosphorous/ Potassium | Soybean Management | Corn Nitrogen |
|---|---|---|---|---|---|
| June 18-24 | 96 | - | - | 54 | - |
| June 25- July 1 | - | 92 | 66 | - | 48 |
| July 2-8 | 84 | 70 | 84 | 332 | 48 |
| July 9-15 | 48 | 46 | 64 | 162 | 26 |
| July 16-22 | - | - | - | 171 | - |
| July 23-29 | - | - | - | 162 | - |
| July 30- August 5 | - | - | 22 | 218 | - |
| August 6-12 | - | 46 | 42 | 54 | 26 |
| August 13-19 | - | 46 | - | 108 | 20 |

## V. Plans for Next Quarter

During the next quarter the collection and processing the 1978 corn and soybean data will be completed and the data analysis will begin.

## E. SUMMARY OF TASK ACTIVITIES



# B3. Specification of a Standardized Multispectral Data Acquisition System for Field Research

## I. Introduction

To develop the full potential of multispectral data acquired from satellites, increased knowledge and understanding of the spectral characteristics of specific earth features is required. Knowledge of the relationships between the spectral characteristics and important parameters of earth surface features can best be obtained by carefully controlled studies over areas, fields, or plots where complete data describing the condition of targets is attainable and where frequent, timely spectral measurements can be obtained. The currently available instrumentation systems are either inadequate or too costly to obtain these data. Additionally, there is a critical need for standardized acquisition and calibration procedures to ensure the validity and comparability of data.

The overall, long-term objective of this project is to develop a multispectral data acquisition system which will improve and advance the capability for field research in remote sensing. The specific objectives are to:

1. Specify, develop and test the prototype of a radiometric instrument system.

2. Develop calibration, measurement and operation procedures.

3. Develop software for data handling capability.

The radiometric instrument will be a multiband radiometer with 8 to 10 bands between 0.4 and 2.4 micrometers; the data acquisition system will record data from the multiband radiometer, a precision radiation thermometer, and ancillary sources. The radiometer and data handling systems will be adaptable to helicopter, truck, or tripod platforms. The general characteristics of the proposed system are that it will be: (i) comparatively inexpensive to acquire, maintain, and operate; (ii) simple to operate and calibrate; (iii) complete with data handling hardware and software; and (iv) well-documented for use by researchers.

The specific results of the proposed project will be: (i) a multiband radiometer; (ii) a data acquisition and handling system; (iii) a machine independent software package; and (iv) a comprehensive system manual documenting the design and use of the above. The most significant result will be the establishment of the capability for researchers to acquire the data to effectively investigate relationships between the physical-biological and the multiband spectral characteristics of crops, soils, forests, water, and geological features.

The instrument system will be a prototype of an economical system which can be utilized by many researchers to obtain large numbers of accurate, calibrated spectral measurements. As such it is a key element in improving and advancing the capability for field research in remote sensing.

During this contract year the specifications for the instrument system are being developed.

## II. Objectives

The objective for this contract year is to coordinate development of the specifications and the preparation of request for quotation (RFQ) for a portable, inexpensive field instrument system with multiple, selectable, spectral bands to measure, record, and organize large amounts of high quality spectral data.

## III. Approach

This effort is the initial step required to acquire instrumentation needed for meaningful field research; i.e., development of an inexpensive standardized, versatile field instrument to provide calibrated intercomparable spectral data when used by various organizations. Between May and October, 1978 specifications and RFQ will be developed.

The general characteristics of the radiometer and data acquisition system have previously been described in our proposal. This description and preliminary specifications will be presented to and discussed with active remote sensing researchers at other institutions with regard to their experimental needs and data handling preferences and capabilities. Potential vendors will be contacted for their reaction to the specifications. Vendors will be encouraged to suggest alternate means to obtain a practical, effective, commercially available hardware system. Final specifications will be prepared in cooperation with personnel from NASA/JSC.

A formal request for quotation will be prepared for submission to qualified vendors. The goal will be to ensure that each subsystem will be available for purchase on a continuing basis form a reliable supplier. The document will be prepared in cooperation with personnel from NASA/JSC.

IV. Accomplishments this Quarter

a. Contacts with vendors.

During this period 20 potential vendors were provided copies of an "Informal Request for Consideration", which listed potential specifications for the Data Acquisition and Handling Module and the Multiband Radiometer Module. Professors Silva and DeWitt made follow-up calls to interested vendors. Professor Silva visited eight vendors to discuss the design and specifications of the data logger. Professor DeWitt visited two vendors with regard to the design and specification of the multiband radiometer.

b. Contacts with researchers and potential users.

Professor Silva visited the USDA, Water Conservation Laboratory at Phoenix, Arizona to discuss specific requirements for the Data Recording-Handling and Radiometer Modules. Extensive discussions with visiting scientists at LARS have proved to be useful in substantiating the need for and specifications of the system.

c. Preparation of Specifications

Preparation of tentative detailed specifications was completed in August and the specifications for the Data Module were forwarded to interested manufacturers for their review and modification. The specifications for the Radiometer were forwarded to users for their reactions and suggestions. It is felt that the first draft of the specifications for the RFQ will be completed in September 1978. Significant developments in the specifications for the Data Module are the capacity for direct reflectance computation and the use of removeable semiconductor data storage (instead of magnetic tape). Significant developments in the specifications for the multiband radiometer are the probable inclusion of a channel for 10.5 to 12.5 micrometers and the use of temperature compensated detectors.

d. Preparation of Proposals

Proposals for the development of the Radiometer and Data Modules were submitted to NASA Headquarters in response to Applications Notice OSTA-78-A and to the Director of the Science and Education Administration, USDA.

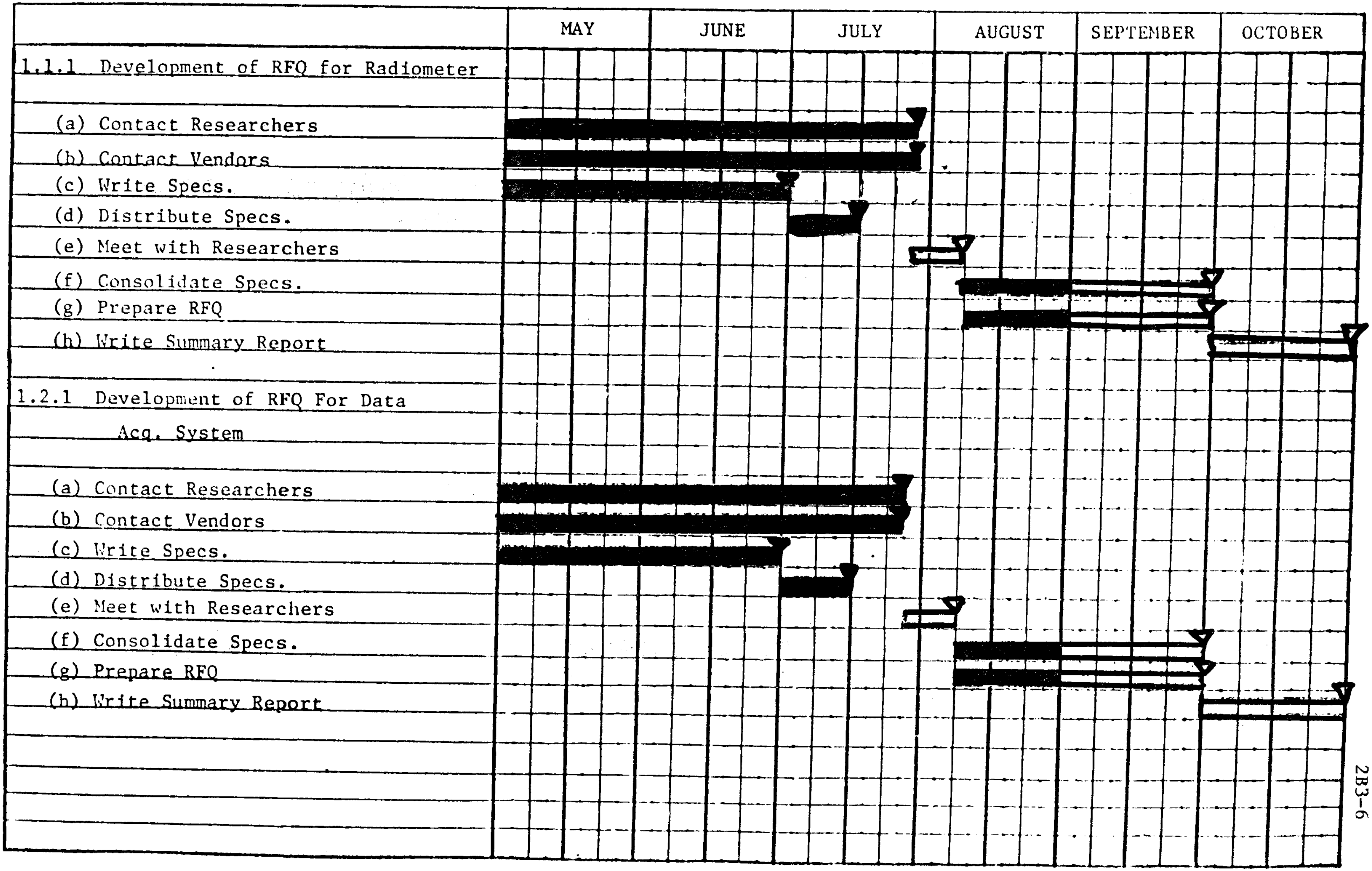
e. Field Tests

An experimental truck-mounted boom has been constructed and tested for measurement of Landsat band bidirectional reflectance factor and radiant temperature. An Exotech Model 100, a Barnes PRT-5 and a motor drive camera were mounted on the boom. The system is being used for corn and soybeans from altitudes of 18 and 11 feet, respectively. The routine use of this system is providing experience which will lead to improved design for an easy to construct, inexpensive, pick-up truck operated system which is sufficiently versatile to serve a large number of researchers. Helicopter operation of an Exotech Model 100 boresighted with a camera was accomplished with the funds of other agencies and projects. Calibration was accomplished on-site with a canvas reflectance panel. The instrument and data acquisition system performed correctly and it was demonstrated that an untrained crew could quickly learn to perform the calibration and data acquisition operations.

V. Plans for Next Quarter

During the next quarter we will meet with researchers and potential users of the instrument system to verify that the specifications are satisfactory, final specifications will be completed, and the RFQ written.

Table I. Task Schedule 1978



## C. Multisensor Radiometric Correction, Correlation, and Applications Analysis

The objective of this task is to develop and evaluate data preprocessing techniques, procedures and software systems for producing radiometrically connected and spatially correlated multisensor data sets for applications information extraction.

The project is divided into two activities: One to investigate methods of modeling sensor characteristics and the other to develop methods of merging and multisensor data to form data sets which will enable enhanced resource mapping potential.

### C1. Multisensor Parametric Evaluation and Radiometric Correction Modeling

The work carried out under this subtask essentially completes the scanner system parameter investigation which was begun in June 1975. Detailed reports on IFOV simulation and information theory methods of scanner band selection have been produced (Mobasseri [1] and Wiswell [2]). Research on generalized basis function representation of scene spectra is nearing completion and will be reported by the end of the fourth quarter. The programs developed in the project are being integrated into a user oriented system and a stand alone document is being prepared to support the system. The following progress items highlight the progress for the quarter.

#### I. Develop and Test Spectral Models

The KL basis function approach to spectral band selection is based on the representation of the spectral response functions by a series expansion of basis functions suitably weighted by coefficients. The basis functions correspond to the eigenfunctions which are solutions to the homogeneous integral equation with the covariance function of the random process as the kernel. The representation theory has been developed and the method has been implemented in a software system as reported previously.

In the past quarter the software system has been updated to give added flexibility to the analysis. The statistics computed from the coefficients in the Karhunen-Loeve expansion are now generated in the same format as the LARSYS statistics decks. This will allow the use of the SEPARABILITY processor to compute divergence and select features.

In preliminary runs using the software system it has been observed that there are portions of the spectrum which are of little value; for example, the water absorption bands. To take advantage of this apriori knowledge a weighted Karhunen-Loeve expansion has been implemented. The apriori knowledge concerning the spectrum is entered by specifying a weight function over the interval.

A schedule of testing and evaluation of this method has been started. Ten data sets taken over three sites at different periods in the growing season will be tested on the system. The analysis procedure will include the computation of the eigenvectors for the KL expansion, evaluation of the classification performance for a sample remote sensing problem, and the comparison of practical sensors with the sensor using the K-L basis functions.

II. Develop and Test Scanner Parameter Analysis System

The results of the scanner parameter selection project dealing with a parametric classification accuracy estimation and interactions among the scene spatial correlation, signal-to-noise ratio and the scanner IFOV was comprehensively reported in the LARS Technical Report #061578. The current effort is aimed at organizing the related software modules and providing a user-oriented package for MSS simulation studies. The processing package will contain five major components.

1. The raw spectral information on cover types is obtained through the EXOSYS field measurement data system. The input to EXOSYS consists of the specific cover type and the date data was collected. The primary output consists of a statistics deck to be used as an input to other processors.

2. The orthogonal basis function expansion and associated minimum mean square error criterion, using the field measurement data, provides a list of

suggested spectral bands. These bands are in turn used to generate the spectral means and covariance matrices for each selected class.

3. The Analytic Classification Accuracy Prediction (ACAP) software in its current state accepts the statistics deck generated in steps 1 and 2 for a given number of classes and provides an estimate of the classification accuracy. ACAP is theoretically capable of processing an arbitrary number of classes and spectral bands. Tentatively, however, these parameters are set at 20 spectral classes and up to 8 channels. The grid size, determining the estimators quality and computation time, is user supplied but otherwise defaults to 11 cells per axis. The printout, in addition to the accuracy estimates, will contain information on the grid size, feature space specification etc.

4. The spatial structure of the scene provides a necessary piece of information to the scanner spatial model. The software is a two-dimensional spatial correlator which provides the spatial correlation matrix for any rectangular field specified. The program requests the appropriate tape and locates the user supplied coordinates of a field and starts execution. The spatial cross-correlation function can be computed if the two desired spectral bands are supplied.

5. The spectral and spatial information available at this step sufficies to process the data through the scanner. This is accomplished by implementing the scanner characteristic function developed previously. The additional information required is the particular size of the IFOV and its functional form, generally assumed Gaussian. The program provides the modified statistics which can be re-processed by ACAP to observe the interaction among various system parameters.

The format of each of the program units will be such that LARSYS type input cards are accepted thus facilitating their usage. One or more case studies will be reported as demonstrations.

## III. Scanner Model Extension to Microwave Wavelengths

Preliminary considerations of the problem of including microwave wavelength in the scanner models were made in the previous quarter. Microwave data was acquired and reviewed for its relevance to the project. This work was continued in this quarter and it was decided that further consideration of microwave wavelengths would not be made in this contract. One reason is that the resources required to complete the multispectral scanner modeling work were greater than expected and it was deemed more important to fully complete this work than start into a new problem area at the cost of not completing the work started in 1976. Furthermore the basic models are expected to be applicable to microwave spectra without modification so that the ability to analyse this data type is included in the present work. Also, the microwave data available was limited and of unknown quality and considerable resources would be required to obtain a useful data base.

## IV. SUMMARY

The major activity during the quarter consisted of planning and programming of scanner parameter analysis system elements. The classification accuracy prediction algorithm was refined and made user oriented. Other elements of the system were studied and preliminary refinement was started. In the fourth quarter all elements of the system will be refined and integrated onto a user system disk accessable by any LARS terminal user. A stand along document will be generated describing the theory and use of the system.

The individual modules of the MSS parameter analysis system is shown in Fig. 2C1-1. Their exact interaction and required input and desired output quantities is the subject of current effort. The EXOSYS spectra processor is not a part of the software development but it is incorporated as an integral system component.

Fig. 2C1-1 A Basic Block Diagram of the MSS Performance Evaluation Process.

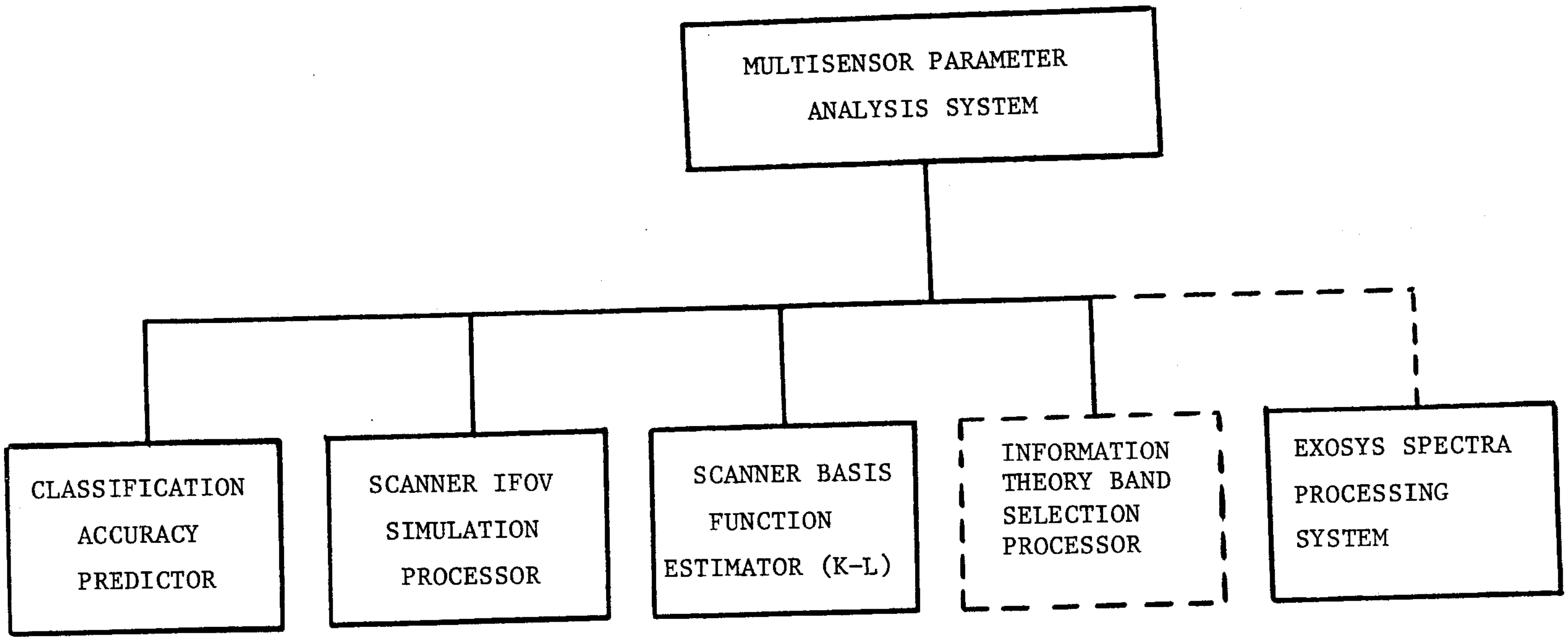
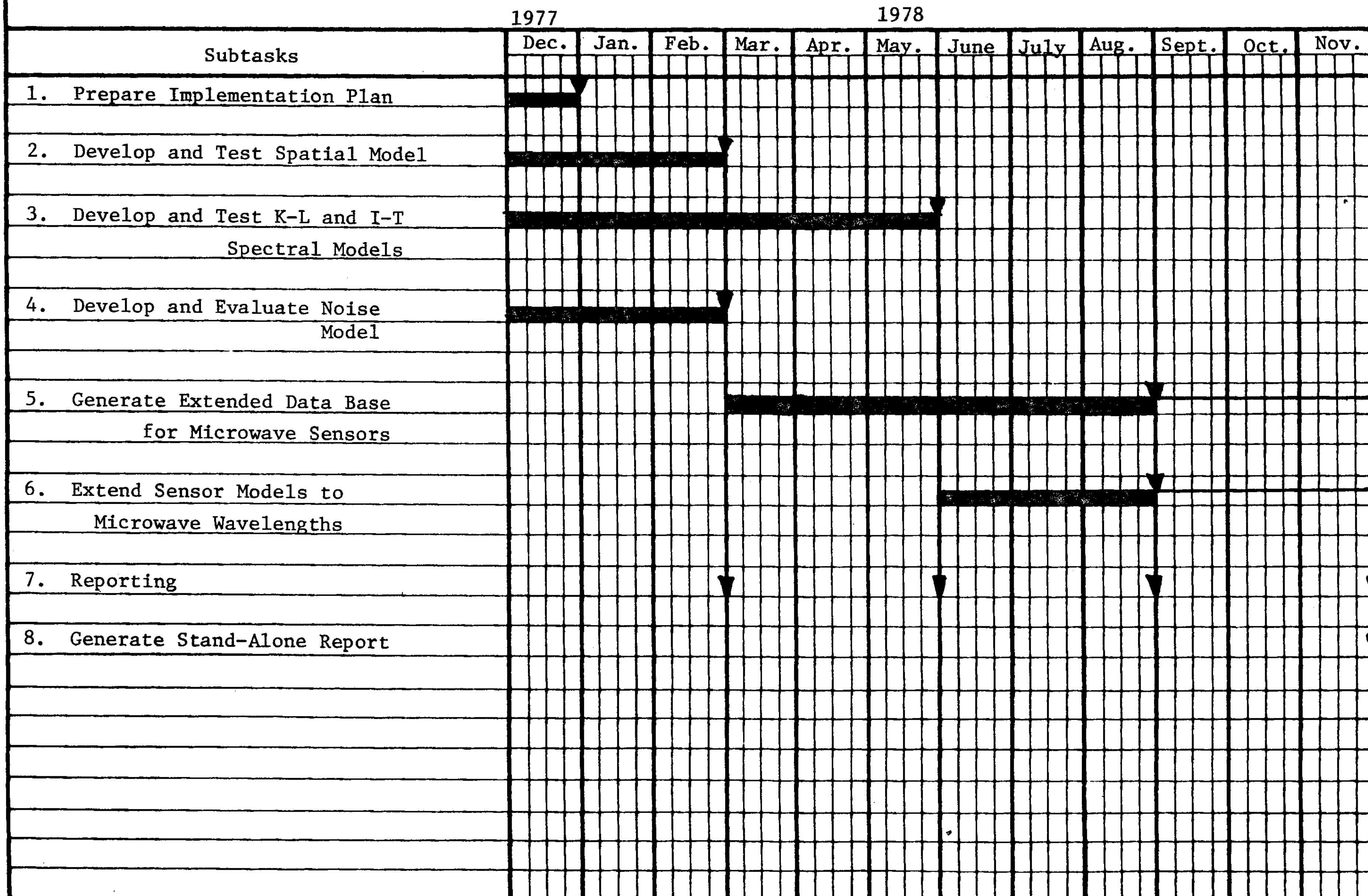


Figure 2C-1 Multisensor Parametric Evaluation and Radiometric Correction Model



## C2. Multisensor Multidate Spatial Feature Matching, Correlation, Registering, Resampling and Information Extraction

This subtask was formulated to conduct research on the problems of merging multiple remote sensing data types and to develop techniques for merging certain data types using the results of the research. The specific data types considered in this contract are synthetic aperture radar (SAR) and Landsat data. Interest is growing in the remote sensing community in the utility of radar imagery as an addition to Landsat data. The tasks are oriented toward determining the spatial and spectral characteristics of SAR data and definition of merging system parameters.

### I. Data Set Survey and Acquisition

The study was formulated on the assumption that three aircraft SAR data sets would be obtainable by at least the end of the second quarter. These were to be flights over Salisbury, Maryland, Gulf coastal zone areas, and over Phoenix, Arizona. A Salisbury flight is in house; however, it is of poor quality and a reprocessed data set is being prepared but has not yet been received. Landsat data for Salisbury is on hand. The Gulf coast flight has not been flown due to equipment problems on the NASA aircraft and may be flown and made available in the fall of 1978. The radar data for the Phoenix site is on hand; however, the time coincident Landsat data which was ordered in March 1978 has not yet been received. Thus none of the expected data sets is complete.

In order to permit spatial distortion investigations to proceed the high noise level SAR from Salisbury was used, a second eastern Maryland shore SAR flight data set near Cambridge, Maryland was acquired and 1972 Landsat data on hand was used as the reference MSS data set for the 1977 SAR data for Phoenix. Thus, three SAR/Landsat data sets were assembled; however, two are not useful for spectral studies and the third is a good data set but from a new area with no ground truth. Nonetheless, significant research was made possible by assembling these data.

## II. Aircraft/SAR Spatial/Spectral Modeling

The spatial distortion characteristics of the three SAR data sets was investigated with respect to Landsat as a reference. Three distortion model sources were utilized. One consists of a systematic error analysis program developed by Goodyear Aerospace for NASA. The second consists of affine and biquadratic models generated by LARS as part of the image registration system. The third source is the SPSS statistical analysis package included in the LARS system programs which utilizes first thru fifth order polynomial representation of distortion. The systematic model was shown to be equivalent to the affine model and is thus not exercised in the cases discussed. No spectral considerations were made due to the poor data quality and/or availability problems.

The geometric distortion of the SAR imagery relative to Landsat was analysed by visually selecting control points from imagery of both data types and processing the points with the various distortion analysis programs. The results of these analyses are described by site:

### a. Salisbury Distortion Model

The results of the distortion model for the Salisbury, MD, data set are found in Table 1. Since the SAR image is very noisy the residuals for the model are large. The errors are approximately the same in both reference frames because there is only a slight scale difference between the original images. The regression modeling improves with increasing degree in general. There are some anomalies in this trend shown between the biquartic and biquintic models. This effect is probably due to the addition of non-signiicant terms to the regression while decreasing the degrees of freedom in the data. Using the affine models, a parametric description of the SAR imagery relative to the Landsat image are obtained. They are as shown below.

| | | |
|---|---|---|
| Line Translation | = | 4.129827 |
| Column Translation | = | -1031.513184 |
| Line Scale Factor | = | 1.006710 |
| Column Scale Factor | = | 1.052094 |
| Angle of Rotation | = | -16.162918 Degrees |
| Shear | = | -0.035668 |
| or Shear Angle | = | -2.0428 Degrees |

Table 2. Parameters for Salisbury SAR-Landsat Distortion Model

b. Cambridge Distortion Model

Using the affine model, parameters for the distortion of the SAR iamge relative to the Landsat image were computed and are as shown in Table 3.

| | | |
|---|---|---|
| Line Translation | = | 379.972656 |
| Column Translation | = | 209.885818 |
| Line Scale Factor | = | 0.348962 |
| Column Scale Factor | = | 0.400670 |
| Angle of Rotation | = | 12.911010 Degrees |
| Shear | = | -0.012832 |
| or Shear Angle | = | -0.7352 Degrees |

Table 3. Parameters for Cambridge SAR-Landsat Distortion Model

The results for the regression modeling of the Cambridge distortion are given in Table 4. Because of the large scale difference between reference frames, the residual errors differ greatly between reference frames. These differences can be accounted for by scaling the residuals. The circular error in the Landsat reference is approximately equal to the scaled circular error in the SAR reference, i.e.,

$$(S_L \sigma_{LSAR})^2 + (S_C \sigma_{CSAR})^2 \doteq \sigma_{LLANDSAT} + \sigma^2_{CLANDSAT}$$

where L and C refer to line and column respectively.

Again the higher degree polynomial regressions model the misregistration more closely. To obtain the 47 point data set used, the points of the 51 point data set whose residuals were greater than twice the standard deviation of the residuals were regarded as bad data points and deleted. The residuals subsequently obtained are reduced significantly.

c. Phoenix Distortion Model

Checkpoints were determined in both data sets. The Pearson's product-moment correlation was used to obtain a measure of the dispersion of the checkpoints over the scene. If the correlation is small, then the dispersion is good. The Pearson's product moment for the chosen data points was -0.0957. The results of the regression distortion analysis is shown in Table 5. The scale difference between the original Landsat and SAR imagery is much greater in the Phoenix data set than in the two previous. Using the affine distortion model, Table 6 was constructed which specifies the distortion in the SAR imager relative to the Landsat image.

| | | | |
|---|---|---|---|
| Line Translation | = | -5219.941406 | |
| Column Translation | = | 2658.081543 | |
| Line Scale Factor | = | 5.158188 | |
| Column Scale Factor | = | 4.284437 | |
| Angle of Rotation | = | 61.473938 | Degrees |
| Shear | = | 0.035129 | |
| or Shear Angle | = | 2.0119 | Degrees |

Table 6. Parameters for Phoenix SAR-Landsat Distortion Model

TABLE 1. EVALUATION OF SALISBURY OVERLAY MODELS

| | | | Residuals in Reference Frame | | | |
|---|---|---|---|---|---|---|
| | | | SAR | | Landsat | |
| DISTORTION MODEL | # of TERMS | # of POINTS | LINE R.M.S. | COLUMN R.M.S. | LINE R.M.S. | COLUMN R.M.S. |
| Affine | 3 | 34 | 11.14532 | 3.54023 | 10.87019 | 3.74205 |
| Biquadratic | 6 | 34 | 11.40823 | 3.51519 | 11.18154 | 3.57602 |
| Bicubic | 10 | 34 | 6.39621 | 3.39698 | 6.62023 | 2.87025 |
| Biquartic | 15 | 34 | 5.64939 | 1.75413 | 5.54359 | 2.15566 |
| Biquintic | 21 | 34 | 4.72798 | 1.93508 | 4.40772 | 2.21761 |

LANDSAT GRID SIZE - 25M. x 25 M.

SAR GRID SIZE - 24M. x 25 M.

REGISTERED GRID SIZE - 25M. x 25 M.

TABLE 4. EVALUATION OF CAMBRIDGE OVERLAY MODELS

| DISTORTION MODEL | # of TERMS | # of POINTS | Residuals in Reference Frame — SAR — LINE R.M.S. | COLUMN R.M.S. | — Landsat — LINE R.M.S. | COLUMN R.M.S. |
|---|---|---|---|---|---|---|
| Affine | 3 | 51 | 11.33830 | 5.77049 | 3.84730 | 2.39370 |
| | 3 | 47 | 7.04462 | 4.35723 | 2.41068 | 1.81457 |
| Biquadratic | 6 | 51 | 10.94553 | 5.47249 | 3.72583 | 2.32059 |
| | 6 | 47 | 6.51474 | 4.03678 | 2.24101 | 1.67478 |
| Bicubic | 10 | 51 | 11.12770 | 5.23024 | 3.77945 | 2.23667 |
| | 10 | 47 | 6.16350 | 3.79314 | 2.08857 | 1.62756 |
| Biquartic | 15 | 51 | 11.50922 | 5.41156 | 3.89265 | 2.32963 |
| | 15 | 47 | 6.16350 | 3.79314 | 2.08857 | 1.62756 |
| Biquintic | 21 | 51 | 11.61732 | 5.44918 | 3.87645 | 2.44588 |
| | 21 | 47 | 6.36936 | 3.73789 | 2.17158 | 1.62720 |

LANDSAT GRID SIZE - 25M. x 25M.

SAR GRID SIZE - 8.7M. x 10.0M.

REGISTERED GRID SIZE - 25M. x 25M.

TABLE 5. EVALUATION OF PHOENIX OVERLAY MODELS

| DISTORTION MODEL | # of TERMS | # of POINTS | Residuals in Reference Frame — SAR — LINE R.M.S. | SAR COLUMN R.M.S. | — Landsat — LINE R.M.S. | Landsat COLUMN R.M.S. |
|---|---|---|---|---|---|---|
| Affine | | | | | | |
| SPSS/CDC | 3 | 17 | 3.89497 | 3.91500 | 0.91148 | 0.66323 |
| SPSS/IBM | 3 | 17 | 3.89497 | 3.91500 | 0.91148 | 0.66323 |
| LARS/IBM | 3 | 17 | 3.53462 | 3.58194 | 0.89926 | 0.80671 |
| Biquadratic | | | | | | |
| SPSS/CDC | 6 | 17 | 3.01697 | 3.37345 | 0.67575 | 0.66635 |
| SPSS/IBM | 6 | 17 | 3.01697 | 3.37345 | 0.67575 | 0.66635 |
| LARS/IBM | 6 | 17 | 2.718 | 2.918 | 0.538 | 0.662 |
| Bicubic | | | | | | |
| SPSS/CDC | 10 | 17 | 2.52669 | 1.53635 | 0.21140 | 0.64790 |
| SPSS/IBM | 10 | 17 | 2.52672 | 1.53693 | 0.21140 | 0.64790 |
| Biquintic | | | | | | |
| SPSS/CDC | 10 | 17 | ——— | ——— | 0.27791 | 0.62092 |
| SPSS/IBM | 10 | 17 | 3.15411 | 0.07095 | 0.27793 | 0.62093 |

LANDSAT GRID SIZE - 76.2M x 61.0M.

SAR GRID SIZE - 14.8M. x 14.2 M.

REGISTERED GRID SIZE - 25M. x 25M.

The circular error in the SAR reference frame is again related to the circular in the Landsat reference by the relation,

$$(S_L \sigma_{LSAR})^2 + (S_C \sigma_{CSAR})^2 = \sigma_{LLandsat} + \sigma^2_{CLandsat}$$

Also in Table 5 the difference in results obtain using different algorithms and machines to implement the regression are illustrated. The residuals shown for the SPSS packages (Statistics Package for the Social Sciences) are larger than those for the LARS Affine and Biquadratic programs. This is probably due to the loss of precision in computing the inverse matrix in the LARS program. The differences in the residual calculated between the SPSS program implementations are due to the precision of the machine used. The IBM/370 version uses a 32 bit word and the CDC 6500 a 64 bit word. These differences become evident first in the higher degree regressions.

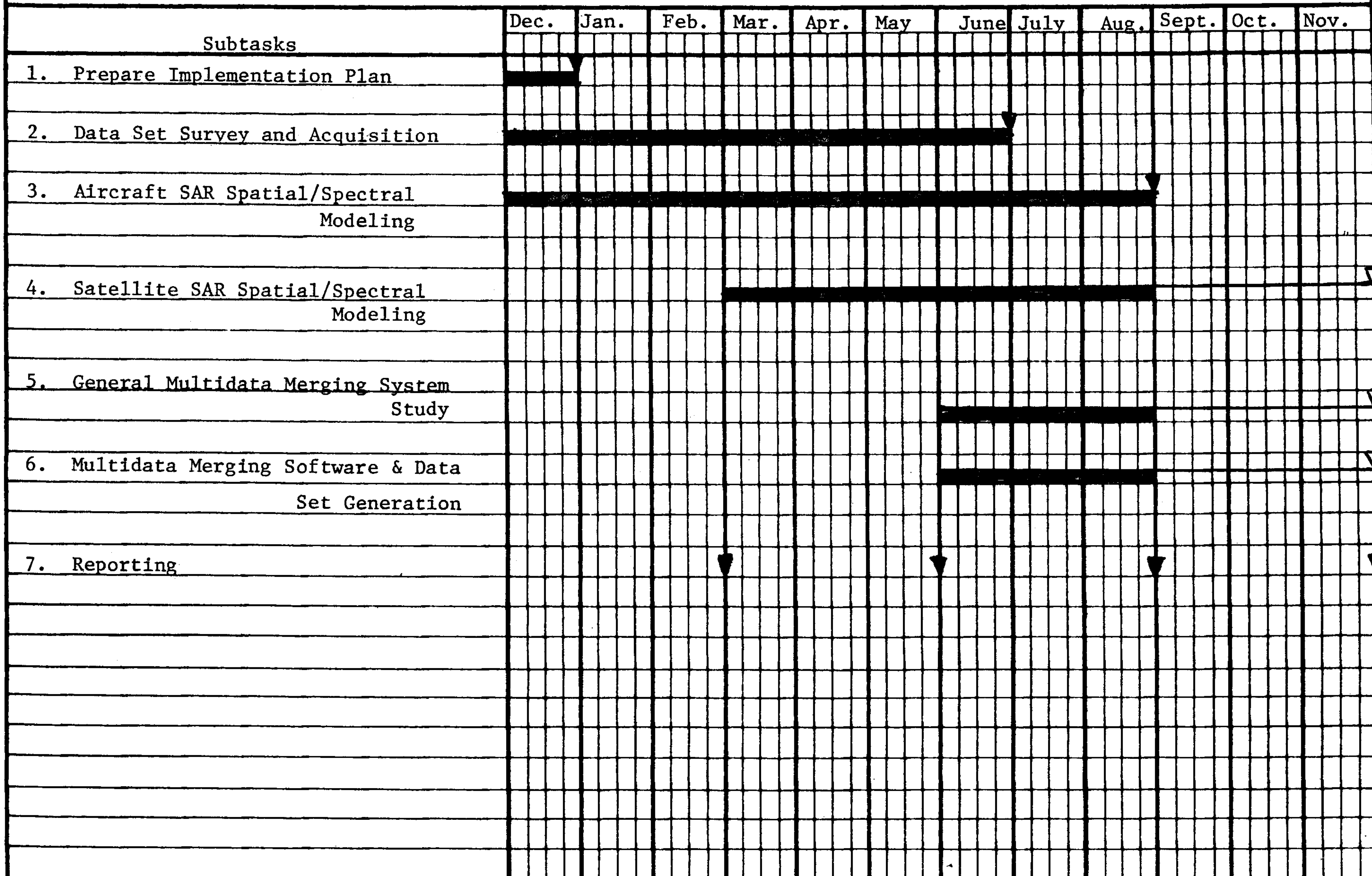
The results indicate that for the small areas considered that the linear models do as well as higher degree models for representing distortion in the SAR imagery. The Salisbury data set was observed to have oscillatory scale errors and is probably not representative of typical flight data. The R.M.S. errors for the other two sites did not significantly decrease for the higher order cases. The Cambridge errors were too high but the Phoenix results was acceptable. Reasons for this will be investigated in the fourth quarter.

Nonetheless, it is recommended that second and possibly third degree distortion functions be provided in a merging system to handle cases with unusual distortion levels.

## III. Satellite SAR Spatial/Spectral Modeling

Data availability problems with aircraft cases resulted in the decision to deal with the satellite case at a low level for the remainder of the contract and include this topic in future studies. Resources will be placed on the aircraft and system aspects. Information on SEASAT SAR and other satellite SAR sensors was acquired and reviewed during the quarter but no satellite data was sought. A frame of SEASAT SAR will be requested; however,

Figure 2C-2 Multisensor Multidate Spatial Feature Matching, Correlation, Registering, Resampling and Information Extraction



it is not expected that data will be received in this contract. The expectation from our results to date is that registration of satellite SAR data will not be significantly different in difficulty than the aircraft case.

IV. Multidata Merging System Activities

General planning for a multidata merging system was carried out in the quarter. Since SAR is the only data type in addition to Landsat which is being considered and due to data availability problems little was accomplished on these two tasks. It is expected that a basic SAR/Landsat merging capability will be defined and in development by the end of the fourth quarter. Hopefully the three data sets planned for will be acquired and registered by that time.

## 3. ASSESSMENT OF METHODS OF ACQUIRING, ANALYZING, AND REPORTING CROP PRODUCTION STATISTICS

This task is terminating as of August 31, 1978. As a result, rather than a Quarterly Report a Final Report will be separately submitted.

# 4. COMPUTER PROCESSING SUPPORT

## I. Introduction

### a. Background (Prior to CY78)

The Laboratory for Applications of Remote Sensing at Purdue University (Purdue/LARS) has developed and maintained an Earth Resources Data Processing System which is used by LARS personnel and remote users at Johnson Space Center's Earth Observations Division (JSC/EOD) and other locations. The implementation of LARSYS on a general purpose computer with time sharing and remote terminal capabilities increases the system's value for a large group of users. The resulting system potentially provides:

* User access, at the users' locations, to remotely sensed data and processing capabilities,
* Centralization and sharing of expensive portions of processing hardware at a cost advantage,
* Centralization of software allowing flexibility in software maintenance, addition, and updating at a cost advantage over independent systems, and
* Ease of training users and sharing experiences through standard data formats, terminology, and shared communication channels.

The Earth Observations Division is planning to install hardware for an Earth Resources Data System (ERDS) in the early 1980's timeframe. The ERDS system must be designed to support world wide coverage for a multi-crop food and fiber program while allowing the processing flexibility necessary for a research and development environment. In addition, the system must be conceptualized and tested over a period expected to have a very limited earth resources budget.

Both hardware and software for the ERDS system must be modular for purposes of development and expansion. Subsystems should execute independently where possible. The most advanced, proven technology must be employed. The system should be effective and flexible with an easy to use, readily available, user interface.

The LARS data processing facilities provide JSC with a test bed for ERDS techniques development:

* Examples of modular software systems exist in the forms of LARSYS, LARSYSDV, LARSYSXP, EXOSYS, etc.
* The capability for independent software subsystems has been developed.
* EOD and LARS both possess proven and advanced processing techniques; drawing from the best techniques available at both organizations should allow the formation of optimal processing software for ERDS.

The decision has been made to upgrade the LARS software/hardware facilities at JSC to provide Procedure 1 processing capabilities and increased terminal support. This upgrade will:

* Improve the capability for techniques exchange (such as P1 or ECHO) between the two organizations,
* Relieve RT&E computational constraints by supplanting or augmenting on-site computing as JSC processing capabilities are implemented at LARS,
* Reduce total costs by improving the efficiency of computer operations,
* Maintain valuable computational capabilities supporting LARS and JSC research and development, and
* Increase access to useful resources for both organizations (data, technology, processing systems, hardware, etc.).

Work toward providing a capability to mutually exchange remote sensing data processing techniques between NASA/JSC and Purdue/LARS had begun prior to this contract year. The state of the exchange efforts as of December 1, 1977 was documented in the "Final Report on Processing Techniques Development" of NASA Contract NAS9-14970, dated November 1977. This report included a "Plan for the Installation of a Data 100 Remote Terminal" which was accomplished during the December-June period of the contract.

b. Review of CY78 Activities: December to May

During December of 1977 the decision was made to significantly expand the scope of and resources available for Task 2.4 in order to:

* Maintain a computational facility at Purdue/LARS,
* Begin to actually centralize SR&T computing, and
* Provide JSC/EOD users access to a more interactive and responsive computational system than was available at JSC.

At that time it was evident that expanded information exchange, hardware development and consulting activities would be required in order to support these objectives. Consequently an agreement was reached to increase personnel drawing on the funds available in the contract, while a cost extension to the contract was negotiated for later in the year.

During the first two quarters of the contract year, several major accomplishments were achieved:

* Hardware, phone lines, and communications software were acquired and upgraded to support an additional Remote Job Entry Station (a Data 100) at JSC;
* Storage media (tape) was selected and space was secured for the RT&E data base:
* Short courses on the use of the LARS computer system and on the use of LARSYSP1 were conducted at JSC and LARS respectively;
* Temp disk storage available to EOD users was increased by 75%, disk space for JSC private minidisks increased from 16 megabytes in Janaury to over 60 megabytes in May;
* Computer usage increased from 10 CPU hours in January to 71 CPU hours in May;
* A LARS computer specialist spent five days at JSC as a visiting consultant;
* The LACIE Phase III data bases were received, cataloged, and placed in the LARS tape library; and
* Design of the RT&E data base was begun and a preliminary review at JSC conducted.

c. Project Objectives

During May discussions were held with a representative (M. Trichel) of the Technical Contract Monitor and with the Operations Branch Chief (D. Hay) and others to establish long range objectives for the computer processing support task. At that time the following umbrella objective was identified:

The LARS computer should serve as the centralized prototype for ERDS; as such, as much candidate ERDS software as is reasonable should be integrated into the LARS system.

Adjunct to this objective were the following goals:

1. The current and historical SR&T data base (field measurements, current and historical imagery, and blind site ground truth) should be maintained at LARS at least through 1981.
2. Certain analysis system software which has been established as "standard" (P1, P2, others) should be maintained on the LARS computer.
3. LARS should support the active use of JSC system software such as FLOCON, Accuracy Assessment, System Verification, etc.
4. Data distribution and packing activities should be supported by LARS.
5. Past 1981, the LARS system should be maintained as the key SR&T research computer.
6. The LARS computer should provide computation for on-going experiment support.

d. Approach

The goals and objectives for Computer Processing Support Task can be organized into Computer Capability Support and Data Base Management Support.

i. Computer Capability

Computer capability support is comprised of those tasks and activities which are required to supply JSC/EOD and other SR&T sites a data processing environment designed for the support of remote sensing technology through a facility including computer and related hardware, software, procedures, training and support personnel. Specific computer capability support tasks may be categorized as either systems hardware and software related (Systems Support) as as assistance oriented (Consulting Support).

Systems Support. To provide the users access to the applications software listed in goals 2, 3 and 6 of Section C above, and to prepare to provide the other SR&T sites access to the LARS computer, certain system hardware related tasks are required. In addition, certain system software alterations are necessary for effective use of the JSC/EOD applications software.

Consulting Support. For the effective use of the LARS computer system, it was recognized that information would need to be provided in a dynamic manner about a wide range of subjects. In addition, examples of certain System features and information exchange sessions outlining the use of software systems and computer utilities were recognized as valuable. Consequently, personnel were assigned to disburse and/or secure information about software systems, computer resources, computer products, programming support and training activities. The tasks associated with System Consulting provide the information and assistance necessary to achieve goals 2, 3, 5 and 7 of Section C.

ii. Data Management

In order to apply the integrated analysis software becoming available on the LARS computer to useful analysis problems, data must be available for analysis. The volume, need for access, and diversity of the data present a significant data management problem. Since the field measurements data base already resides at Purdue, and since (to fulfill goal 1) it will be necessary for the current and historical imagery data bases and the blind site ground truth data base to be implemented at Purdue, it makes sense for LARS to support future data distribution (goal 4).

e. Summary Schedule

Figure 4-1 is the 25 month Summary Schedule for major Computer Processing Support tasks and is presented according to the organization outlined in Section D. Since it is LARS' goal to be responsive to additional computational support needs as they arise, it is likely that additional tasks for the computer support activity will be identified and pursued beyond the latter portion of 1978.

TASK 2.4: COMPUTER PROCESSING SUP

Computer Capabilities M

I. COMPUTER CAPABILITIES

A. System Support

- Remote Job Entry Station at JSC
- Acquire IBM 360/20 Capability for JSC RJES
- Recommend JSC 2780 Replacement
- Provide Shared SR&T System to SR&T Sites
- Support Additional JSC Keyboard Terminals
- Establish JSC/LARS Tape Transfer Capabilities
- Upgrade Batch Machine Support
- Provide JSC Accounting by User Group
- Initiate LARSYSP1 IPL System
- Create Time Limit per Interactive Session Software
- Secure Disk Storage Space
- Insure Computer Financial Support
- Quarterly Report Input on System Support Tasks

B. Provide Consulting Support for "SR&T Computer System at LARS"

- Establish Consulting Activities
- Provide System Information
- Demonstrate EXEC's by Programming EODLARSYS Prompting EXEC
- Make Statistical Packages Available
- Exchange Information
- Quarterly Report Input on Consulting Tasks

II. DATA BASE MANAGEMENT

- Design Data Base for Historical Data
- Select Media and Format of Digital Data Base
- Obtain Data Storage Space
- Receive Landsat Data Bases
- Catalog Landsat Data in Segment Catalog
- Implement Tape Referencing Capability
- Implement Landsat Data Search Capability
- Implement Data Base
- Data Base Quarterly Report Input

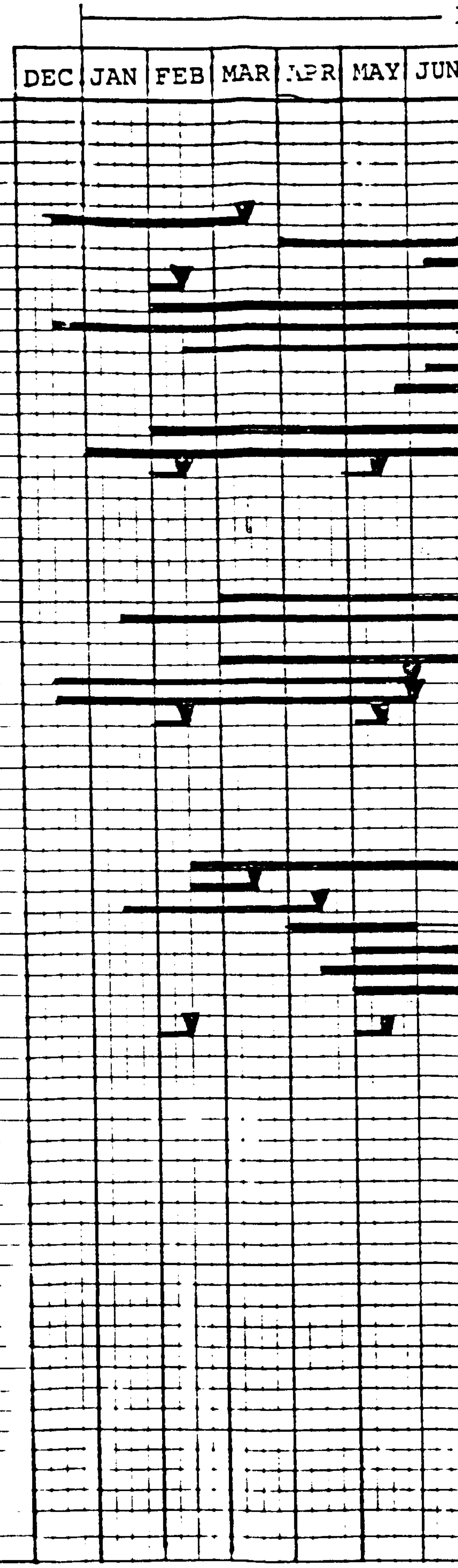
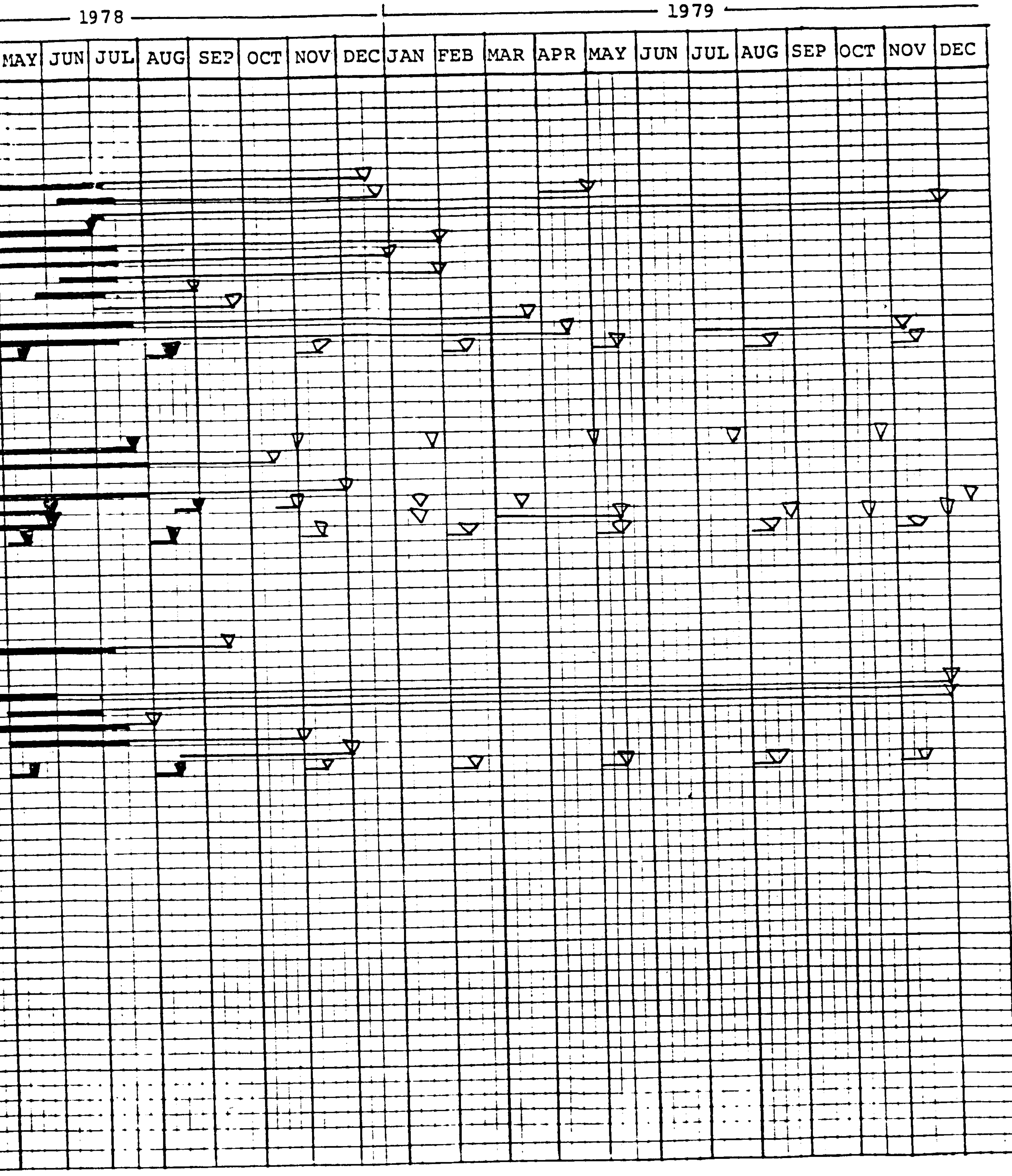



Figure 4-1

ING SUPPORT SUMMARY SCHEDULE

ities Milestone Chart



II. Project Status Report

Figure 4-2 presents the detailed milestone chart documenting the schedule status of the known subtasks associated with the Computer Processing Support Activity over a 25 month period. The following is a discussion of those subtasks which were active during the third quarter.

a. Computer Capabilities

i. System Support

Acquire IBM 360 Model 20 Capability for the Data 100. The Data 100 acquired by JSC has the capability to function as an IBM 360 Model 20 (HASP) terminal as well as an IBM 2780 terminal. There are several advantages of operating in HASP, rather than 2780, mode. For example, the HASP communications software supports data compression for repeated characters, allows the Job Entry Station to receive and send data concurrently, and allows the operator of the Remote Job Entry Station to communicate with other ID's on the computer and vice versa.

During this quarter the capability to operate the JSCTEXAS link in IBM 360/20 HASP emulation mode was achieved. The communications software required major modifications before successful operation was possible. The HASP line driver, DMTSML, had to be modified to support local modifications made to RSCS and CP. Considerable effort was also required to find and correct errors in the software as supplied by IBM. All supported features of the DMTSML line driver are now operational; however, the features supported by DMTSML are a subset of those in the HASP protocol. Multiple printers, card readers, card punches, and multiple data streams are not supported. The multiple punch, reader, and data stream features would allow increased throughput, especially during tape transfers. The RASP communications software has been obtained from the IBM Users' Group, SHARE. This software is a largely rewritten version of the IBM supplied RSCS which claims improvements in operating efficiency, dependability, and fuller protocol feature support. Implementation of the RASP software

TASK 2.4: COMPUTER PROCESSING SUPP

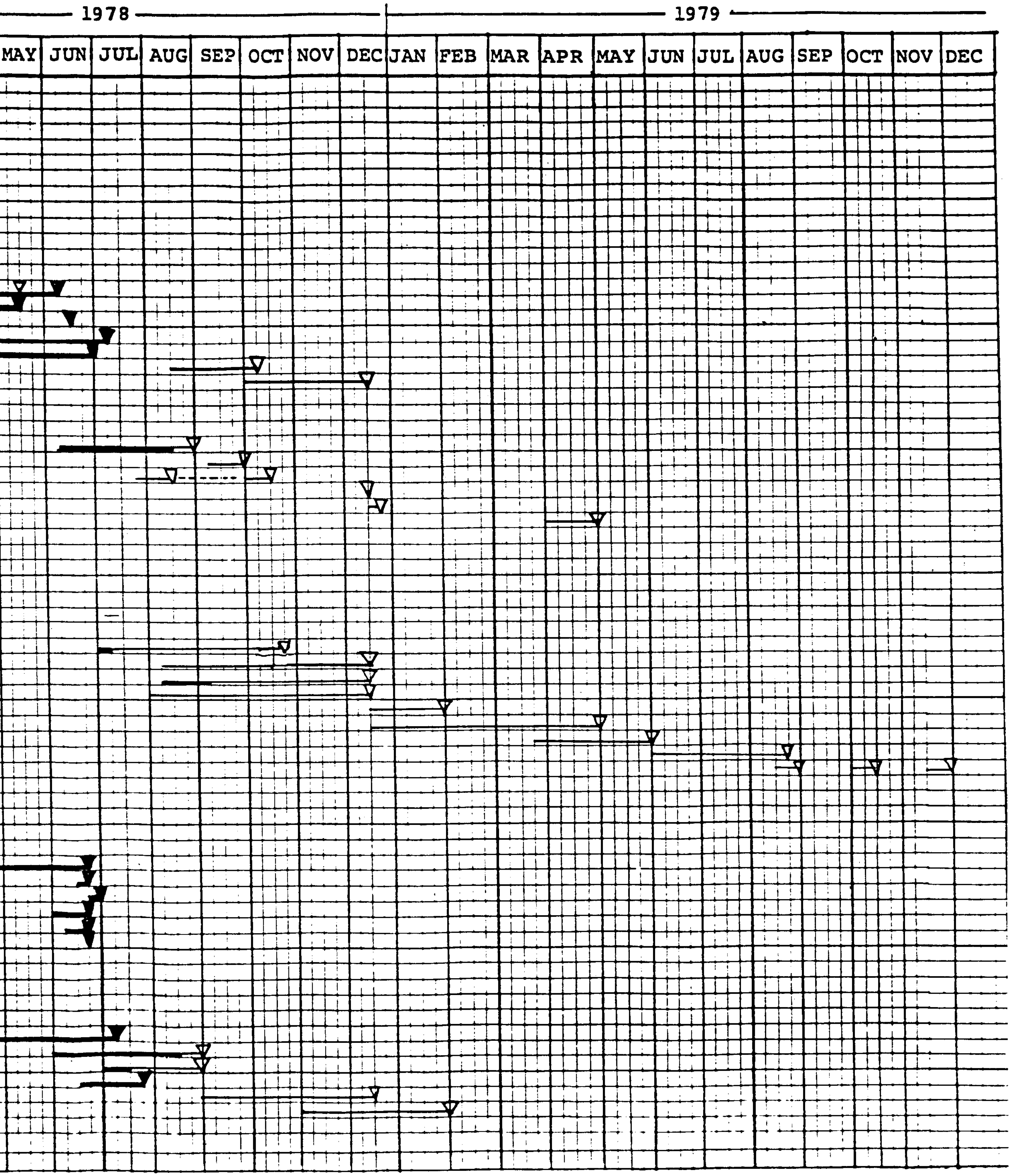
Computer Capabilities Mi

| | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|
| I. COMPUTER CAPABILITIES | | | | | | | |
| A. System Support | | | | | | | |
| Remote Job Entry Station at JSC | | | | | | | |
| Order 9600 baud phone line for Data 100 | | | | | | | |
| Install phone line | | | | | | | |
| Reconfigure communication controller for Data 100 | | | | | | | |
| Alter communications software for Data 100 | | | | | | | |
| Implement Data 100 as IBM 2780 RJES | | | | | | | |
| Acquire IBM 360/20 Capability for JSC RJES | | | | | | | |
| Alter and debug CP communications software | | | | | | | |
| Alter 3705 communications software | | | | | | | |
| Operate JSC Data 100 as an IBM 360/20 RJES | | | | | | | |
| Obtain Release 5 of IBM communications software | | | | | | | |
| Obtain RASP communications software | | | | | | | |
| Evaluate RASP software | | | | | | | |
| Implement RASP or Release 5 software | | | | | | | |
| Recommend JSC 2780 Replacement | | | | | | | |
| Examine commercially available hardware | | | | | | | |
| Report and confer with JSC | | | | | | | |
| Recommend 2780 replacement (proposal) | | | | | | | |
| Receive approval | | | | | | | |
| Order equipment | | | | | | | |
| Install equipment | | | | | | | |
| Provide Shared SR&T System to SR&T Sites | | | | | | | |
| Establish list of candidate sites | | | | | | | |
| Provide computer ID's | | | | | | | |
| Make available interim dial-up access | | | | | | | |
| Contact candidate sites and review needs and available equipment | | | | | | | |
| Investigate available communication services | | | | | | | |
| Investigate satellite communications data links | | | | | | | |
| Identify equipment needs | | | | | | | |
| Propose support to SR&T sites (proposal) | | | | | | | |
| Establish computer and software training programs | | | | | | | |
| Order equipment | | | | | | | |
| Train SR&T site users | | | | | | | |
| Install equipment | | | | | | | |
| Support Additional JSC Keyboard Terminals | | | | | | | |
| Formulate terminal expansion plan | | | | | | | |
| Order new LIB, 2741 replacements, line sets, cables | | | | | | | |
| Alter CP and 3705 for new LIB | | | | | | | |
| Install new LIB | | | | | | | |
| Receive and install 2741 replacements | | | | | | | |
| Install line sets and cables | | | | | | | |
| Alter CP for new lines | | | | | | | |
| Host modem/multiplexor installation visit | | | | | | | |
| Establish JSC/LARS Tape Transfer Capabilities | | | | | | | |
| Secure Data 100 tape drive documentation | | | | | | | |
| Initial software design specifications | | | | | | | |
| Implement initial tape transfer capability | | | | | | | |
| Document tape transfer software | | | | | | | |
| Develop and document tape transfer procedure | | | | | | | |
| List Data 100 capabilities, upgrade desires | | | | | | | |
| Upgrade tape transfer capability | | | | | | | |
| Document upgrade software and procedure | | | | | | | |

Figure 4-2a

ING SUPPORT DETAILED SCHEDULE

ities Milestone Chart



TASK 2.4: COMPUTER PROCESSING SUP

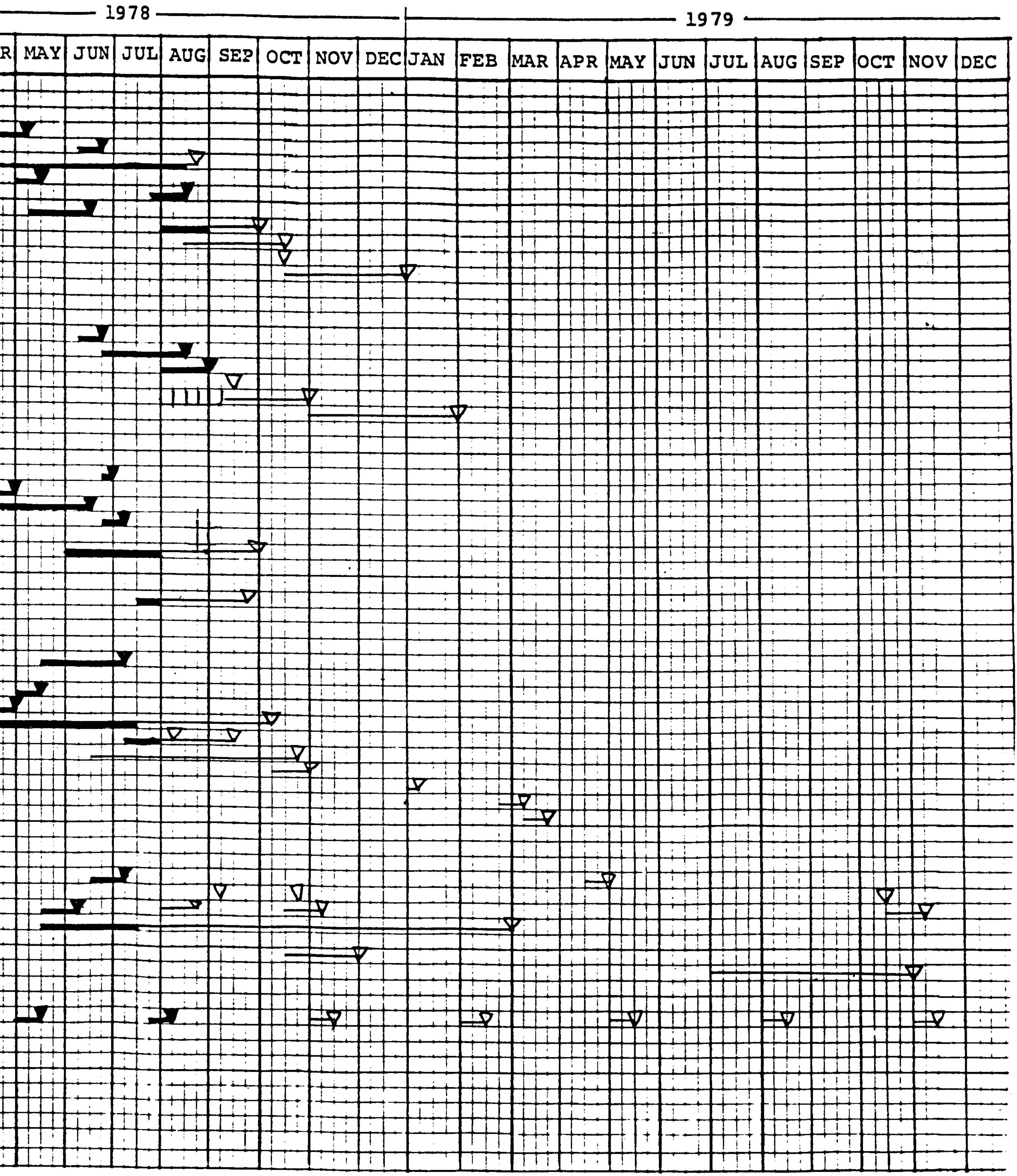
Computer Capabilities M

| Task | DEC | JAN | FEB | MAR | APR | MAY | JU |
|---|---|---|---|---|---|---|---|
| Upgrade Batch Machine Support | | | | | | | |
| Assess initial JSC batch needs | | | | | | | |
| Implement pseudo batch 370 for P1 use | | | | | | | |
| Implement 370 batch machine (BATEOD) | | | | | | | |
| Increase size of 360 batch machine to 2M (BATLONG) | | | | | | | |
| Implement tape transfer batch capability (TAPTRAN) | | | | | | | |
| Document method of placing batch output in HOLD status | | | | | | | |
| Implement basic rate 370 batch machine (BATJSC) | | | | | | | |
| Assign read passwords to JSC disks | | | | | | | |
| Reassess SR&T batch requirements | | | | | | | |
| Examine system batch requirements | | | | | | | |
| Recommend systems batch capabilities | | | | | | | |
| Implement JSC/SR&T specific batch capabilities | | | | | | | |
| Provide JSC Accounting by User Group | | | | | | | |
| Identify JSC user groups | | | | | | | |
| Produce group CPU accounting program | | | | | | | |
| Identify accounting report recipients | | | | | | | |
| Assign monthly operator to programs | | | | | | | |
| Obtain a JSC specific metering scheme | | | | | | | |
| Augment CPU report with metering function | | | | | | | |
| Initiate LARSYSP1 IPL System | | | | | | | |
| Secure disk space | | | | | | | |
| Identify load modules and machine sizes | | | | | | | |
| Alter LARSYSP1 code to execute in 768K | | | | | | | |
| Make CP changes necessary for the IPL system | | | | | | | |
| Document IPL system characteristics and maintenance steps | | | | | | | |
| Create Time Limit Per Interactive Session Software | | | | | | | |
| Secure Disk Storage Space | | | | | | | |
| Identify current disk usage | | | | | | | |
| Move appropriate ID's to CMS370-only disk | | | | | | | |
| Expand temp disk capacity | | | | | | | |
| Remove LARSYSNt source from system | | | | | | | |
| Investigate available disk sources | | | | | | | |
| Document disk shortage for JSC | | | | | | | |
| Secure estimate of JSC disk needs | | | | | | | |
| Make disk recommendation to JSC (proposal) | | | | | | | |
| Order disks | | | | | | | |
| Receive disks | | | | | | | |
| Implement additional space | | | | | | | |
| Insure Computer Financial Support | | | | | | | |
| Estimate and communicate funding needs to JSC | | | | | | | |
| Review work statement modifications | | | | | | | |
| Respond to RFP's | | | | | | | |
| Communicate advantages of long term funding | | | | | | | |
| Arrange to sell third shift | | | | | | | |
| Secure 550-650K computer use committment (1979) | | | | | | | |
| Secure long term funding committment | | | | | | | |
| Quarterly Report Input on System Support Tasks | | | | | | | |

Figure 4-2b

SSING SUPPORT DETAILED SCHEDULE

ilities Milestone Chart



TASK 2.4: COMPUTER PROCESSING SUP

Computer Capabilities M

DEC | JAN | FEB | MAR | APR | MAY | JU

B. Provide Consulting Support for "SR&T Computer System at LARS"

Establish Consulting Activities
- Identify consulting level
- Identify and document consulting team
- Make visiting consultant trips
- Host JSC visitors

Provide System Information
- Provide abstract list
- Provide 2 sets of LARS Abstracts
- Distribute CP/CMS documentation
- Document computer system hardware
- Outline and reference software system at LARS
- Provide Mead output product and cost figures
- Begin distribution of 2.4 minutes
- Project administration trips
- Demonstrate EXOSYSDV capability
- Convert Atmospheric Transmission data tape
- Establish SR&T news capabilities

Demonstrate EXEC's by programming EOD/LARSYS Prompting EXEC
- Formulate prompting EXEC requirements with JSC
- Present example EXEC
- Obtain review and revise requirements
- Upgrade prompting EXEC
- Document prompting EXEC
- Communicate any LARSYSP1 bugs encountered to JSC

Make Statistical Packages Available
- Discuss systems requirements with IMSL
- Discuss system requirements with SAS
- Rent SPSS
- Fix BMD problem
- Investigate DISCRIM problems with SPSS
- Receive IMSL
- Install IMSL-single and double precision versions
- Install version 7.2 of SPSS
- Install version 8 of SPSS

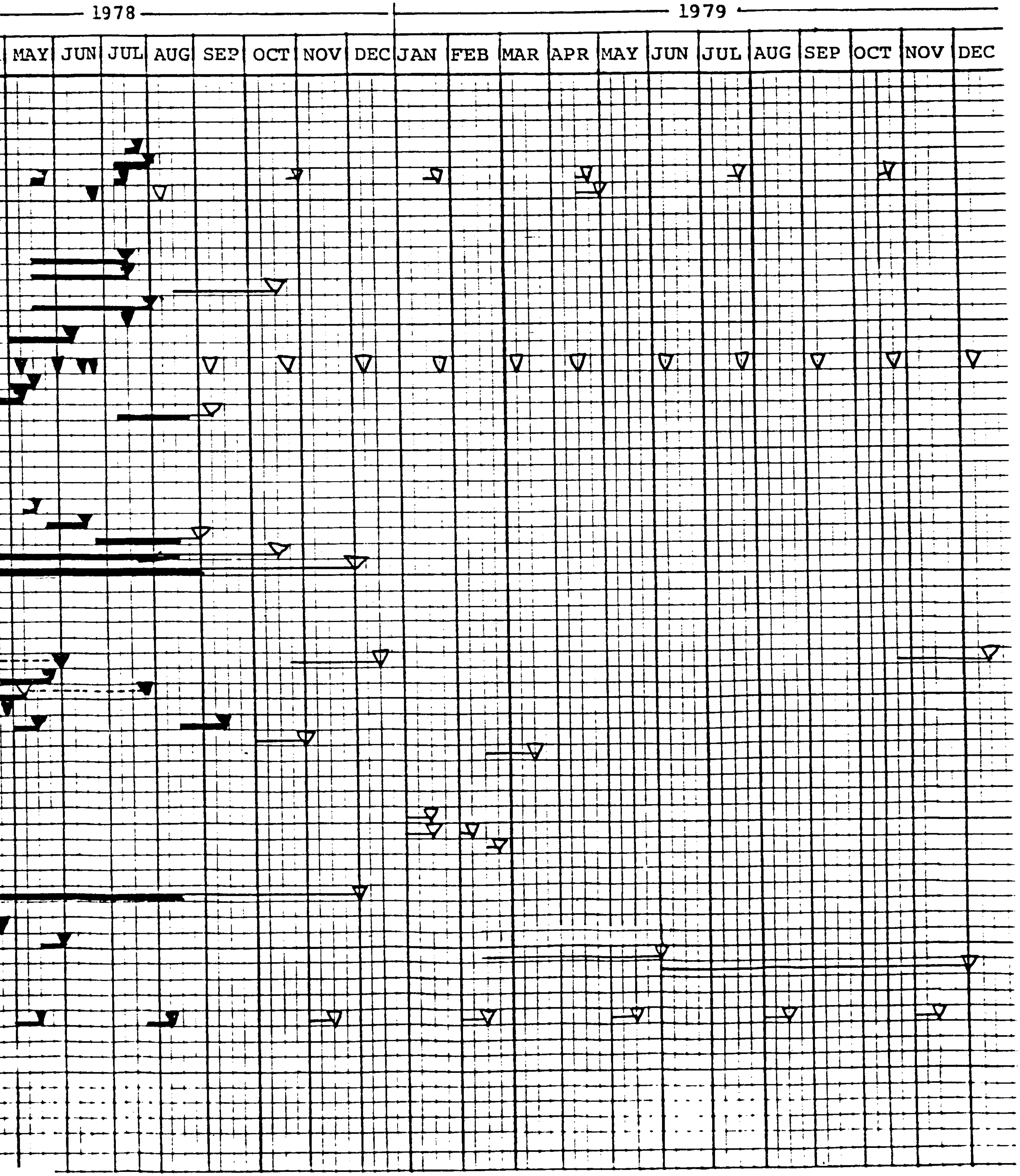
Exchange Information
- Prepare course on CMS370, LARS system characteristics
- Present course at LARS
- Present course at JSC
- Formulate requirements for P1 course at LARS
- Publicize P1 course at LARS
- Assist LARS users with LARSYSP1
- Begin receiving and distributing FMCO bulletin
- Update & expand Scanlines distribution
- Request Purdue to obtain FTS lines
- Plan course for future SR&T site users
- Present course for future users

Quarterly Report Input on Consulting Tasks

Figure 4-2c

SING SUPPORT DETAILED SCHEDULE

lities Milestone Chart



TASK 2.4: COMPUTER PROCESSING SUP

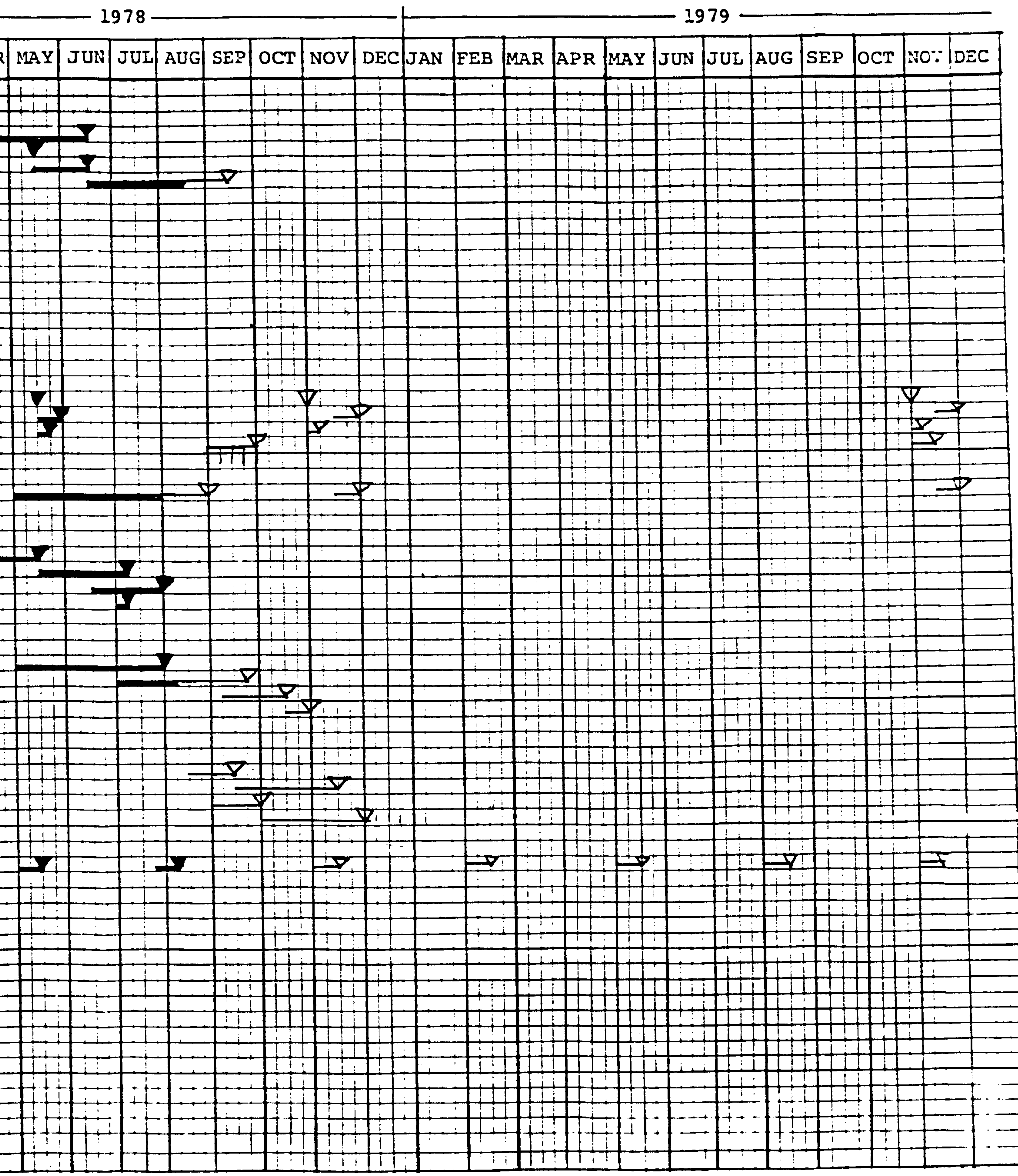
Computer Capabilities M

| | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|
| **II. DATA BASE MANAGEMENT** | | | | | | | |
| Design Data Base for Historical Data | | | | | | | |
| Discuss data base contents and requirments with JSC | | | | | | | |
| Present strawman design | | | | | | | |
| Upgrade and present upgraded design | | | | | | | |
| Complete design of historical data base | | | | | | | |
| Select Media and Format of Digital Data Base | | | | | | | |
| Present relevant system considerations to JSC personnel | | | | | | | |
| Recommend media and format | | | | | | | |
| Obtain Data Storage Space | | | | | | | |
| Order tape racks | | | | | | | |
| Install tape racks | | | | | | | |
| Receive Landsat Data Bases | | | | | | | |
| Receive tapes | | | | | | | |
| Label, forward/rewind, enter on tape racks | | | | | | | |
| Communicate data receipt | | | | | | | |
| Copy to 1600 bpi | | | | | | | |
| Catalog Landsat Data in Segment Catalog | | | | | | | |
| Implement Tape Referencing Capability | | | | | | | |
| Write program requirements | | | | | | | |
| Write program | | | | | | | |
| Document program | | | | | | | |
| Demonstrate at JSC | | | | | | | |
| Implement Landsat Data Search Capability | | | | | | | |
| Write program requirements | | | | | | | |
| Write programs | | | | | | | |
| Document program | | | | | | | |
| Demonstrate program at JSC | | | | | | | |
| Implement Data Base | | | | | | | |
| Design data entry software | | | | | | | |
| Implement data entry software | | | | | | | |
| Design data maintenance software | | | | | | | |
| Implement data maintenance software | | | | | | | |
| Data Base Quarterly Report Input | | | | | | | |

Figure 4-2d

SING SUPPORT DETAILED SCHEDULE

lities Milestone Chart




e 4-2d

would require major systems modifications to both CP and to the RASP software itself to support other system software modifications required by the LARS system. It will be necessary to determine the advantages and disadvantages of RASP, the impact on the user and on the system during the next quarter so that a recommendation concerning the implementation can be made.

Recommend JSC 2780 Replacement. Since 1972 Johnson Space Center's Earth Observations Division has had access to the LARS computer through an IBM 2780 Remote Job Entry Station. During recent years, this terminal has frequently been down and in need of repair. Terminal technology has also experienced many improvements since 1972. These factors, coupled with the increased usage of the LARS computer by JSC/EOD, make the replacement of the IBM 2780 remote terminal attractive. The first step toward 2780 replacement is the examination of the commercially available terminal hardware. Such an examination is being pursued jointly by staff located at JSC and by staff at LARS. The commercially available hardware will be evaluated and a recommendation in the form of a proposal will be submitted to JSC for the replacement of the 2780. Once approval is received, equipment will be ordered, and after a standard waiting time of 90 to 120 days, equipment will be installed and tested.

Candidate replacement systems for the JSC 2780 Remote Job Entry System are being examined. Keith Philipp attended presentations by IBM, Data 100 and Paradyne while on a visiting consultant trip to JSC. A Paradyne representative also made a presentation to LARS personnel during July. The IBM and Data 100 systems are direct replacements for the JSC 2780 system. The Paradyne PIX II system uses a different method to connect to the mainframe and appears to be directly connected. All communication code is contained within the PIX II and is transparent to the mainframe. The protocol used is IBM SDLC which is a full duplex line protocol. In addition, extensive character and big compression techniques are used which also extend the apparent bit capacity of the communications line.

Provide Shared SR&T System to SR&T Sites. One of the goals listed in Section 1C for Support project is for the LARS computer to serve as a primary SR&T research computer after 1981. Many possible advantages would accrue if the SR&T community shared data processing facilities for research and development:

* Reduced total operating cost by improving the efficiency of operations through synergy,
* Improved inter-organization communication of problems and technical advantages,
* Maintenance of valuable capabilities supporting remote sensing research and development,
* Increased access to such useful resources as data, technology, by selected SR&T research sites.

The first step was to identify a list of candidate SR&T sites which might benefit from access to the LARS computer. Once this was done, computer ID's were placed on the LARS system for each of these sites and information about how to access the LARS system via a dial-up keyboard terminal was made available for distribution to these sites by JSC as needed. These activities make access to the LARS computer by remote SR&T sites possible on a limited basis. Texas A&M University and Fort Lewis College began to make use of the LARS system during this quarter.

In order for remote sites to make more extensive use of the LARS computer, more extensive communication systems, computer hardware and support software are necessary. To minimize the expense of such hardware and to identify the possible benefits of the LARS system to each of the candidate SR&T research sites, LARS personnel are contacting the list of candidate sites, discussing what equipment is used and available at the remote sites, and evaluating the suitability of each site's equipment as a remote terminal to the LARS system. During this quarter, computer personnel at the University of California, Berkeley (UCB) have been contacted and their currently available equipment and processing needs discussed.

Various communications services and networks will also be investigated so that the cost of transmitting data between remote sites and the LARS site may be minimized. JSC personnel have transmitted information about TELENET to LARS. The availability and expense of satellite communications are being explored. General Telephone and Electronics Corporation will be making a presentation at LARS during late August outlining system considerations, communication capabilities and costs of satellite communication systems. Once these investigations are complete, equipment needs for each individual SR&T research site will be identified and, for those sites which a terminal link to the LARS system seems feasible and beneficial, individual plans will be submitted to JSC as separate proposals.

Training programs in the use of the LARS system and the specialized remote sensing software available on the LARS system will be developed in conjunction with JSC. Upon approval of each individual remote site proposal, equipment will be ordered, the newly developed training program will be administered to the new users, and equipment will be installed at the prospective site.

Support Additional JSC Keyboard Terminals. The expanded JSC usage of the LARS computer called for not only an additional Remote Job Entry Station (discussed above), but also for expanded access through additional keyboard terminals. The first step in supporting additional keyboard terminals was to furmulate a terminal expansion plan. This plan identified how hardware at LARS would have to be altered, the number of additional JSC terminals to be supported, and the time schedule for the implementation of the additional terminals.

In order to support additional terminals at JSC, hardware changes were made to the IBM 3705 communications controller, the 3705 emulator program and to CP. The type 3 LIB and type 3B line sets, which are designed to support only local IBM 2741 type terminals, were replaced with the more flexible type 1 LIB and type 1A line sets. The removal of the LIB type 3 made it necessary to replace the four 2741's which were in use at LARS.

Software in the communications controller and the 370 was altered to support the new terminal configurations at LARS and at JSC, cables, line sets, the line interface base and 2741 replacements were installed; and LARS personnel hosted a visit by Glen Prow and Craig Utterback of Lockheed Electronics Corporation for the installation and checkout of the modem and multiplexer which supported the additional JSC keyboard terminals. Problems were encountered with telephone line outages, bad cables, improper switch settings on the multiplexer cards, and incorrect line definition in the emulator program. The line and cable problems were solved within 48 hours but the switch settings and line definition problems required 2 weeks of trial-and-error experimenting before rectification.

Establish JSC/LARS Tape Transfer Capabilities. Prior to this contract year, tape data such as the Landsat data for LACIE segments had to be shipped to LARS via the U.S.Postal System. A JSC user wishing access to a tape located at JSC, but to be analyzed on the LARS system, had to wait from 3 weeks to a month for that tape data to become available at Purdue. In order to reduce this wait time, the Data 100 Remote Job Entry Station installed at JSC included a tape drive. At LARS, documentation on the characteristics and use of the Data 100 tape drive and the steps the Data 100 operator had to perform in order to use the drive was secured. Software was designed to support transfers of tape data between the two sites and an initial implementation of a tape transfer capability was programmed. Tape transfer software for the initial implementation was successfully demonstrated during this quarter and is currently being documented. During programming of the tape transfer capability, many bugs were uncovered in the Data 100 load programs.

The tape transfer software is presently being used in a quasi-operational mode. Procederally,the transfers are being handled through Glen Prow at JSC. A user wishing to transfer a tape either to or from LARS would take an input or output tape to Glen along with a control card deck. The Data 100 operators at JSC are being trained in order to help users in setting up their control cards. Copies of the output are automatically sent to Glen Prow at JSC and Joanne Rayburn at LARS to maintain a record of transfers and to also allow a convenient method for requesting an update to the authorized ring-in userids.

The experience gained from that initial implementation has lead to the identification of several modifications to the Data 100 software which would result in greatly enhanced tape transfer capabilities.

After having completed several successful tape transfers between the IBM 370/148 (at LARS) and the Data 100 at JSC, it is now appropriate to examine the possibilities of expanding the existing capabilities. Presently, a single tape file may be transmitted in either direction and multiple tape files may be transmitted to the Data 100.

In order for the transfer capability to be used operationally some additional Data 100 capabilities would be desired. First, the ability to position the output tape on the Data 100 is needed. This could be implemented by adding an FF=nn parameter to the '..MT OU=60' PCL card, where nn would be the number of tape files to skip, the default would be zero. Second, the ability to transmit multiple tape files from the Data 100 without operator intervention and without sending the entire tape is desirous. This could be implemented by adding an NF=mm parameter to the '..MT EX=60' PCL card, where mm would be the number of contiguous tape files to be sent, the default would be one. This parameter would function in a manner analogous to the ET parameter. Third, in both the ET and the proposed NF parameters, CC records of zeros should be sent when intermediate tape marks are encountered. Also, two CC records of zeros should be sent when a double end-of-file is encountered (this could happen prematurely on the NF parameter). A summary of these Data 100 enhancements are as follows:

a) FF=nn parameter added to the '..MT OU=60' PCL card to enable positioning of an output tape.

b) NF=mm parameter added to the '..MT EX=60' PCL card to enable selection of contiguous intermediate files to be transferred.

c) CC records of zeros to be transmitted when intermediate tape marks are encountered.

d) Two CC records of zeros to be sent when a premature end-of-tape is encountered.

The above proposed changes would greatly enhance the capabilities of Data 100 and provide a tape transfer capability which could be used operationally.

The above enhancements would still rely on the Data 100 operators to initiate the transfer properly. To avoid human errors it would be ideal if the tape transfer software on the 370 could control the tape operation on the Data 100. In this manner the only requirement of Data 100 operators would be to mount the desired tape on the Data 100. To a small degree this is already done on a transfer to JSC; along with the tape, data control information may be sent to write tape marks and to rewind the tape. For this to be done in a transfer to LARS would require a major modification to software running on the Data 100. This is one of the possibilities what will be investigated in the coming months.

If JSC should decide to pursue these alterations with Data 100, an upgrade of the LARS produced tape transfer software would be made and documented.

Upgrade Batch Machine Support. JSC usage appears to differ somewhat from Purdue usage of the computer system in terms of the mix of system resources required by the individual users. It was, therefore, likely that batch machine requirements for support of JSC users were somewhat different than the batch machine characteristics needed to support LARS users. A preliminary assessment of JSC batch needs based on input from JSC users was made in February. Among the batch needs of JSC users which were not supported by the available LARS batch machines was the need to run CMS370 in a batch mode. In order to accomodate this need, a psuedo batch machine was quickly implemented on ID JSC750 specifically for the support of LARSYSP1 operating under CMS370 in batch mode.

During this quarter a priority rate batch machine (BATEOD) was implemented to support CMS370 and the 2 megabyte machine size often needed by JSC users. The CMS360 batch machine charged the basic CPU rate (BATLONG) was expanded from 512K to 2M of core to support JSC SPSS batch requirements. A specialized batch machine (TAPTRAN) was implemented to specifically support tape transfers between JSC and LARS. A new batch machine (BATJSC) has been added to support the SR&T research community. BATJSC is a two megabyte machine with a 150 minute time limit which will operate under CMS370. This machine qualifies for the lower cost basic CPU rate (like BATLONG). Experience with JSC use of these batch machines (BATEOD, BATLONG, TAPTRAN, and BATJSC) is expected to lead to recommendations for future batch upgrades and additions.

In order to allow JSC users to access the programs stored on their 191 disks, all minidisks associated with JSC ID's have been assigned read passwords. Bill Shelley and Sue Schwingendorf both dedicated portions of their visiting consultant trips to presentations on the use of batch machines and helping individual users to run batch jobs.

It is important for JSC users to be able to put any printer and/or punched output in a hold status. This is easy for the user to do when running in interactive mode, but not so easy when running batch. Consultants at LARS are currently able to supply JSC users with the list of commands necessary to place batch output in hold status. This method is awkward, however, and a 'hold' option is currently being implemented for inclusion on the BATCH OUTPUT card in the standard BATCH MACHINE definition deck which preceeds each batch job. Not only will users be able to specify hold status when the option is available, but also the number of copies of output.

Since the initial assessment of JSC batch needs, usage of the LARS terminal via JSC has increased in volume and scope. In addition, it is anticipated that additional SR&T sites will eventually be using the LARS system. Therefore, batch requirements for SR&T use will be re-examined as will overall system batch requirements for the entire LARS system.

New systems batch capabilities will be recommended to the systems group within the LARS Computer Facility. The systems group may then choose to support certain batch capabilities which JSC has supported to this point. Those batch capabilities required by JSC, but not supported by the LARS system group, will then be implemented and supported under the JSC contract.

Provide JAS Accounting by User Group. The Purdue Computer Processing Support Task (SR& T TASK 2.4) consumed over 1/3 of the total LARS computer usage during the month of June and July 1978. This usage is not expected to decrease. The community of users under this task is wide and varied including users from Purdue, Lockheed, NASA, IBM, Texas A & M , and Ft. Lewis College, Colorado. The systems accounting programs available at LARS provide accounting information only on a project basis. In order to better understand, monitor and control usage by the diverse user community supported under SR&T Task 2.4, more detailed accounting information was needed. To secure this information, the various user groups supported by this project were identified.

This new accounting report by user groups has been designed and programmed during this quarter. By the end of the quarter, it will be operational. A LARS person will be assigned to run it every week to produce a weekly report and at the end of each month for a complete monthly report. The recipients of the report will be those people responsible for the groups. Additional report recipients will be added by personnel at JSC. JSC personnel will monitor and regulate user groups based on this report.

In order to better control the time of usage and the computer expenditures of the various user groups, personnel at JSC have suggested that they develop their own specific metering system to allocate basic rate and priority rate CPU time. Once this system has been designed and documented, it will be added as an adjunct to the accounting by user group report.

Initiate LARSYSP1 IPL SYSTEM. The initial implementation of the EODLARSYS and Procedure 1 software on the LARS Machine required 2 megabytes of core to execute. Because of the way LARS batch machines operate, it was very difficult to run a LARSYSP1 job in a batch environment. A LARSYSP1 IPL system has been implemented by LARS personnel with core requirements reduced from 2M to 768K. To support the IPL system, disk space had to be secured and those load modules required by each separate EODLARSYS processor identified. Changes to the 370 control program (CP) were necessary for the IPL system to be recognized. IPL system characteristics and maintenance requirements are being documented so that the LARSYSP1 IPL system may be maintained by personnel at JSC. The programmer documentation will include instructional information for generating the overlay modules along with EXEC routines to simplify the updating process.

Setting up a LARSYSP1 IPL system has three benefits for system users. The first benefit is that by using the IPL system, the user is insured of using the current version of the prompting EXEC and the EODLARSYS software. The second benefit is that the IPL system helps reduce the total system load and thus indirectly benefits the users with improved response and reduced CPU times. This second benefit was accomplished by generating overlay modules (See Figure 4-3) for the EODLARSYS software and thus reducing storege requirements from 2M to 768K. An added advantage of the overlay structure is that storage requirements are determined by the largest processor versus the sum of the sizes of all processors. When adding additional processors to the EODLARSYS software, the overlayed version remains at a somewhat constant size whereas the 2M version would continue to grow with each additional processor. The third advantage is that by using modules, rather than text decks, the CPU and response times required to load a processor are reduced and only those modules (processor) used are loaded.

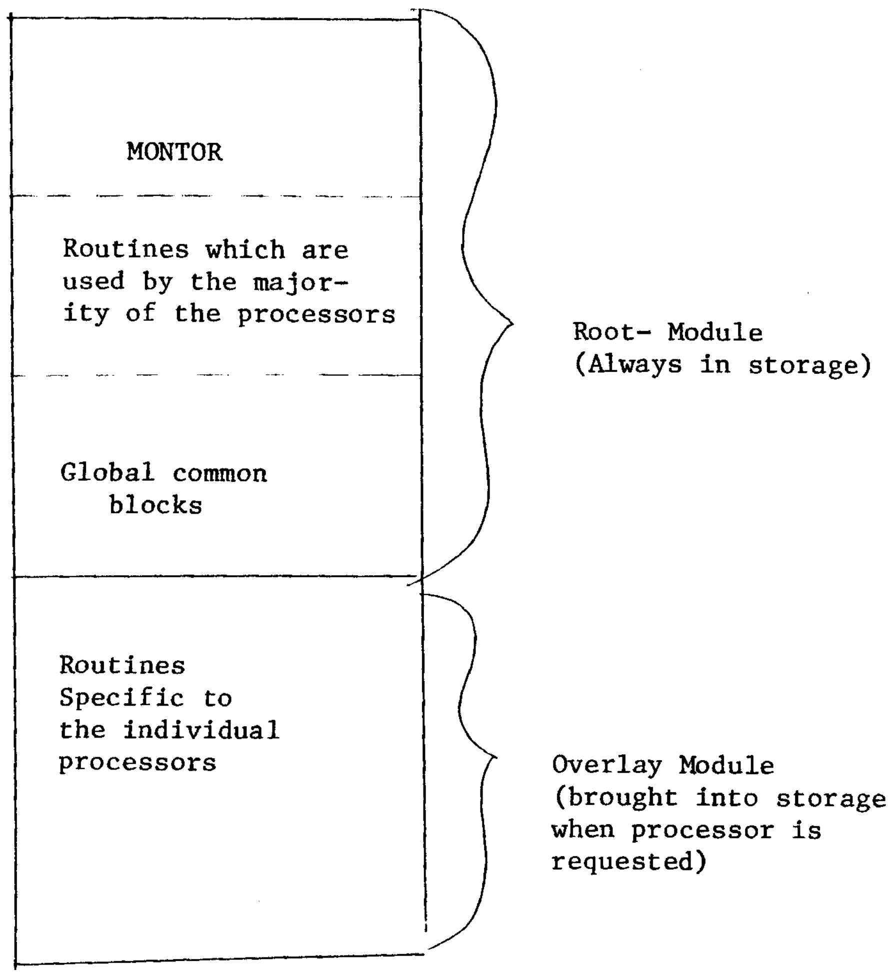



Figure 4-3. EOD LARSYS Overlay Structure

C reate Time Limit per interactive Session Software. Several JSC users have encountered bugs while their programs were executing in a disconnected mode. The result of this problem has been that several jobs have run away, consuming multiple hours of CPU time. In order to prevent this problem in the future, a way to limit the amount of CPU time which may be used by a single job has been requested. The capability to limit CPU time used per job requires an alteration to the interface software between the user's virtual machine and the 370's control program (CP). This task will be pursued during the next quarter.

Secure Disk Storage Space. The increase in usage and users on the LARS system has resulted in an increased need for disk storage space. To alleviate this problem, several steps have been taken. During this quarter, an investigation was begun into the available disk suppliers and the costs of available disks. Purdue's disk shortage has been communicated to JSC so that any possible government sources of disk which might be available to LARS might be identified. Programs which would execute in CMS370 have been transferred to the IBM 3350 disks (3350's are not capable of supporting CMS 360 usage). Temporary disks were in very high demand as JSC usage began to climb in May. To help alleviate this problem, temporary disk storage space was increased by 75%. (The increase in temporary disk space was made possible by the transfer of CMS370 programs to the 3350 disks.) Copies of the source (FORTRAN) programs for certain LARS systems have been removed from disk storage and are maintained only on tape at the present time.

At this point, and for the forseeable future, disk space is expected to remain a critical problem. At present there are only 17 free 2314 cylinders and 11 free 3350 disk cylinders. At the present time, it is difficult to assign a new ID any number of cylinders larger than 2. Basic Systems maintenance usage is currently large due to the current project to install VM/370 Release 5. We are investigating the effects of forcing the deallocation of currently assigned space such as spooling area, paging area and system library space. Such deallocation may very adversely effect system performance.

An estimate of JSC disk needs has been requested of JSC personnel. When the estimated JSC disk space requirements are received and the investigation of available disk sources have been completed, a recommendation will be made to JSC that LARS obtain an appropriate amount of additional disk space with a controller for the additional disk units. This recommendation will be in the form of a proposal. Upon approval of the proposal, the disk and disk controller will be ordered. When the disks have been received at LARS, they will be implemented and, with the appropriate control program (CP) modifications, additional space will become available to users of the LARS system.

Insure Computer Financial Support. One of the contributing factors to the increased usage of the LARS computer by JSC personnel was the need to maintain computational facility at LARS. We intend to continue to review and communicate our financial situation ($550-650K of computer use is needed from SR&T LARS research projects and the Computer Processing Support Task during CY79)

(a) Estimate and Communicate Funding Needs to JSC. JSC's use of the computer resources on this project have exceeded expectations. Therefore, the usage has been monitored closely, reports have been submitted frequently, and needs have been described in a letter to Jon Erickson dated August 4, 1978. That communication indicated that as of August 1, 1978, even with the recent cost extension, only approximately $52,000 was available in the project and that at the present rate of usage, this will last to approximately the third week in September. A request for an additional $120,000 for computer services for the remainder of the contract period was made in that letter.

(b) Long Term Planning. During this quarter, several activities have been pursued with reference to a long term arrangement for this project. The first of these activities concern an implementation plan modification. The modification was necessary due to the cost extension received approximately August 1st.

Therefore, we took this opportunity to not only revise the implementation plan for this project period, but also to indicate activities for the next year. The implementation plan modifications have been submitted and are expected to be further refined during the next quarter.

The second activity pursued has been discussions dealing with the sale of the third shift to NASA/JSC. These discussions are expected to lead to a concrete proposal and response by the end of October 1978.

The third activity includes the securing of a long term funding commitment . It is felt that computer services could be provided at a cheaper rate if a long term funding commitment of approximately 3 to 5 years were in effect. This will be more carefully studied over the next three quarters with the advantages of the long term funding being communicated by February 20, 1979 leading to a long term funding commitment by the end of the next contract year.

ii. Provide Consulting Support for"SR&T Computer System at LARS"

There are various tasks being carried on that can be classified as assistance oriented: information exchange, consulting and support of user needs, documentation and training.

Establish Consulting Activities. The first step in providing consulting activities to JSC was to assemble a team of experts at LARS to assist JSC users with obtaining resources and training on the LARS computer system. Periodically members of this team of specialists have travelled to JSC to act as consultants to the various users there. This consulting team is also responsible for hosting visitors to LARS from JSC.

A number of LARS specialists are responsible for consulting tasks. The team consists of Bill Shelley, Keith Philipp, Sue Schwingendorf, Luke Kraemer, Jeanne Etheridge, Nancy Fuhs, and Ross Garmoe. A fairly up-to-date list of the tasks each of these people is responsible for is included in Appendix A. Consulting comprises a very substantial portion of the work performed under this contract. The number of users of the system and their computer usage reflect the success of our consulting support.

(a) Visiting Consultants. Consulting activities include the bimonthly visits that members of the consulting team have made to JSC. These visits last a week, and the LARS person lectures on and demonstrates various aspects of our system and spends time helping users on a one-to-one basis. During this quarter, three LARS Specialists visited JSC.

From May 22 - May 26, Susan Schwingendorf served as a visiting consultant at JSC. While there, she presented a seminar on the use of batch machines, demonstrated the EODLARSYS EXEC, discussed the availability of IMSL and assisted new users with CMS370.

During the week of July 10, Bill Shelley and Keith Phillip made a visiting consultant trip to JSC. Items discussed during their visit included LARSYSP1 prompting EXEC, the LARSYSP1 IPL system, how to use batch machines, the tape transfer system, candidate configurations for future terminal hardware.

(b) User Support Activities. During this quarter 17 computer ID's were added to the Purdue/LARS system; 13 for use by people at JSC, 3 for LARS support of project activities and 1 night batch machine for JSC. In addition, about 20 requests to alter existing ID's were handled.

Thirty blank tapes were received from JSC the end of May and entered into LARS tape slots 3900-3929. These are being used to receive tape transfer data from JSC. In early June, four CCT's were transmitted to LARS using the tape transfer programs, and were subsequently reformatted into LARSYS format.

Provide System Information. Numerous and varied forms of documentation and information about the LARS computer system are provided to JSC users through the consulting team. Examples of information transmitted this period include a list of abstracts of LARS programs and two copies of thos abstracts, various CP/CMS manuals, a diagram of computer system hardware (Appendix B), a short description of the software systems available on the LARS computer (Appendix C), etc.

In July of this quarter, 2 complete sets of LARS abstracts and an abstract list were sent to Glen Prow. Glen Prow is the contact at JSC for any documentation we have sent or any that we will be sending in the future. He also recently received a 2-page document which briefly describes the software systems available at LARS and how to access them.

This document refers users to Glen Prow if they wish to look at LARSYS User's Manuals and System Manual, LARS Abstracts, SPSS Pocket Guide, LARS'SCANLINES, the IMSL library document, LARS Computer User's Guide, and a demonstration of graphing capabilities in the EXOSYS software system and the control cards for EXOSYS.

Personnel at Houston have been provided with all current CP/CMS documentation. Ross Garmoe and Keith Philipp are planning to test Release 5 on Saturday, August 19 and, if all goes well, they hope to have it on the system soon. Once it becomes available, JSC users will be sent all necessary documentation concerning Release 5.

Several demonstrations have also provided information about the capabilities of the LARS system. A sample Mead output product and cost figures related to that product have been provided to JSC for evaluation of that product's utility to several specific JSC output product needs. A demonstration package for the EXOSYSDV software system has been prepared and transmitted to JSC personnel. An atmospheric transmission data tape in a Univac object code format has been converted to IBM format for the accuracy assessment group at JSC.

An SR&T NEWS capability is being implemented so that any users of the LARS system may obtain information about the most recent system alterations or capability upgrades by typing 'NEWS SR&T'. Disk space has been obtained to support this function and its availability is estimated to be early September.

<u>Demonstrate EXEC's by Programming EODLARSYS Prompting Exec.</u> One very powerful tool available on IBM's Conversational Monitoring System (CMS370) is the EXEC File. EXEC files are composed of strings of job control commands augmented with testing and branching capabilities. In order to aid JSC users in their use of EXEC files, LARS consultants agreed to demonstrate the EXEC language by programming a Prompting EXEC for the LARSYSP1 software. Prospective users at JSC and Lockheed personnel responsible for the implementation of LARSYSP1 on the Purdue System were

interviewed and requirements for the Prompting EXEC were formulated. With these requirements in mind, an initial EXEC was programmed (this quarter) and later demonstrated during a visiting consultant trip. Based on comments resulting from the demonstration, the Prompting EXEC requirements were revised. This EXEC will be upgraded, documented, and its maintenance turned over to JSC.

In the process of implementing the Prompting EXEC, consulting personnel at LARS have encountered several LARSYSP1 bugs. These software bugs are being communicated to the Lockheed staff responsible for the conversion of the LARSYSP1 software.

Make Statistical Packages Available. In order to evaluate the results of demonstrations and experiments related to the development of remote sensing technology, a number of statistical analysis capabilities are necessary. LARS, at the current contract's inception, had a version of the Statistical Package for the Social Sciences (SPSS) and the Bio-medical Statistics Package (BMD). JSC users had requested that the possibility of acquiring the International Mathematical and Statistical Library's (IMSL) and the Statistical Analysis System (SAS) be investigated. System requirements for IMSL and SAS were examined resulting in the elimination of SAS as a viable package on the LARS computer because of its incompatibility with the way CMS performs disk I/O.

IMSL was ordered and received prior to this reporting period. During May 1978, an existing Fortran program was modified to read the IMSL source tape and separate the IMSL subroutines into individual files on the PURDUE/LARS computer. These files were then compiled and the source, listing and text files were stored on tapes 523, 524, and 525 respectively. The text files are also available in CMS370 by inssuing the command:

GETDISK JSCDISK 19E

A majority of the IMSL routines can be single or double precision. On the source tape, the single precision version is provided, with double precision statements "commented out". Since the double precision text files do not appear to be compatible, we are in the process of editting the source files to provide a text library of double precision IMSL routines.

There is a maintenance fee that has to be paid yearly to SPSS, Inc. for their statistical package. Because of change in personnel at LARS, this fee did not get paid until this quarter although it was due in December 1977. This contract paid half of the $600 fee.

In SPSS, the discriminant analysis routines do not work on Release 7.1 which runs under CMS370; they do run on Release 6 which runs under CMS360. SPSS intends to have Release 7.2 ready by the end of August 1978 with a working version of the discriminant analysis routines. Hopefully, it will be ready and can be installed some time in September. Since we have not had much experience with SPSS personnel, we have set the installation date in October for Release 7.2 in order to give them and us some leeway. Release 8, with additional desirable features and options, should be available in the spring of 1979. Also, SPSS Pocket Guides for users were ordered and sent to Mike Pore at JSC.

Exchange Information. In order to provide a general background on the ust of the LARS computer, personnel at LARS prepared a short course on the use of the LARS system and CMS370. Since many computer users at LARS had not yet become familiar with CMS370, a trial run of this short course was conducted at LARS prior to the presentation of the short course at JSC.

During this quarter, we reorganized the training materials for this course so that it can easily be presented again for new users of our system. In September, part of this course will be presented to LARS personnel to encourage them to use CMS370 instead of CMS360. The course is scheduled to again be presented at JSC in January, 1979.

In order to keep personnel at LARS informed of activities at JSC and personnel at JSC informed of activities at LARS, the organizations have decided to exchange their respective information bulletins. The Facility Management Bulletin for the Earth Observations Division is currently being distributed to certain members of the LARS staff and posted on bulletin boards at LARS, and LARS' SCANLINES is being sent to a number of JSC personnel.

In order to facilitate communications between Purdue/LARS and JSC/EOD, the Purdue telephone officer has been asked to request an FTS line at LARS. Since he is in the process of dealing with FTS for the entire campus, he is at the present time studying Purdue's total FTS need and will make a recommendation at the end of this study. At the present time, he has not given an indication of when the study will be complete or when the FTS line will be requested. It is estimated that this will not occur before January 1, 1979.

b. Data Base Management

i. Data Base Design & Implementation

Design Data Base for Historical Data. The data base proposed in the previous Quarterly Report is currently being updated to include additional data fields and files for a better coverage of important information. Major changes in the data base include new fields in the Segment Index Data File which further define the location of the segments, i.e., Country, State, County, Agro-Physical Unit Description and Crop Reporting District. In the Acquisition List Records, newly added fields will contain such information as Orbit Number, Time Data Collected, Peak Sharpness, Cloud Cover, etc. Two new files, a Crop Names List and a Crop Status List, have also been added to the design. These two files will be indexed by the Dot Label Table; therefore, storage will be saved by elimination of duplicate crop names and their statuses. Probably the most important addition to the design though, is a pointer field which indicates the corresponding CAMS/CAS data file for each analysis. This pointer is included because the CAMS/CAS interface tape contains abundant information which may be valuable. Rather than consuming disk space to duplicate this data, a pointer was included in the Dot Label File. See Appendix D for a detailed description of the data base. Further updates to the data base design, expecially in files other than the Acquisition List and the Segment Index, are expected as implementation and testing proceed.

Receive Landsat Data Bases. To support the research needs of the SR&T community, it is necessary for users to have both processing software, which is available in the form of LARSYSP1, and the data to be exercised by that software. Consequently, the LACIE Phase II and Phase III data bases have been unloaded from disk storage in Building 30 and shipped to Purdue. Upon reaching Purdue, tapes are labelled and placed in tape racks. Because the tension on the tape drives at Purdue may differ from tape drive tension on the drive at JSC which wrote the tapes (and degrade the ability of the LARS tape drives to read the tape successfully), all tapes received from JSC are placed on a LARS drive, forward filed to the end of the tape, and then rewound. When labelling and retensioning operations are completed, a letter verifying receipt of the data is sent to JSC.

The 1976 Phase II Data Base was completed at LARS the beginning of June with the addition of tape #76110 which was inadvertantly left out of the shipment. Hence, JSC tape 76001 is in LARS tape slot 7223 and JSC tape 6110 is in LARS slot 7332, with intermediate tapes in between.

A serious problem was discovered with some of the data base tapes sent from Houston: they stick to the tape units. The tapes unloaded from the segment data base at JSC come to Purdue in 800 bpi. The LARS computer system has 9 tape drives which read 9-track tapes. However, only 4 of these tape drives are capable of reading 800 bpi tapes, while all 9 are capable of reading 1600 bpi. In order to allow more than 4 users at JSC to concurrently access the data bases available on the LARS system, and to improve the reliability of the tape data, the historical data base will be copied to 1600 bpi tapes.

The following is an estimate of the resources it will take to copy the Phase II and Phase III data bases (333 tapes):

i. Approximately 3-4 weeks to convert the entire library to 1600 bpi.

ii. Approximately 80 clock hours of batch machine time to run all copies (based on tapecopy done August 8 which took 15 minutes.

iii. Approximately 9.5 to 10 CPU hours to run all copies (based on 1 tapecopy done on August 8 which took 111.51 seconds or .030 CPU hours--$2497.50). The CPU cost could vary depending on the number of files on a tape to be copied.

iv. Service Staff time of about 5 hours ($47.25).

v. Professional Staff time of 1 hour ($19.50)

A total cost of about $2,564.25 is estimated.

Tapes containing the LACIE Transition Year data base are expected to be shipped, received, and entered into the data library during the next quarter.

Catalog Landsat Data in the Segment Catalog. The Segment Catalog is a portion of the historical data base which contains reference and ancillary information about the data stored in the data base. As Landsat segment data is received, information about the newly received segment data is to be recorded in the Segment Catalog.

Since the design of the historical data base is nearing completion, implementation of a skeletal version of this data structure for testing purposes is under way. During this testing period, a better appraisal of storage requirements will be made. Also, the initial implementation of the Segment Catalog will allow users of the Landsat data currently at LARS to use the data search and data acquisition software (discussed below) to support their research needs. After the design of the Segment Catalog has been finalized, the test structure will be reformatted to the desired record layout.

Implement Data Base. In conjunction with the design of the current historical data base, we have begun an index which details how and where the necessary data can be accessed. Each field in the data base must be defined clearly and the source of data for each field must be identified.; e.g., Landsat, System, Analyst,... When the data base and index are close to completion, then the software for data entry will be designed and implemented. Plans for the Segment Index and Acquisition List are already being made and a test data base with these filed will be in operation soon. As with all data bases, a system pf programs will also have to be implemented to maintain the data. Design of this software will not begin until the data base and data entry software reach a more definite stage of development. LARS will design and implement software necessary to initiate and maintain the historical data base at Purdue.

It should be noted that for the processing algorithms to make efficient use of the data stored in the data base, interface software between the data base and the processing system (e.g., LARSYSP1) should be designed and implemented. LARS would be glad to provide input to such software; however, resources are not available in the 2.4 contract to support a programming effort of the size necessary to adequately provide interface software.

ii. Data Management Software

Implement Tape Referencing Capability. To locate the specific LARS tape and file which contains Landsat data for a specific acquisition of a specific segment, utility subroutines (SEGFO and GETACQ) have been written. These subroutines take segment and acquisition numbers as input and return specific information about those segments and acquisitions (such as the tape and file of the data). These programs are in the process of being documented and will be demonstrated at JSC. Program abstracts for SEGFO and GETACQ appear in Appendix E.

SEGFO searches a segment index file in order to secure information about:

Acquisition numbers, corresponding tape and file numbers, number of channels, number of columns, latitude, longitude and ERTS scene frame ID for acquisitions of the user's specified segment number.

GETACQ accepts a unit number, a segment number and an acquisition number as input. It then locates the tape and file where the specific acquisition of the desired segment is archived and mounts and positions the tape to that file.

The user may gain access to these routines by typing the following commands in CMS370 mode:

'LINK JSC DISK 19E 19E'

'ACCESS 19E B'

'EXEC GETACQ'

The last command 'EXEC GETACQ', initiates necessary file definitions and links, and accesses the disks which house the segment index information and the necessary text decks.

LARS will maintain the tape referencing software, making alterations as the format of the Segment Catalog is updated.

Implement Landsat Data Search Capability. LARS is in the process of implementing algorithms which will allow the Landsat segment data to be searched based on a set of user specified input criteria. The output of this program will be the segments and acquisitions which satisfy the user criteria or an error message, should no segment and acquisition satisfy these criteria. On completion of this program, it will be documented and demonstrated for appropriate JSC personnel. The search capability for the data contained in the tape header records should be implemented during the next quarter.

## III. Programmetric and Technical Issues

### a. Coordinating SR&T Research Site Access to the LARS Machine

The benefits of centralizing the computational support for SR&T efforts are fairly obvious to those supplying the funds (reduced total costs, improved efficiency); those trying to test and evaluate newly developed technology (immediate access to software and appropriately formatted data, a common operating environment and baseline system for comparisons); and those assembling systems utilizing new algorithms (immediate access to all newly developed software which has been implemented to be compatible with the baseline processing system).

Several major steps have been taken to achieve a centralized SR&T computer system utilizing the Purdue/LARS computer:

1. The philosophical decision has been made to centralize the SR&T computational resources.
2. A baseline analysis system has been implemented at LARS (LARSYS/Procedure 1).
3. An extensive SR&T data base is being shipped to and implemented at Purdue.
4. Computer accessibility for JSC users has been more than doubled, and data transfer capabilities have been greatly enhanced between JSC/EOD and Purdue/LARS.
5. Training courses have been prepared and presented by both LARS and JSC.
6. New software developed by certain JSC contractors (IBM, LEC) is being implemented and tested on the central SR&T computer.
7. Computer ID's and dial-up terminal access is available for other members of the SR&T research community to access the Purdue/LARS system on a limited basis. (Two institutions, Texas A&M and Fort Lewis College are now doing so).
8. Specialized SR&T software support routines are being implemented on the central computer (specialized batch machines, SR&T News files, data search and tape referencing utilities, etc.)

9. Communications systems (including satellite communications) and terminal hardware options are being investigated for the identification of cost effective means to tie other SR&T research sites into the centralized system with much greater throughput capability than is provided through dial-up keyboard terminals.

These steps represent considerable progress toward the establishment of a centralized computer site. Even more impressive is the relatively short time period it has taken to achieve these accomplishments. Considerable work does remain, however:

* The various remote SR&T research organizations must come to understand the benefits of a centralized computational facility, plan their access and use of that facility, and aid in the planning and implementation of terminal hardware and the training of their research and development people in the use of the central site.
* Clear programming and documentation standards must be established and documented so that newly developed research software can be shared by the entire SR&T community and to significantly reduce the cost of integrating new algorithms into demonstration and test systems. JSC should allocate people and funds to produce these standards immediately if the first year of the algorithm development under the Multicrop project is to be beneficial.
* A detailed training course for remote SR&T site users should be formulated by Purdue/LARS and JSC/EOD personnel:
  - i How to access and use the LARS computer system.
  - ii How to access and use the LARSYSP1 (and/or P2) baseline software.
  - iii How to use special SR&T utilities (batch, SR&T News, data search, etc.).

iv Programming standards for research software (e.g., baseline system compatibility, universal format capability, commenting practices, transferability, etc.).

v Documentation standards

vi Standard algorithm evaluation, tests, procedures and techniques.

vii Procedures for requesting data.

viii Others.

To accomplish these goals, it is suggested that a committee of personnel from SF3, SF12, and Purdue be established to plan and manage the integration of other SR&T research sites into the user group of the SR&T computer system.

b. Usage Projections

It would help prevent bottlenecks and shortages of various system resources if projections of computer usage can be made for two to three month period. LARS has been able to successfully monitor and plan for systems use by Purdue researchers. The Laboratory does not have sufficient resources or information to project usage by non-Purdue sites. As more sites begin to utilize the computational facilities at LARS, systems problems and resource shortages are likely to occur unless ballpark estimates of usage over a six to eight month time period (the time necessary to react to demands for increased or decreased hardware) from the remote sites can be obtained. We will continue to do our best to keep problems to a minimum, provide the best service possible with the available resources, and be as responsive to the needs of our collective users. Should usage projections indicate the need for additional equipment, we will seek counsel and assistance from our contract monitor at JSC.

# APPENDIX A

LARS' Consulting Team

## LARS Consulting Team

1. Bill Shelley
   a. Implement, document, and train JSC personnel in the Data 100 tape transfer procedure.
   b. Consult with users at LARS about LARSYSP1 problems and pass information on to Pat Aucoin.
   c. Consult with JSC users about programming problems, including converting programs from other computers to the LARS computer.

2. Keith Philipp
   a. Resolve problems with RSCS.
   b. Resolve modem and line problems with Glen Prow.
   c. Answer needs for additional teletype terminals.

3. Susan Schwingendorf
   a. Update and add computer userids.
   b. Write information for and about JSC in the LARS monthly SCANLINES.
   c. Consult on BMD and IMSL problems.
   d. Answer needs for new SR&T remote terminal sites.
   e. (Same as Shelley's c).

4. Luke Kraemer
   a. Design historical data base and implement sections of it.
   b. Consult with JSC users about problems encountered when running in batch mode.
   c. Answer needs for additional batch machines and enhancements to current ones.
   d. Be familiar with and coordinate data base storage.

5. Jeanne Etheridge
    a. Act as SPSS coordinator to obtain information about new releases, install releases, maintain list of users who receive newsletters, etc.
    b. (Same as Shelley b).
    c. (Same as Shelley c).
    d. Be responsible for the JSC accounting by user groups.
    e. Work with Glen Prow to insure that he has available LARS system documentation.

6. Nancy Fuhs
    a. Consult with users on SPSS problems.

7. Ross Garmoe
    a. Be responsible for disk storage needs.
    b. Advise JSC on a replacement for their IBM 2780 remote terminal station.

# APPENDIX B

## LARS Computer System Configuration

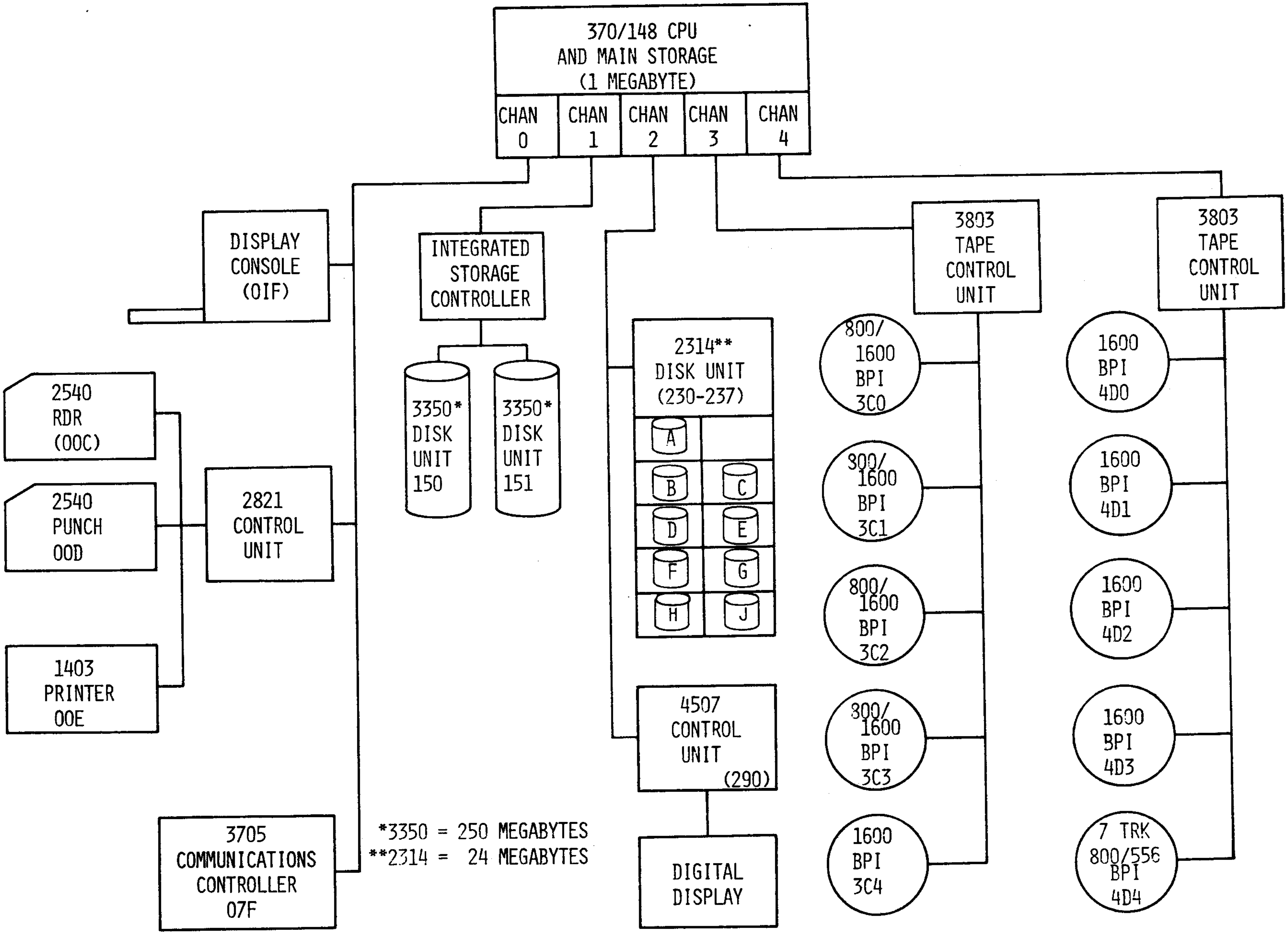



Figure 4-4 Purdue/LARS Computer Configuration

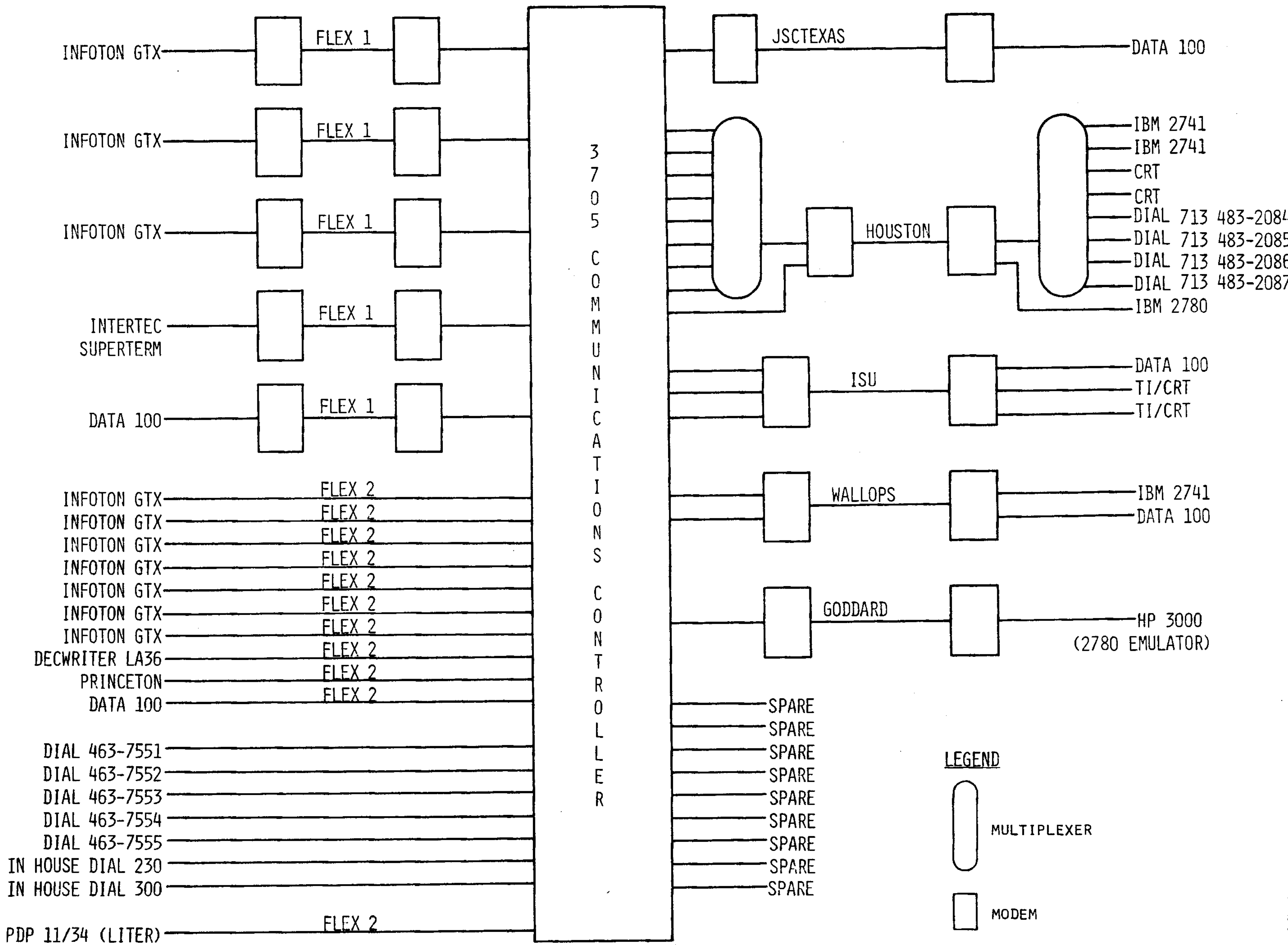



Figure 4-5 Purdue/LARS Terminal Configuration

# APPENDIX C

## Software Systems on the LARS Computer

| | Control Cards | Access to Source | Documentation |
|---|---|---|---|
| 1. | NA | NA | IBM 370 manuals |
| 2. | NA | NA | IBM CP-67/CMS User's Guide |
| 3. | NA | NA | IBM 370 manuals |
| 4. | 'i larsys'<br>'reference all'<br>and LARSYS User's Manual Vol. 3 | 'i cms370'<br>'getdisk lssource' | a. LARSYS User's Manuals Vol. 1-3**<br>b. LARSYS System Manual**<br>c. LARSYS Abstracts 1-699** |
| 5. | 'i larsysdv'<br>'reference larsysdv' | 'i cms370'<br>'getdisk dvsource' | See control cards. If seriously interested in other documentation, contact Jeanne Etheridge. |
| 6. | see documentation | NA at this time | a. 'i cms370'<br>'print SPSS document S'<br>b. SPSS, Norman Nie et al., McGraw Hill book Co., 1975, 2nd edition<br>c. SPSS Pocket Guide** |
| 7. | see documentation | 'i larsys'<br>'run taplib bmd source bmd05R'<br>where bmd05R is an example of a program name | a. LARS Abstract 637**<br>b. May 1978 ScanLines**<br>c. BMD Biomedical Computer Programs W.J. Dixon, editor, U. of California Press, 1970 |
| 8. | see documentation | Fortran - tape 523, files 1-4<br>Fortran Listings - tape 524, files 1-6<br>Text - tapes 525, files 1-4 | a. The IMSL Library, Vols. 1 & 2**<br>b. June 1978 Scan Lines** |
| 9. | see documentation | NA | LARS Computer User's Guide<br>LARS Information Note 011977** |
| 10. | see documentation | NA | LARS Computer User's Guide<br>LARS Information Note 011977** |
| 11. | 'i exosys'<br>'reference exosys' | NA | LARSYS Abstract 5000** |
| 12. | 'i exosys'<br>'reference exosysdv' | NA | a. Demonstration**<br>b. $GSPEC control cards** |

**See Glen Prow

## LARS Systems

| | System | Contact | Supported | Access |
|---|---|---|---|---|
| 1. | VM-CP | Ross Garmoe/Keith Philipp | yes | 'login' userid |
| 2. | CMS360 | Ross Garmoe/Keith Philipp | yes | 'i cms360' |
| 3. | CMS370 | Ross Garmoe/Keith Philipp | no* | 'i cms370' |
| 4. | LARSYS | Bill Shelley/Jeanne Etheridge | yes | 'i larsys'<br>'run larsys' |
| 5. | LARSYSDV | Bill Shelley/Jeanne Etheridge | no* | 'i larsysdv'<br>'run larsys' |
| 6. | SPSS | Mike Pore/Nancy Fuhs/<br>Jeanne Etheridge | no* | 'i cms370'<br>'spss' name<br>where name is the filename of control card deck on disk and filetype is SPSS. |
| 7. | BMD | Sue Schwingendorf/Nancy Fuhs | no* | 'i larsys'<br>'run bmd bmd05R'<br>where bmd05R is an example of a BMD program |
| 8. | IMSL | Sue Schwingendorf/Jeanne Etheridge | no* | 'i cms370'<br>'getdisk JSCDISK 19E'<br>to access text decks |
| 9. | System Batch Machines | Jeanne Etheridge/Luke Kraemer | yes | send card deck to userid BATCH |
| 10. | User Batch Machines | Jeanne Etheridge/Luke Kraemer | no* | send card deck to userid BATCH |
| 11. | EXOSYS | Larry Biehl/Jeanne Etheridge | no* | i exosys<br>run exosys |
| 12. | EXOSYSDV | Larry Biehl/Jeanne Etheridge | no* | i exosys<br>run exosysdv<br>(need 768K userid) |

*This system is currently receiving partial support by one or more LARS projects.

# APPENDIX D

## Segment Catalog

# APPENDIX D

## Segment Catalog

There are at least 6 separate data bases associated with the Multicrop Experiment:

* Data base of acquisitions of Landsat data,
* Data base of wall-to-wall ground observations for each segment,
* Data base of labels and label information for each segment,
* Data base of agronomic observations data,
* Data base of crop calendar data, and
* Data base of meteorological data.

All of these data bases should be organized on a segment-by-segment basis and at least 3 of these data bases (the Landsat data, the ground observation data, and the dot label data) are primarily digital in nature and should be stored in a computer-compatible, computer-indexed form.

Computer indices pointing to the location of various elements of the various data bases associated with each segment, together with the value of certain specific variables for each segment, will compose a Segment Catalog. This document is the current design of that Segment Catalog.

The Segment Catalog (See Fig. 4-6) will itself be composed of six separate data files:

1) The Segment Index,
2) The Acquisition List,
3) The Dot Label Table,
4) The Ground Observations Index,
5) The Ground Observation Fields and
6) Repeated Measurement Records

The last three files compose the Ground Observations Table. All Segment Catalog files will be stored on disk and will be readily accessible through user oriented routines. Routines will be designed to perform two separate functions, 1) producing data base status reports for users and 2) providing the data analysis system (e.g., LARSYSP1) routines direct access to the various data components which the processing systems require.

The Segment Index data file is a master index for the Segment Catalog. It is composed of two types of information:

1) Information which is unique to each segment (e.g., the segment latitude, the segment longitude, the county in which the segment is located, the state in which the segment is located, etc.), and
2) Pointers to the other data files within the Segment Catalog.

The Segment Index data file will include two pointers to other Segment Catalog data files. For example, the first pointer for the Acquisition List data file will point to the first acquisition over the segment of interest in the Acquisition List and the second pointer for the Acquisition List file will point to the last acquisition which has been entered into the data base. The Acquisition List, the Dot Label Table and the Ground Observation Index will each be double linked lists. Fig 4-7 presents an example of how the records in the Segment Index File might appear. If there are no entries in a particular data file for a segment, both pointers to that data file in the Segment Index File will be set to 0. For example, if no satellite data has been collected for a given segment, no entries for that segment will be present in the Acquisition List and the pointers in the Segment Index for the first acquisition and the last acquisition in the Acquisition List will both be set to 0.

Fig 4-8 presents the candidate set of elements for the Acquisition List File. Of particular interest are the first two elements of each record. The first element, called the previous acquisition element, points backwards through the Acquisition List. This element represents the acquisition list record number which contains information about the acquisition prior to the current acquisition for the segment of interest. When there is no previous acquisition in the data base, this pointer will be set to -N, where N is the pointer to the record in the Segment Index for the segment of interest. The second element in the Acquisition List points to where information about the next chronological acquisition taken is located. If the current Acquisition List record contains information about the most recent acquisition in the data base, then the next acquisition value will be set to -N, where N is again the record in the Segment Index data file which contains information about the segment.

Figures 4-9, & 4-12-4-14 represent candidate configurations of the Dot Label Table data file and the Ground Observations Table data file of the Segment Catalog. Like the Acquisition List, these data files have as their first two entries, pointers to the previous and the next entries.

Fig 4-10 & 4-11are simple label files which can be accessed by either the Dot Label Table or the Observations Field Records.

SEGMENT CATALOG

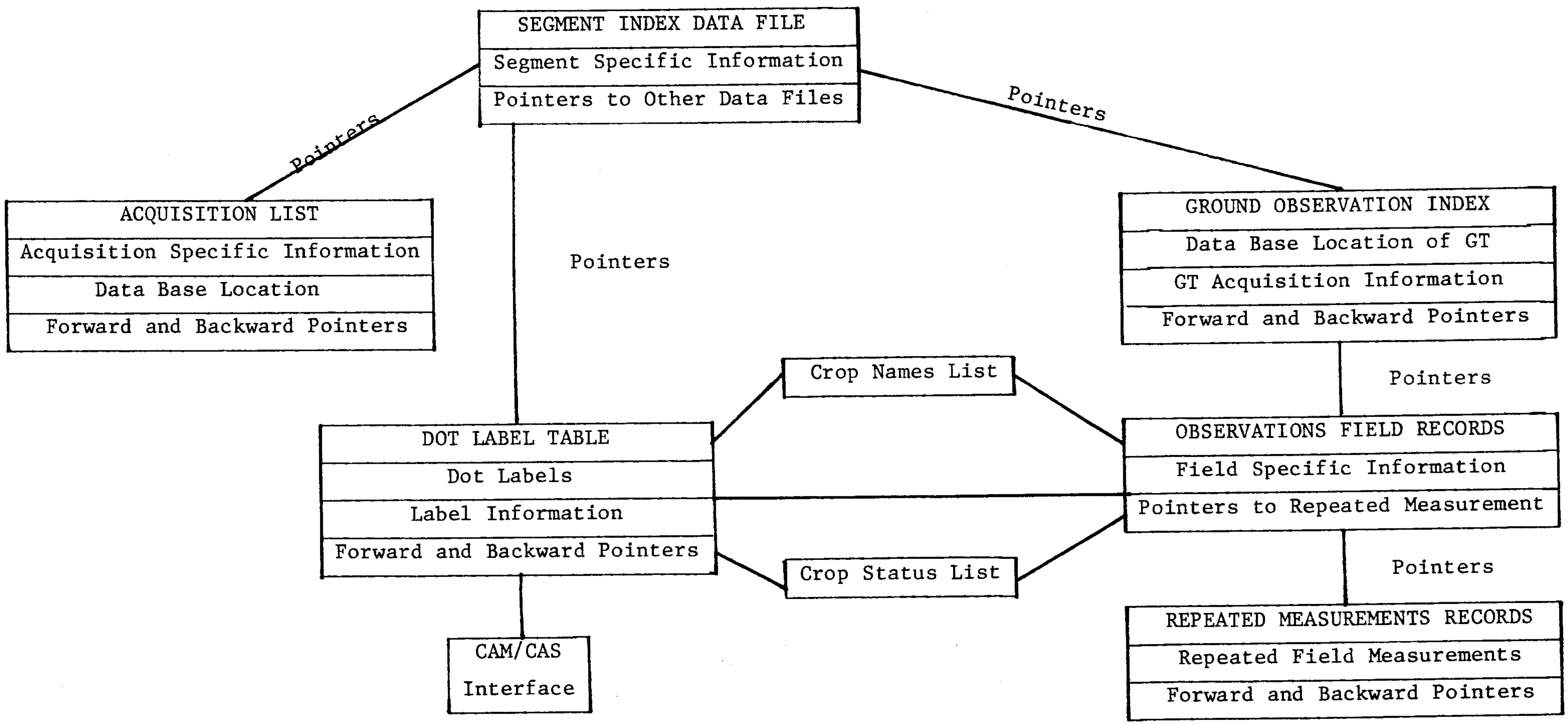



Figure 4-6

Format of Segment Index Records

| Entry | | Format | Bytes |
|---|---|---|---|
| Segment Number | | I*2 | 1-2 |
| Segment Center Latitude (Minutes North) | | I*2 | 3-4 |
| Segment Longitude (Minutes West) | | I*2 | 5-6 |
| Date Segment Initiated: (YYDDD) | | I*4 | 7-10 |
| Segment Descriptor (County, State, Other) | | 8A4 | 11-42 |
| Country (Number Coded) | | I*2 | 43-44 |
| State (Number Coded) | | I*2 | 45-46 |
| County (Number Coded) | | I*2 | 47-48 |
| Agro-Physical Unit | | I*2 | 49-50 |
| Crop Reporting District | | I*2 | 51-52 |
| Acquisition List Pointer: | First Entry | I*4 | 53-56 |
| | Last Entry | I*4 | 57-60 |
| Label Index Pointer: | First Entry | I*4 | 61-64 |
| | Last Entry | I*4 | 65-68 |
| Ground Observation Index: | First Entry | I*4 | 69-72 |
| | Last Entry | I*4 | 73-76 |
| Undefined | | | 77-80 |

Figure 4-7

Format of Acquisition List Records

| Entry | Format | Bytes |
|---|---|---|
| Previous Acquisition | I*4 | 1-4 |
| Next Acquisition | I*4 | 5-8 |
| Sensor System | A8 | 9-16 |
| Orbit Number | I*4 | 17-20 |
| Scene Frame ID (SFI) | I*4 | 21-24 |
| Reference SFI | I*4 | 25-28 |
| Reference SFI for Ground Observations | I*4 | 29-32 |
| Date Data Collected (YYDDD) | I*4 | 23-36 |
| Time Data Collected (GMT) | I*4 | 37-40 |
| Date Entered in Acquisition List (YYDDD) | I*4 | 41-44 |
| Goddard Processing Date | I*4 | 45-48 |
| Date of Unload Tape | I*4 | 49-52 |
| Segment Number | I*2 | 53-54 |
| Sun Elevation (Min.) | I*2 | 55-56 |
| Sun Azimuth (Min.) | I*2 | 57-58 |
| Peak Sharpness | R*4 | 59-62 |
| Normalized Peak to Background Ratio | R*4 | 63-66 |
| Cloud Cover | L*1 | 67 |
| Processing Flag | L*1 | 68 |
| Greeness of Soils Line | L*1 | 69 |
| Haze Number | L*1 | 70 |
| Tape Number | I*2 | 71-72 |
| File Number | L*1 | 73 |
| First Channel | L*1 | 74 |
| Last Channel (NC) | L*1 | 75 |
| Lines of Data | I*2 | 76-77 |
| Columns of Data | I2 | 78-79 |
| Bias Factor for Channel 1 | I2 | 80-81 |
| Gain Factor for Channel 1 | I2 | 82-83 |
| : | : | : |
| Bias Factor for Channel NC | I2 | 77+NC+4-77+NC+4 |
| Gain Factor for Channel NC | I2 | 78+NC+4-79+NC+4 |

Figure 4-8

Format of Dot Label Table Records

| Entry | Format | Bytes |
|---|---|---|
| Previous Label Entry | I*4 | 1-4 |
| Next Label Entry | I*4 | 5-8 |
| Segment Number | I*2 | 9-10 |
| Analyst Identifier | L*1 | 11 |
| Number of Categories | L*1 | 12 |
| Labelling Convention | I*2 | 13-14 |
| Experiment | I*2 | 15-16 |
| Date of Labelling (YYDDD) | I*4 | 17-20 |
| Acquisitions Used in Labelling: | | |
| Date #1 (YYDDD) | I*4 | 21-24 |
| Date #2 (YYDDD) | I*4 | 25-28 |
| ⋮ | | |
| Date #8 (YYDDD) | I*4 | 39-52 |
| Category Names: | | |
| Crop Annotated as Category 1 | I*2 | 53-54 |
| Crop Annotated as Category 2 | I*2 | 55-56 |
| Blank Fill or Crop Annotated Catetory 3 | I*2 | 57-58 |
| ⋮ | | |
| Blank Fill or Crop Annotated Category 30 | I*2 | 111-112 |
| Pointer to First Test Field | I*4 | 113-116 |
| Pointer to Last Test Field | I*4 | 117-120 |
| Pointer to First DO/DU Field | I*4 | 121-124 |
| Pointer to Last DO/DU Field | I*4 | 125-128 |
| CAMS/CAS Pointer | I*4 | 129-132 |
| Number of Labels (NC) | I*2 | 133-134 |
| Labels and Annotation: | | |
| Labelled Line for Dot 1 | I*2 | 135-136 |
| Labelled Column for Dot 1 | I*2 | 137-138 |
| *Dot Label for Dot 1 | L*1 | 139 |
| **Dot Annotation for Dot 1 | L*1 | 140 |

Figure 4-9

Format of Dot Label Table Records

| Entry | Format | Bytes |
|---|---|---|
| Dot Status for Dot 1 | L*1 | 141 |
| ⋮ | | |
| Labelled Line for Dot NC | I*2 | 128+7*NC-129+7*NC |
| Labelled Column for Dot NC | I*2 | 130+7*NC-131+7*NC |
| *Dot Label for Dot NC | L*1 | 132+7*NC |
| **Dot Annotation for Dot NC | L*1 | 133+7*NC |
| Dot Status for Dot NC | L*1 | 134+7*NC |

* $1 \leq N \leq 30$ ==> Type one dot corresponding to catetory name N

**$129 \leq N \leq 158$ ==> Type two dot corresponding to category name N-128

** 0 ==> A Field Pixel

1 ==> Dot in DO area

2 ==> Dot in DU area

3 ==> Dot is an edge pixel

4 ==> Dot is a boundary pixel

Figure 4-9

Crop Name List

| Entry | Format | Bytes |
|---|---|---|
| Name for Label 1 | A8 | 1-8 |
| Variety for Label 1 | A8 | 9-16 |
| Name for Label 2 | A8 | 17-24 |
| Variety for Label 2 | A8 | 25-32 |
| ⋮ | | ⋮ |

Figure 4-10

Crop Status List

| Entry | Format | Bytes |
|---|---|---|
| Name of Status 1 | A8 | 1-8 |
| Name of Status 2 | A8 | 9-16 |
| ⋮ | | ⋮ |

Figure 4-11

## Ground Observations Table

### Ground Observations Index

| Entry | Format | Bytes |
|---|---|---|
| Previous Ground Truth Entry | I*4 | 1-4 |
| Next Ground Truth Entry | I*4 | 5-8 |
| Segment Number | I*2 | 9-10 |
| Date of Initial GT Record (YYDDD) | I*4 | 11-14 |
| Date of GT Reference (YYDDD) | I*4 | 15-18 |
| Pointer to Acquisition List for First W to W GT | I*4 | 19-22 |
| Pointer Acquisition List for last W to W GT | I*4 | 23-26 |
| Number of Fields Monitored for Agronomic Data | I*2 | 27-28 |
| Pointer to First Monitored Field | I*4 | 29-32 |
| Pointer to Last Monitored Field | I*4 | 33-36 |

Figure 4-12

## Observation Field Records

| Entry | Format | Bytes |
| --- | --- | --- |
| Previous Field Monitored | I*4 | 1-4 |
| Next Field Monitored | I*4 | 5-8 |
| Segment Number | I*2 | 9-10 |
| Field Number | I*2 | 11-12 |
| Field Identifier | A8 | 13-20 |
| Crop Names Entry | I*2 | 21-22 |
| Crop Status Entry | L*1 | 23 |
| Date Planted (YYDDD) | I*2 | 24-25 |
| Row Width (Meters) | R*4 | 26-29 |
| Nitrogen Fertilization | I*2 | 30-31 |
| Pointer to First of Repeated Measures Data | I*4 | 32-35 |
| Pointer to Last Repeated Measures Data | I*4 | 36-39 |
| Number of ARCS (NARC) | I*2 | 40-41 |
| Line Coordinate 1 | I*2 | 42-43 |
| Column Coordinate 1 | I*2 | 44-45 |
| Line Coordinate 2 | I*2 | 46-47 |
| Column Coordinate 2 | I*2 | 48-49 |
| ⋮ | | ⋮ |
| Line Coordinate NARC | I*2 | 38+NARC*4-39+NARC*4 |
| Column Coordinate NARC | I*2 | 40+NARC*4-41+NARC*4 |

Figure 4-13

Repeated Measurement Record

| Entry | Format | Bytes |
|---|---|---|
| Previous Measurement | I*4 | 1-4 |
| Next Measurement | I*4 | 5-8 |
| Segment Number | I*2 | 9-10 |
| Field Number | I*2 | 11-12 |
| Date Measured (YYDDD) | I*4 | 13-16 |
| Maturity | L*1 | 17 |
| % of Ground Cover | L*1 | 18 |
| % of Green Leaves | L*1 | 19 |
| Condition | L*1 | 20 |

Figure 4-14

# APPENDIX E

## Tape Referencing Program Abstracts

MODULE IDENTIFICATION

Module Name: GETACQ Function Name: LARSYS P1 SUPPORT

Purpose: To mount and position a tape to the file containing a given acquisition

System/Language: CMS/FORTRAN

Author: John Dolan Date: July 18, 1978

Latest Revisor: ______ Date: ______

MODULE ABSTRACT

GETACQ finds which tape a given acquisition is located on. It then mounts the tape and positions it to the file containing the acquisition.

1. Module Usage

GETACQ

CALL GETACQ (UNIT, SEGMNT, ACQ, ERROR)

Input Arguments:

UNIT - I*4 is the FORTRAN unit number on which the tape is mounted.

SEGMNT - I*4 is the segment number whose acquisitions we will search.

ACQ - I*4 is the target acquisition number. We look through all the segments matching SEGMNT until this acquisition is found.

Output Arguments:

ERROR - I*4 returns the status of the attempt to find the acquisition and mount the tape.

0 = the mounting went flawlessly. Northing went wrong in the subroutine.

1 = the acquisition wasn't found. Not tape was mounted.

2 = There were problems positioning the tape to the correct file.

3 = What is on the tape doesn't match what's supposed to be on the tape. After this error the tape will still be mounted and positioned to that file.

2. Internal Description

GETACQ finds the acquisition by calling SEGFO which searches a table for the segment and acquisition. Among the things return are the tape and file numbers of the acquisition. If the tape number returned is equal to the tape number of the tape currently mounted (as GETACQ sees it), then the tape is rewound and positioned, otherwise the new tape is mounted. After the tape has been positioned, the header record is read in and the segment and acquisition numbers on the tape are compared with what is supposed to be on the tape.

3. Input Description

Not Applicable

4. Output Description

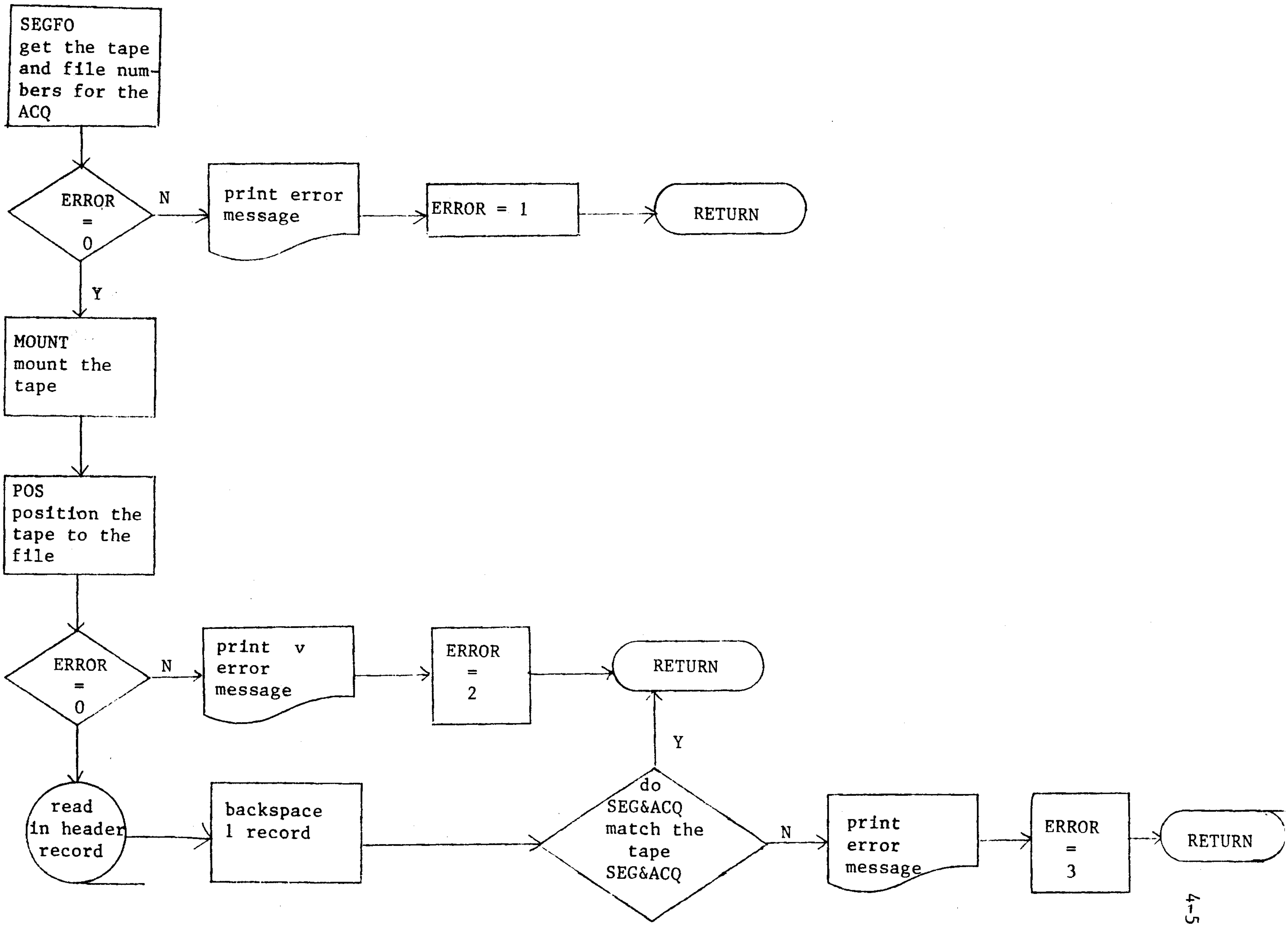
Not Applicable

5. Supplemental Information

Because GETACQ calls SEGFO, the index table - currently (7/20/78) on JSCDISK 19D - must be accessed, and the following filedef (370) must be made:

```
FILEDEF  10  SEGMENT INDEX filemode (XTENT 65000 LRECL 80 PERM)
```

6. Flowchart


SEGFO get the tape and file numbers for the ACQ
ERROR = 0
N
print error message
ERROR = 1
RETURN
Y
MOUNT mount the tape
POS position the tape to the file
ERROR = 0
N
print v error message
ERROR = 2
RETURN
read in header record
backspace 1 record
do SEG&ACQ match the tape SEG&ACQ
Y
N
print error message
ERROR = 3
RETURN

## MODULE IDENTIFICATION

Module Name: SEGFO   Function Name: LARSYS P1 SUPPORT

Purpose: Return data cross section indexed by segment and acquisition

System/Language: CMS/FORTRAN

Author: John Dolan   Date: June 7, 1978

Latest Revisor: ________   Date: ________

## MODULE ABSTRACT

SEGFO searches the LACIE database for a given segment - and an optionally given acquisition list - and returns the associated information.

1. Module Usage

SEGFO

```
CALL SEGFO (SEGNUM, ACQCNT, ACQ, INDEX, ERROR)
```

Input Arguments:

SEGNUM - I*4 the segment number to be sought.

ACQCNT - I*4 the number of acquisitions requested.

ACQ - I*4 array dimensioned 64 containing the acquisition values.

Output Arguments:

INDEX - I*4 array dimensioned 12 by 54 contains the information for each acquisition from the Database.

ERROR - I*4 the error message/return code variable.
0 = successfully found the segment for all desired acquistions.
1 = segment not found
2 = segment found, but not for any of the acquisitions
3 = segment found, but only for some of the acquisitions.

2. Internal Description

SEGFO performs a binary search on the database until the segment number, SEGNUM, is found. After the start of the segment block has been found, a linear search is performed until the given acquisitions are found or the end of the segment block is encountered. An acquisition count, ACQCNT, of zero indicates all of the acquisition values are to be returned.

3. Input Description

Not Applicable

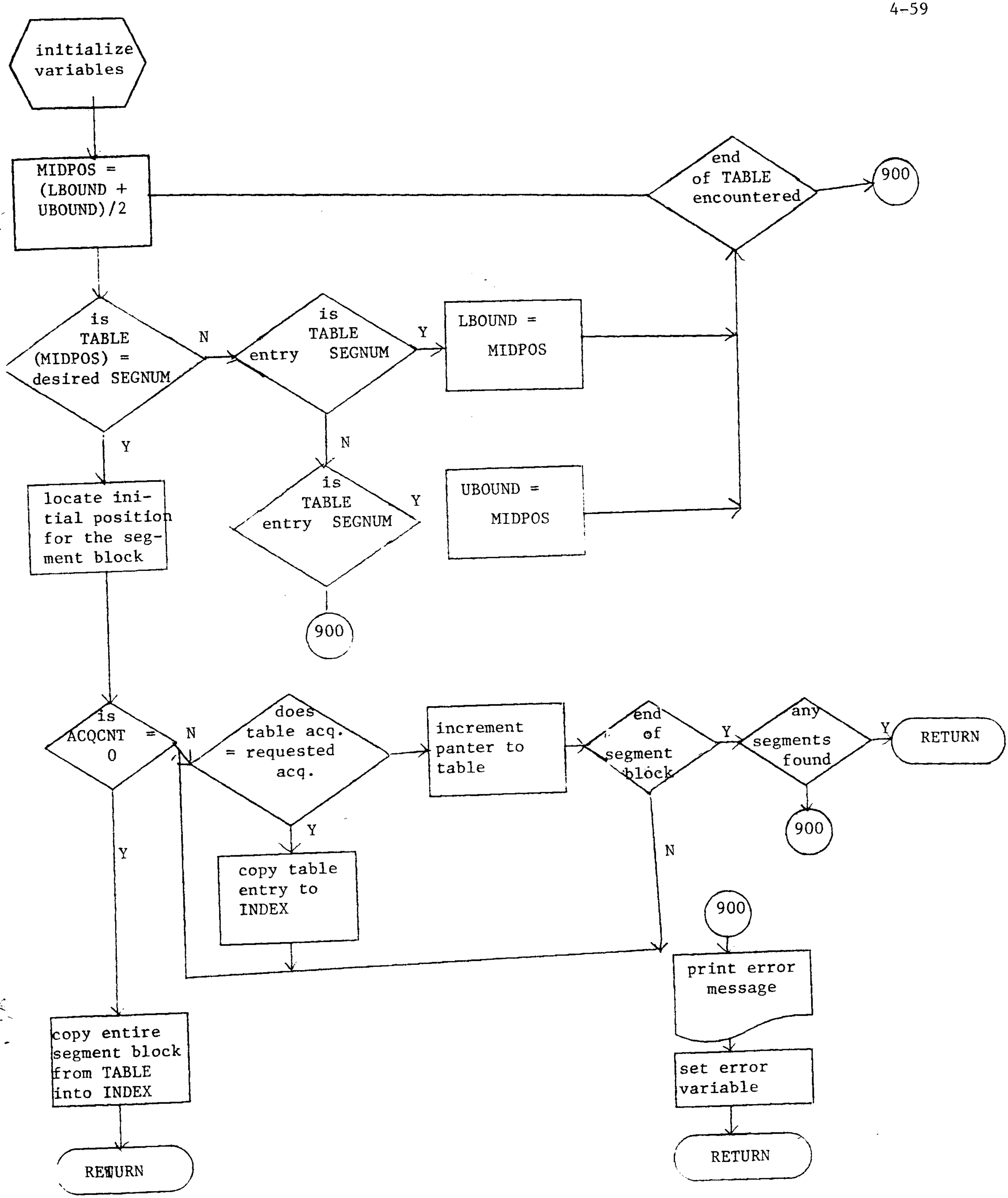
4. Output Description

Array INDEX contains the following information contained in columns:

```
INDEX(1,...)    = tape number
INDEX(2,...)    = file number
INDEX(3,...)    = number of channels
INDEX(4,...)    = number of columns
INDEX(5-7,...)  = latitude
INDEX(8-10,...) = longitude
INDEX(11,...)   = ERTS scene-frame ID
INDEX(12,...)   = acquisition
```

5. Supplemental Information

Any error causes immediate return to the calling routine. An informative error message is printed out, and the return code, ERROR, is set to the appropriate value, but all other error handling is left to the calling routine.



initialize variables
MIDPOS = (LBOUND + UBOUND)/2
end of TABLE encountered
900
is TABLE (MIDPOS) = desired SEGNUM
N
is TABLE entry SEGNUM
Y
LBOUND = MIDPOS
Y
N
locate initial position for the segment block
is TABLE entry SEGNUM
Y
UBOUND = MIDPOS
900
is ACQCNT = 0
N
does table acq. = requested acq.
increment panter to table
end of segment block
Y
any segments found
Y
RETURN
900
Y
Y
copy table entry to INDEX
N
900
print error message
set error variable
RETURN
copy entire segment block from TABLE into INDEX
RETURN