LARS Contract Report 022878

QUARTERLY REPORT

Reporting Period: December 1, 1977 - February 28, 1978
Contract Number: NAS 9-15466
Title of Investigation:

Research in Remote Sensing of Agriculture,
Earth Resources, and Man's Environment

Principal Investigator:

D. A. Landgrebe
Laboratory for Applications of Remote Sensing
Purdue University
West Lafayette, Indiana 47906

Submitted to:

NASA Lyndon B. Johnson Space Center
Attn: J. D. Erickson, Mail Code SF3
Research, Test, and Evaluation Branch
Houston, Texas 77058

STAR INFORMATION FORM

1. Report No. 022878	2. Government Accession No.	3. Recipient's Catalog No
4. Title and Subtitle Quarterly Report December 1, 1977 - February 28, 1978		5. Report Date February 28, 1978
		6. Performing Organization Code
7. Author(s) D. A. Landgrebe		8. Performing Organization Report No 022878
9. Performing Organization Name and Address Laboratory for Applications of Remote Sensing 1220 Potter Drive, Purdue University West Lafayette, Indiana 47906		10. Work Unit No.
		11. Contract or Grant No. NAS9-15466
12. Sponsoring Agency Name and Address NASA Johnson Space Center Houston, TX 77058		13. Type of Report and Period Covered Quarterly Report Dec. 1, 1977-Feb. 28, 1978
		14. Sponsoring Agency Code
15. Supplementary Notes		

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

17 Key Words (Suggested by Author(s))		18. Distribution Statement	
19. Security Classif (of this report) Unclassified	20. Security Classif (of this page)	21. No. of Pages	22 Price*

*For sale by the National Technical Information Service, Springfield, Virginia 22161

NASA JSC

1. AGRICULTURAL SCENE UNDERSTANDING

A. Analysis of Spectral Data for Physical Understanding

I. 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 biological and physical characteristics of crops and soils. Knowledge of how important agronomic and physical factors affect reflectance is necessary for the optimal use of current Landsat technology as well as for design and development of future remote sensing systems.

The primary data analyzed to date are the spectrometer data acquired by the truck- and helicopter-borne systems. These data are particularly useful because the spectral data are acquired in very small wavelength bands and are calibrated in terms of bidirectional reflectance. The narrow wavebands (i.e., complete spectra) permit simulation of the response in any specified waveband. Thus, analysis is not restricted to a fixed set of bands such as Landsat MSS or one of the aircraft scanner systems. Calibration of the data permits valid comparisons to be made among dates, locations, and sensors. Additional advantages of these data compared to Landsat are: no boundary pixels, higher spatial resolution, higher signal-to-noise ratio, and a more complete sampling of the crop through the growing season.

In addition, analysis is currently being conducted on a data set acquired by LARS Exotech Model 100 at the Williston, North Dakota, agriculture experiment station (AES) in 1977. The major advantage of this instrument which acquires one spectral measurement in each of the four Landsat MSS bands, is that data acquisition is rapid. For example, the 70 plots at the AES could be measured in about one hour compared to the four to five hours to measure them with the Exotech 20C. This data set is thus ideally suited for investigation of time of day effects.

Two tasks have been completed during this quarter: (1) analysis of the 1975 data set from the Williams County, North Dakota, intensive test site (ITS) and (2) preparation of a document to serve as an introduction to the LACIE Field Measurements crop spectra. All other analyses are still in progress.

II. Objectives

The overall objective of this task is to design and perform analyses of spectral data to enhance our understanding of the reflectance properties of agricultural crops, how these properties depend upon specific agronomic and other physical variables, and how changes in reflectance are affected by other "nuisance" parameters which are not ordinarily of interest. The results of these analyses will be interpreted to determine: physical interpretations of basis vectors; spectral/temporal features of particular crops or crop conditions; and predictive relationships between the crop identity, agronomic variables, physical variables, and the reflectance spectra.

III. Approach

The spectral data which have been used thus far in this analysis effort are:

(1) Truck-mounted spectrometer data acquired over experimental plots at the Williston, North Dakota, and Garden City, Kansas, experiment stations during 1975 and 1976.

(2) Helicopter-mounted spectrometer data acquired on the intensive test sites in Williams County, North Dakota, and Finney County, Kansas, during 1975 and 1976.

(3) Landsat band radiometer data acquired at the Williston AES in 1977.

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 thematic mapper bands. In addition, the spectral data will be analyzed using several transformations of the reflectance values including greenness, brightness, ratios, and vegetation index. A study to investigate the use of basis functions to represent spectra and to relate the coefficients to agronomic and physical factors is being conducted.

The overall analysis approach is discussed here with specific details in the results section. Reflectance data were plotted 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 ground cover, height, maturity stage, and time of day to spectral response represented as band means or in basis function form. Analysis of variance and discriminant analysis are being used to determine the separability of wheat from other cover types.

IV. Analysis Results

The two tasks which have been completed are the document entitled "An Introduction to Crop Spectra from LACIE Field Measurements" and the 1975 Williams County, North Dakota, ITS analysis. These two tasks will be discussed, followed by some preliminary results of analyses which are still in progress.

a. "An Introduction to Crop Spectra from LACIE Field Measurements"

"An Introduction to Crop Spectra from LACIE Field Measurements" was completed during this quarter. This document describes the types of data which were acquired during the Field Measurements program and contains plots illustrating sources of variability in the reflectance of wheat and its confusion crops. This report has been submitted to NASA/JSC for publication.

b. Analysis of 1975 Williams County ITS

The results obtained from this data set concerning the separability of wheat from other cover types were presented in LARS Contract Report 112677 [1]. During this quarter, the relationship of agronomic factors and reflectance was studied. The only agronomic variables which were measured on the ITS were percent ground cover, maturity stage, and height. Using only the data acquired prior to wheat ripening, all three variables measured were highly correlated (Table 1A-1).

Table 1A-1. Linear correlations of agronomic data acquired prior to wheat ripening (Williams County ITS, 1975).

	Maturity	Height	Percent Cover
Maturity	1.00	.98	.92
Height		1.00	.92
Percent Cover			1.00

Linear correlations were computed to relate maturity, height, and percent cover to spectral response in the Landsat MSS and proposed thematic mapper bands (Table 1A-2). Again, only the spectra acquired prior to ripening were used. Maturity stage, which was recorded in relatively wide categories, was not as highly correlated with reflectance at any wavelength as were the other two variables. Maturity stage and height were most highly correlated with reflectance in the visible and middle infrared wavelengths. Percent ground cover was the variable most strongly related to reflectance, achieving correlations of .81 and -.84 in the near and middle infrared wavelengths, respectively. The correlations were lower than those found at the Williston AES for these variables. Two possible reasons for the lack of correlation are inaccurate measurement of agronomic variables or greater atmospheric effects than with the lower altitude spectrometer. The first explanation is probably the largest contributor because agronomic measurements were acquired at one location in the field which may not be representative of the entire field and measurements were less precise than on the AES.

To further investigate the relationship of agronomic factors with reflectance, regression equations were derived to predict each agronomic variable from spectral response (Table 1A-3). The six proposed thematic mapper bands did a significantly better job in prediction of height, maturity

Table 1A-2. Linear correlations of agronomic variables with reflectance in the Landsat MSS and proposed thematic mapper bands using only spectra acquired prior to wheat heading (Williams County ITS, 1975).

Band (μm)	Maturity	Height	Percent Cover
.5-.6	-.65	-.70	-.71
.6-.7	-.63	-.68	-.71
.7-.8	.54	.56	.76
.8-1.1	.61	.64	.81
.45-.52	-.71	-.75	-.78
.52-.60	-.64	-.68	-.69
.63-.69	-.66	-.71	-.74
.76-.90	.61	.64	.81
1.55-1.75	-.65	-.69	-.67
2.08-2.35	-.75	-.80	-.84

Table 1A-3. R^2 values for prediction of agronomic variables by reflectance (Williams County ITS, 1975).

	Predictor Variables (Bands)		
Agronomic Variable	6 Thematic Mapper	Best 4 Thematic Mapper	Landsat MSS
Height	.76	.73	.64
Maturity	.74	.70	.61
Ground Cover	.89	.88	.81

stage, and percent ground cover than did the Landsat MSS bands. To study the question of whether this was due to the selection or the increased number of bands, the best four thematic mapper bands for prediction of each agronomic variable were selected by running all possible regressions. In each case, the R^2 values decreased slightly from all six bands but were still substantially larger than those obtained by the four Landsat bands. The same four bands (.45-.52, .76-.90, 1.55-1.75, and 2.08-2.35 μm) were selected as optimal for height, maturity stage, and percent ground cover.

The final analysis was to determine which agronomic variables accounted for the variability in a given wavelength band. A subset of agronomic variables and their powers were selected by stepwise regression and all possible regressions were run on this subset. The optimal models (Table 1A-4) were chosen according to C_p values, an indication of bias in the regression equation [2,3]. Date was very important in prediction of response in the visible wavelengths while percent ground cover contributed greatly to response in the near IR.

Table 1A-4. Optimal models for prediction of band means from agronomic variables.

Band (μm)	Variables	R^2
.5-.6	Date, GC^4	.64
.6-.7	Date, Mat^2, Mat^4, GC^4	.70
.7-.8	GC, Mat^4	.75
.8-1.1	GC, Mat^4	.80
.45-.52	Date, Ht, Ht^4, GC^4	.72
.52-.60	Date, Ht, GC^4	.63
.63-.69	Date, GC^4	.70
.76-.90	GC, Mat^4	.80
1.55-1.75	Mat, $Date^2$, Mat^2, Mat^4, GC^4	.75
2.08-2.35	Date, Mat, GC, Mat^2, Mat^4	.86

GC = Percent Ground Cover; Ht = Height; Mat = Maturity Stage

c. Basis Function Study

One hundred Karhunen-Loeve (K-L) basis functions were derived for the 1976 Williston AES data. Parallel regression analyses were conducted using reflectance in Landsat bands, reflectance in the proposed thematic mapper bands, and coefficients of the first nine K-L functions. Regression equations were derived to predict each agronomic variable by the four Landsat band reflectances, the four Landsat bands and their squares, and so on. This was also done for the thematic mapper bands and the basis function coefficients.

The results of this analysis are presented in Table 1A-5. In addition to those presented, several other agronomic variables (number of stems per meter row; weight of dry biomass; and dry weight of leaves, stems, and heads) and powers up to the eighth were studied.

Table 1A-5. R^2 values for prediction of agronomic variables from Landsat bands, proposed thematic mapper bands, and Karhunen-Loeve coefficients (Williston AES, 1976).

	Power of Equation	Growth Stage	Plant Height	Percent Green Leaves	Fresh Biomass Weight	Percent Plant Moisture	Leaf Area Index
Four Landsat Wavelength Bands	1	.708	.699	.559	.755	.728	.833
	2	.772	.798	.683	.779	.773	.870
	3	.781	.803	.684	.789	.789	.878
Six Thematic Mapper Wavelength Bands	1	.829	.841	.773	.776	.889	.852
	2	.880	.895	.802	.810	.909	.879
	3	.889	.910	.822	.818	.915	.885
First Nine Karhunen-Loeve Coefficients	1	.759	.725	.652	.729	.783	.852
	2	.835	.814	.760	.798	.824	.881
	3	.844	.853	.791	.809	.843	.886

The data set analyzed contains about 200 observations. The higher powers of equations are not presented due to the large proportion of available degrees of freedom used in the regression. The largest increase (.11) between third and eighth power equations was obtained for prediction of percent green leaves by the Landsat bands. In almost all other cases, however, the increase in R^2 between third and eighth power equations was .05 or less. Higher powers of all variables are not required for a good R^2 although some terms in higher powers may be significant.

The basis function coefficients are more strongly related with all agronomic factors than are the Landsat band means. Thus, use of the complete spectrum seems to be a preferable approach for prediction of crop growth than use of the Landsat bands. It must be noted, however, that the proposed thematic mapper bands consistently obtain higher R^2 values than the K-L coefficients. A current hypothesis from this study is that the six thematic mapper bands give a very good representation of the entire spectrum for crop identification and condition assessment. Testing of this hypothesis needs to be conducted for other crops, locations, and sensors.

d. Analysis of 1976 Garden City, Kansas, Data

Initial analyses consisting of qualitative evaluations of the 1976 experiment station data have been carried out. Leaf area index, height, and fresh weight were graphed over date to see how the canopy develops. Reflectance was graphed against wavelength to look at effects of the experimental treatments.

Plots of reflectance across wavelength for four varieties of winter wheat (Figure 1A-1) showed little difference in spectra. Observations indicated that the varieties developed at nearly the same rate.

Planting date and irrigation seemed to greatly influence spectral reflectance. By April 18, four days after irrigation, there was little difference in reflectance or plant characteristics of early planted dryland and late planted irrigated wheat (Figure 1A-2). Irrigated early wheat had much greater biomass, height, and leaf area index and greater reflectance in the near IR than other treatments. Dryland late wheat had the lowest amount of vegetation and the highest reflectance in the middle IR, due mainly to the substantial contribution of soil reflectance.

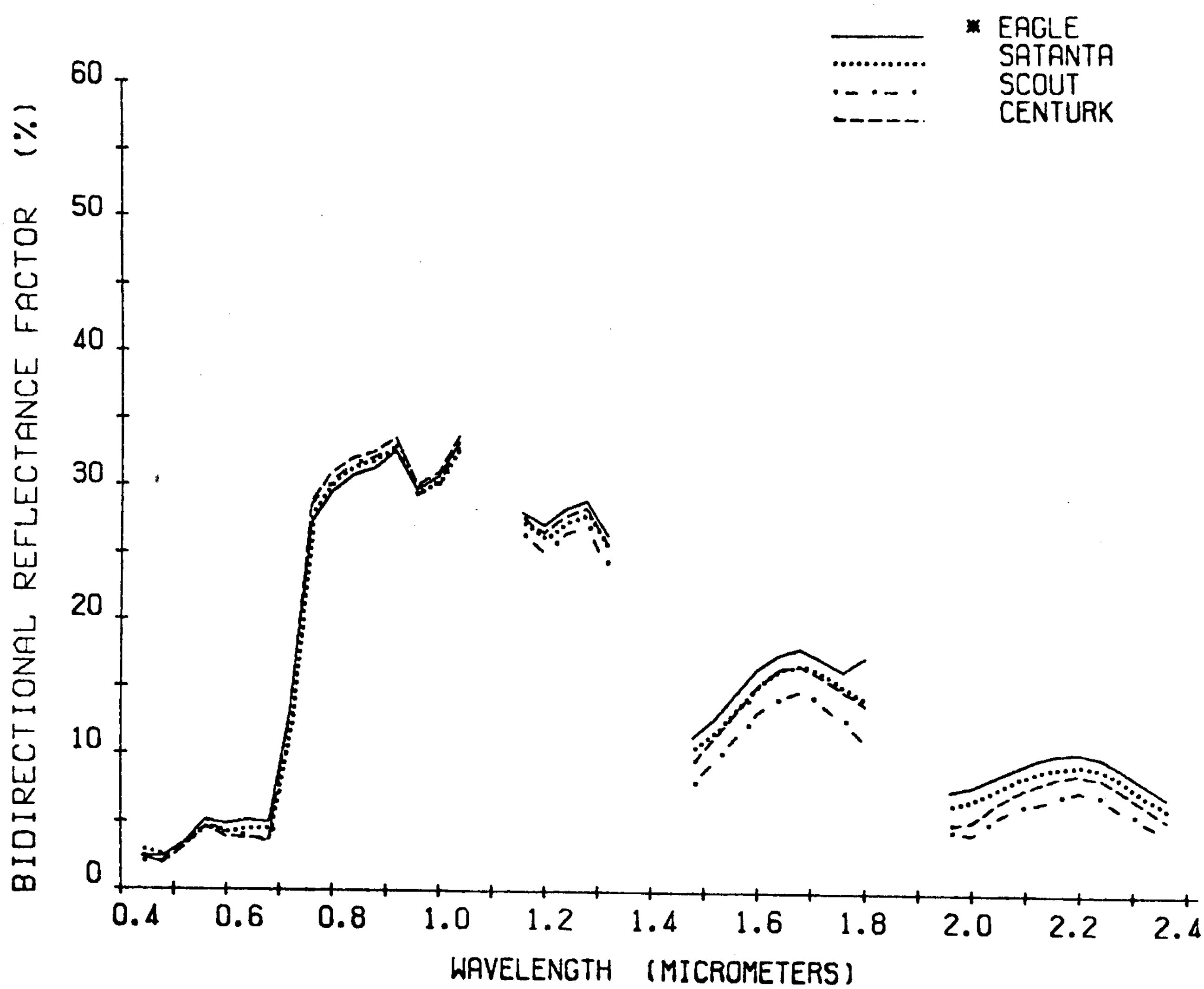


Figure 1A-1. Difference in reflectance of several varieties of winter wheat (Garden City, Kansas; May 17, 1976).

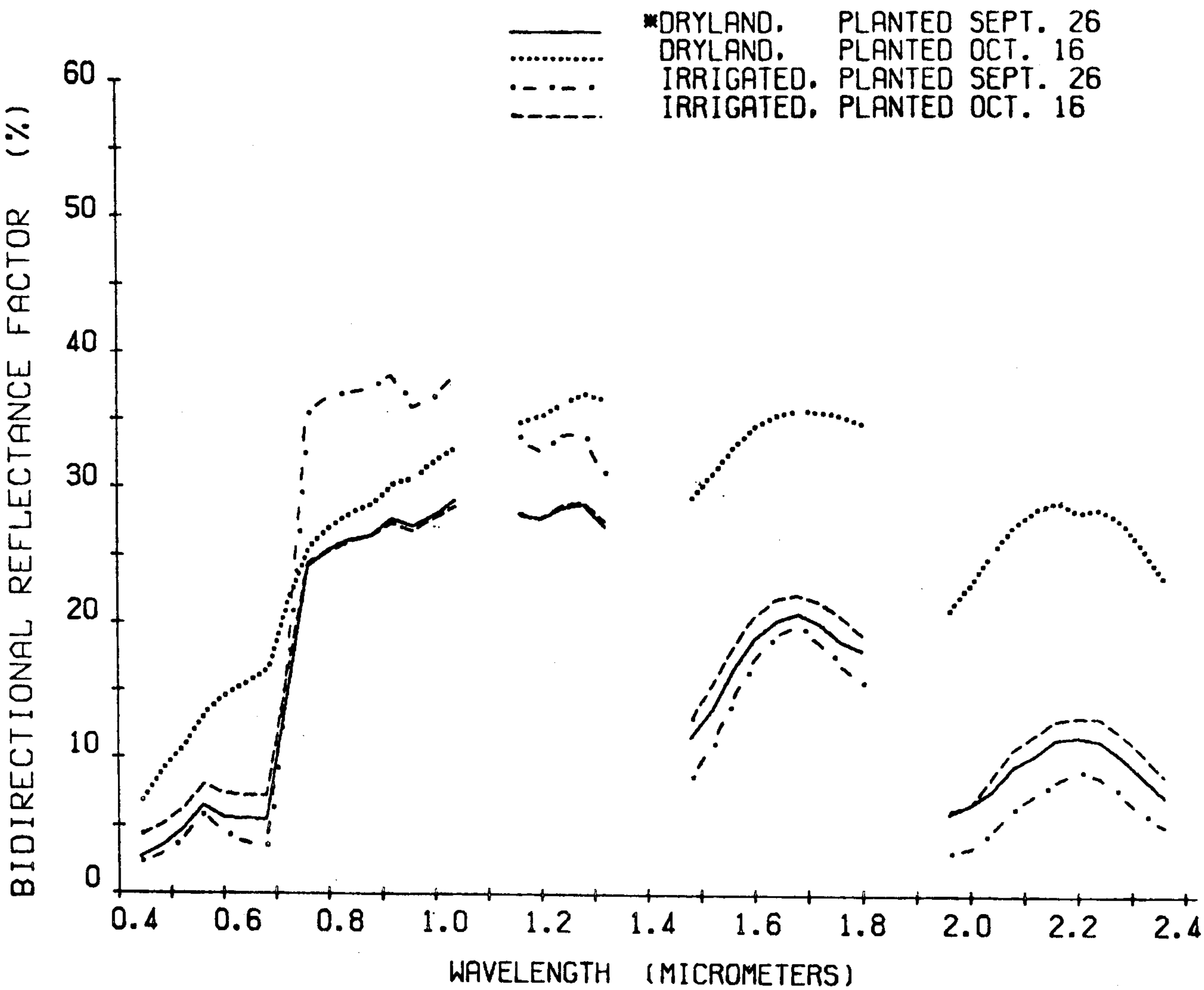


Figure 1A-2. Difference in reflectance of winter wheat due to planting dates and irrigation treatments (Garden City, Kansas; April 18, 1976).

The wheat plots showed a strong green vegetation reflectance on May 14 (Figure 1A-3). Reflectance curves appear to be grouped by planting dates, especially in the middle IR. Early planted wheat had greater biomass and was more mature than late wheat.

On May 29, the green vegetation reflectance was again strong (Figure 1A-4). The irrigated plots reflected more radiation from 0.4-2.4 μm, were taller and greener, and had greater biomass and leaf area than the dryland plots.

By June 10, the near IR reflectances had decreased and the middle IR reflectances had increased (Figure 1A-5). Dryland wheat, which was maturing at a faster rate, had higher reflectances than irrigated wheat.

V. Plans for Next Quarter

Analyses will continue and should be completed on the data acquired at the two experiment stations in 1975 and 1976. In addition to the types of analyses conducted to date, transformations of reflectance values will be related to agronomic variables. Analysis will continue on the time of day experiment and the basis function study. Investigation of the effects of view angle and direction and sun angle on spectral response will begin.

Analysis will continue on the ITS data sets from North Dakota and Kansas in 1976 and will be completed on the 1975 Kansas data. These analyses will also investigate the relationships of transformed reflectance to agronomic variables and will consider models other than linear or polynomial.

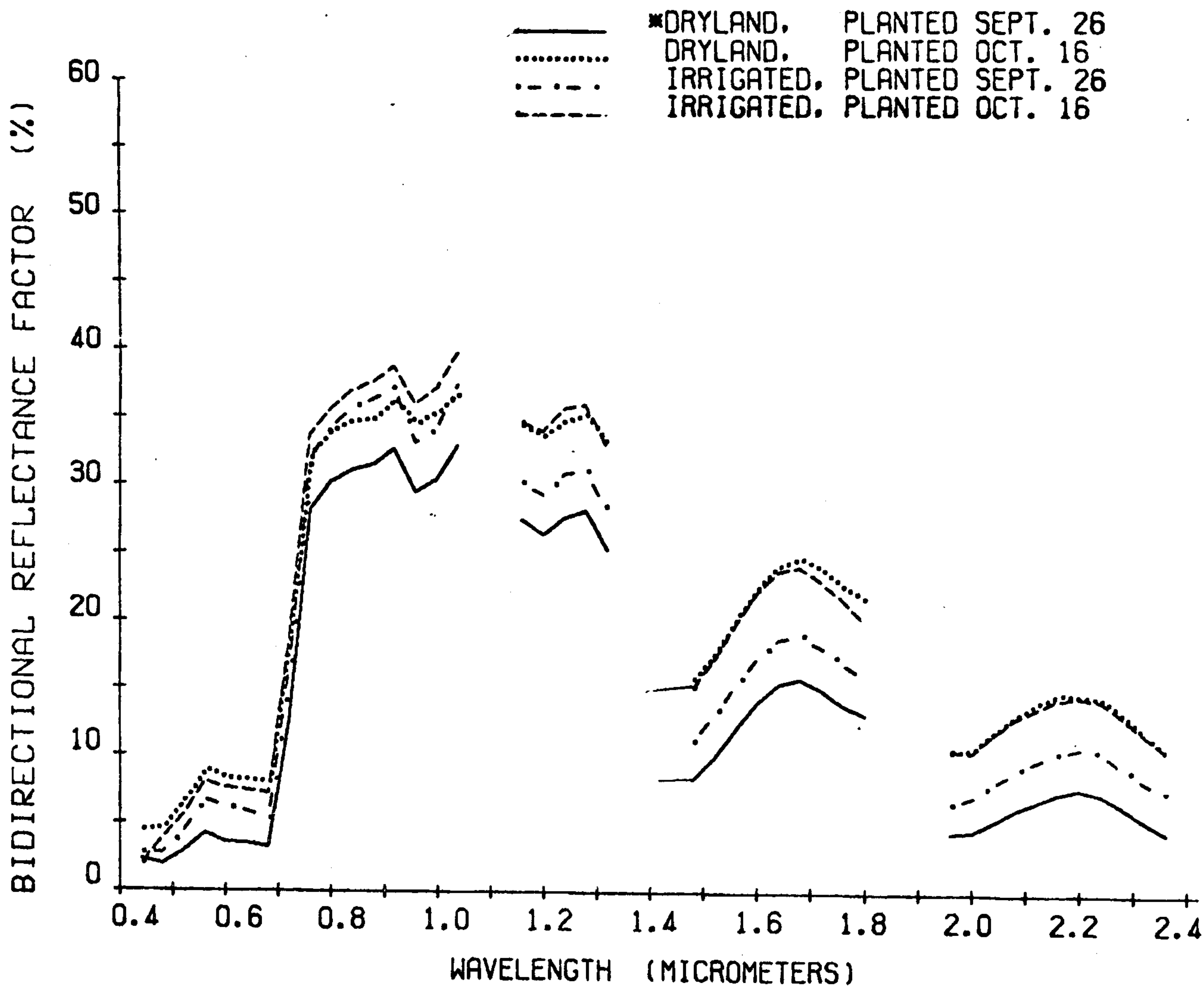


Figure 1A-3. Difference in reflectance of winter wheat due to planting dates and irrigation treatments (Garden City, Kansas; May 14, 1976).

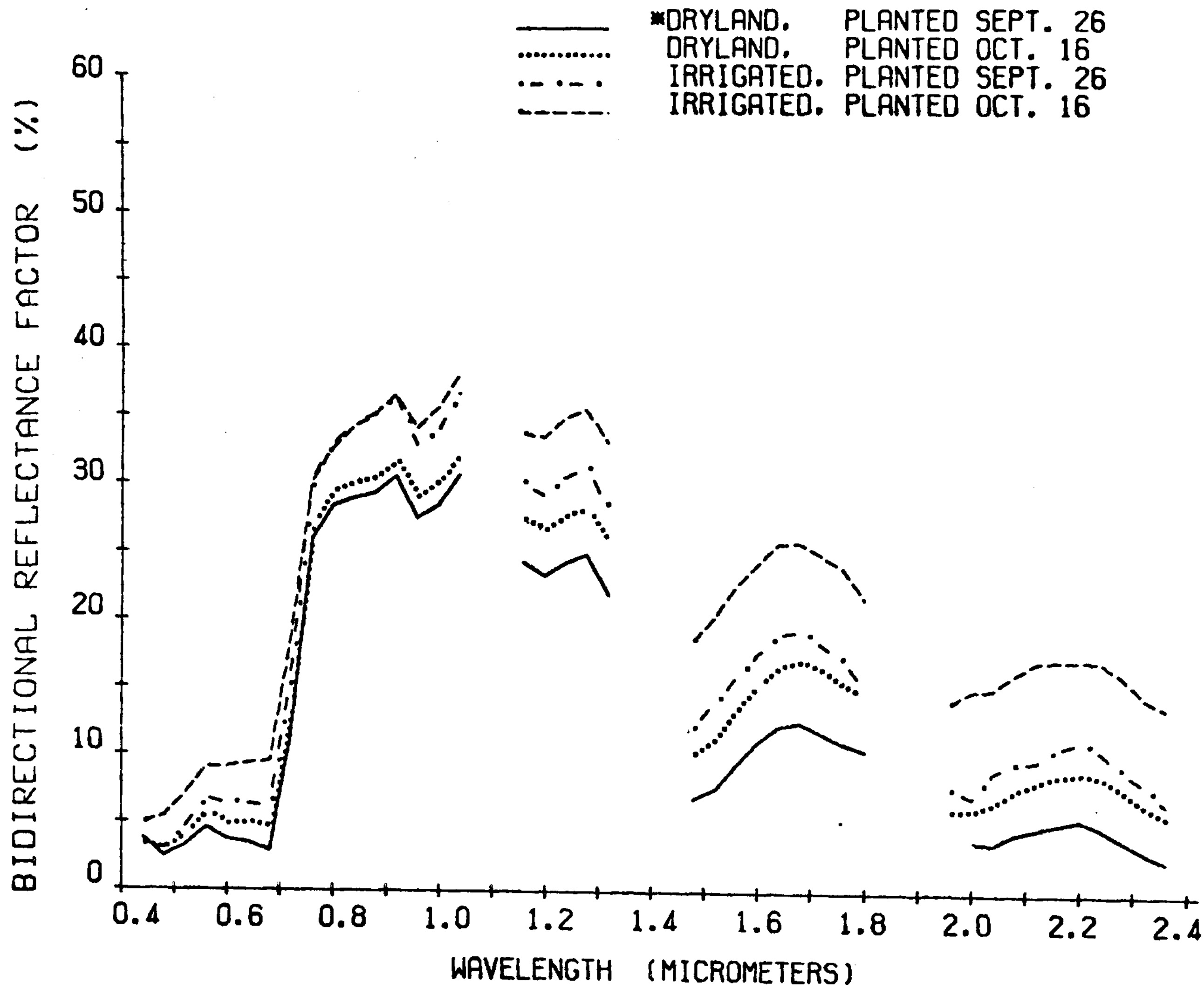


Figure 1A-4. Difference in reflectance of winter wheat due to planting dates and irrigation treatments (Garden City, Kansas; May 29, 1976).

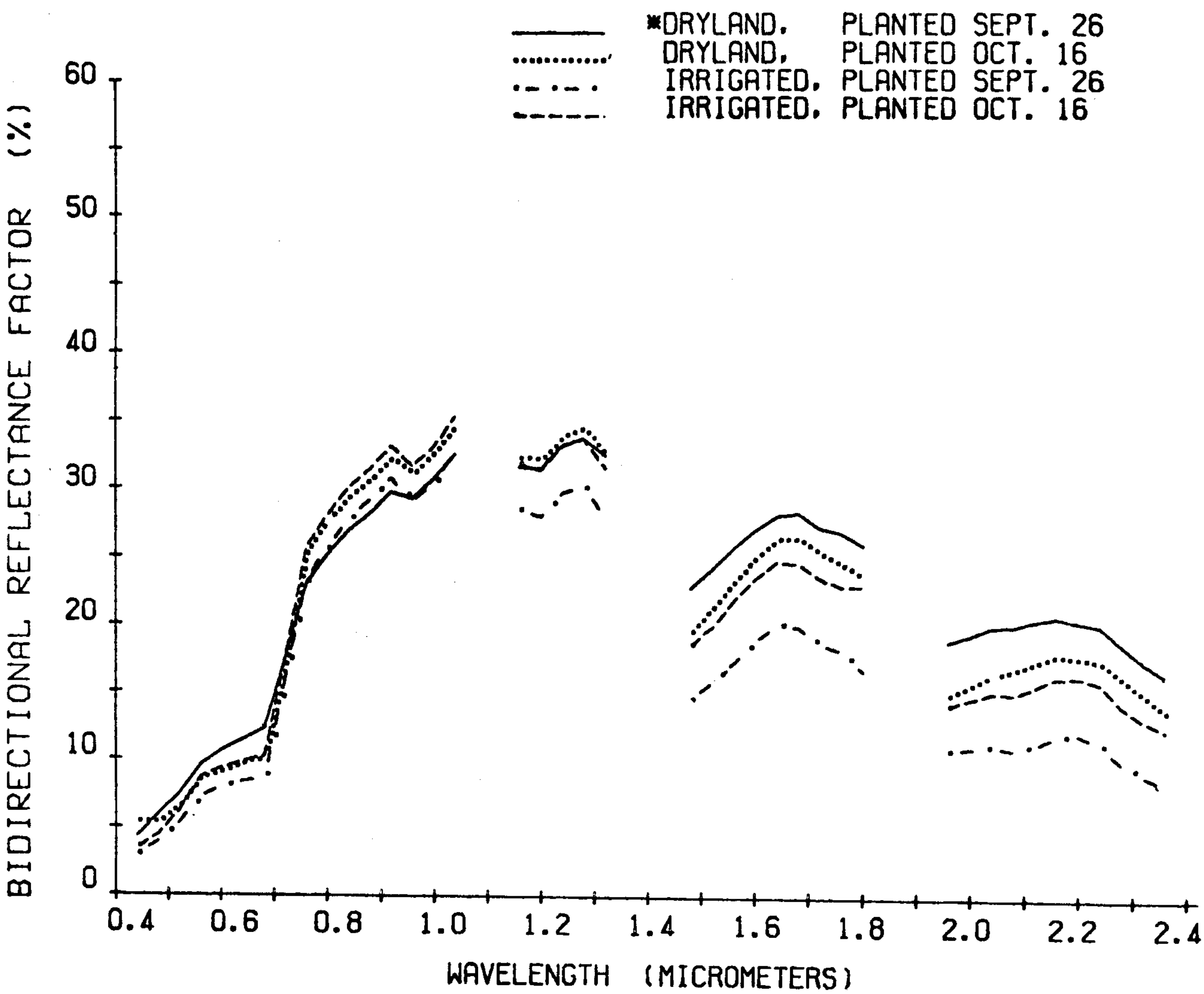


Figure 1A-5. Difference in reflectance of winter wheat due to planting dates and irrigation treatments (Garden City, Kansas; June 10, 1976).

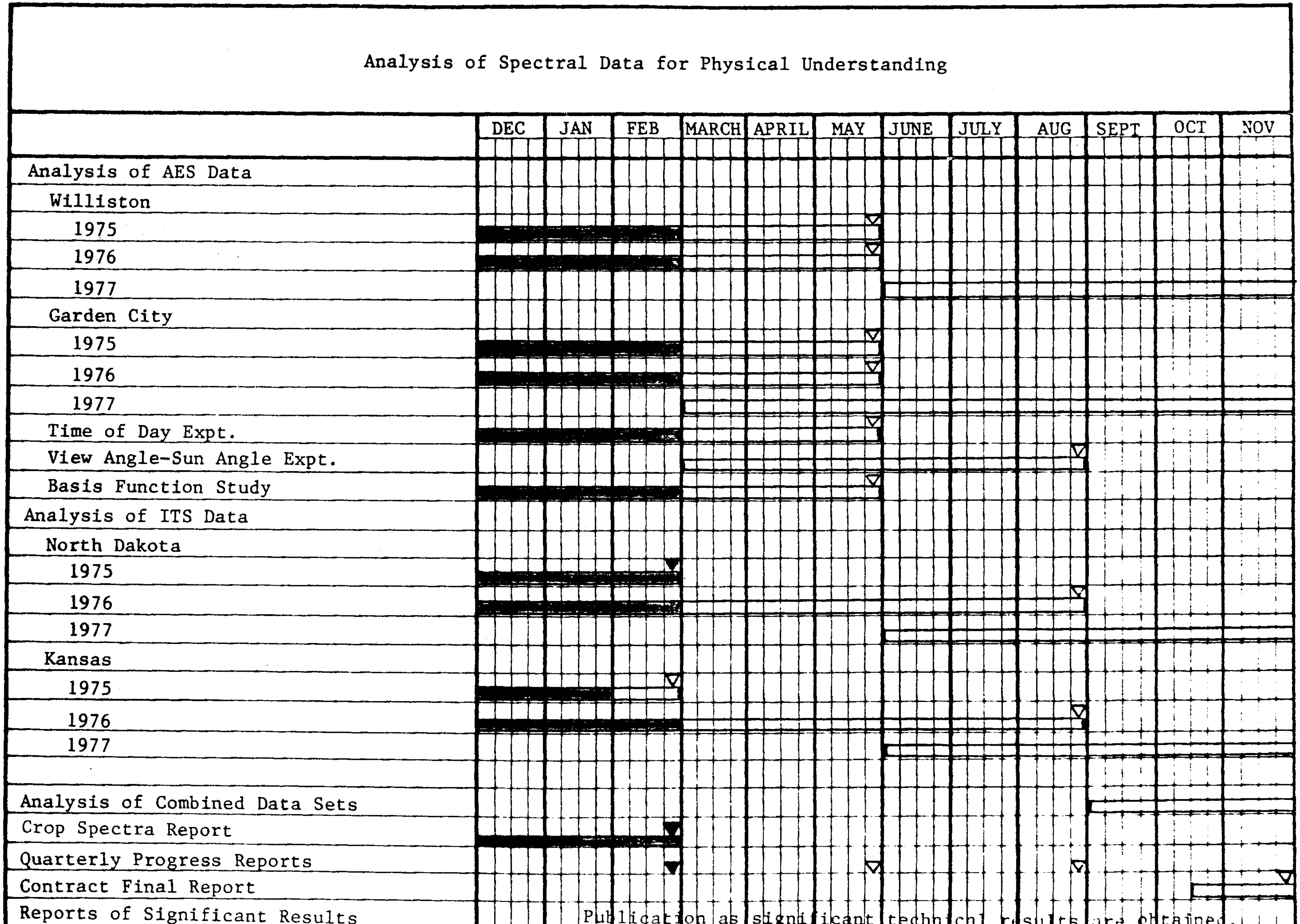
VI. References

1. Landgrebe, D.A. 1977. Final Report, Nasa Contract NAS9-14970, June 1 - November 30, 1977. Volume 1, pp. A-50 - A-58.

2. Mallows, C.L. 1973. Some Comments on C_p. Technometrics 15, pp. 661 - 675.

3. Daniel, C. and F.S. Wood. 1975. Fitting Equations to Data. Wiley, pp. 86 - 99.

Detailed Implementation Schedule



B. Field Measurements Data Management

Activities this quarter have included preparation of the implementation plan, completion of the task of upgrading the Exotech 20C reformatting software, progress toward completion of reformatting the 1976-77 spectrometer data (FSS, FSAS, and Exotech 20C) and completion of the first phase of upgrading the spectrometer analysis software (EXOSYS).

I. Implementation

The implementation plan was completed in late December. The implementation plan represents the most realistic goals with the funds and people available and the known needs for the data.

Exotech 20C Reformatting Software. The new reformatting software to process the present Exotech 20C spectrometer data was completed in late December. With the new reformatting software, less time (both computer and personnel) are needed to process the data than with the old. The new software system includes the capability to use the cosine correction in processing to correct for changes in illumination between the time the reference target is measured and the time the scene is measured. (Our normal field procedure is to use the solar port to correct for such changes in illumination. However, for certain experiments, use of the solar port is not possible - for example the sun angle-view angle experiments

The new software also incorporates additional information in the header record for each observation. These include - calibration table number, zenith illumination angle, azimuth illumination angle, radiant temperature, heads per square meter, fresh biomass, dry biomass for - green leaves, yellow leaves, dead leaves, stems, heads and total. Information describing these changes and additions will be sent with the data.

At present the new reformatting software system doesn't include the capability to process the thermal Exotech 20C data (the long wavelength unit). No thermal Exotech 20C data were collected this past year. This additional capability will be needed at some future date. No major revision will be required though since the new software was designed with the need to handle the thermal data in mind.

II. Status of the 1976-77 Spectrometer Data Processing

Field Spectrometer System (FSS). All of the 1976-77 FSS data have been received from NASA/JSC. All of the ancillary information have been key-punched. The only item needed to process the FSS data are the calibration table(s) to be obtained from the FSAS and Exotech 20C data collected over the canvas calibration panels.

Field Signature Acquisition System (FSAS). The FSAS data were received during this quarter. New tapes were received recently to replace two of the tapes which were unreadable by our computer. The data appears to be good. Some of the header records however, need to be edited because of duplicate observation numbers for the same dates and un-recognizable information.

Exotech 20C Field System. The Exotech 20C data collected over the gray canvas calibration panels have been completed. Preliminary analysis of the FSAS and Exotech 20C data over the helicopter calibration panel (gray panel 1) indicate that they are in close agreement. Also the post-season calibration data collected over the painted barium sulfate field reference standards were processed. The post-season measurements are nearly identical (within 2%) with the pre-season measurements.

Some progress was made toward completing the processing of the 1975 and 1976 sun angle-view angle data. Processing of the angle data was stopped and processing of the 1977 North Dakota plot data was begun after notification from NASA/JSC of an urgent need for the data. It will be difficult to meet the deadline wanted. It cannot be overstressed about the need for NASA/JSC to notify contractors of upcoming deadlines farther in advance than was the case here (preferably four months in advance of the time the user needs the data, instead of a few days before a user needs the data).

III. Spectrometer Analysis Software Development (EXOSYS)

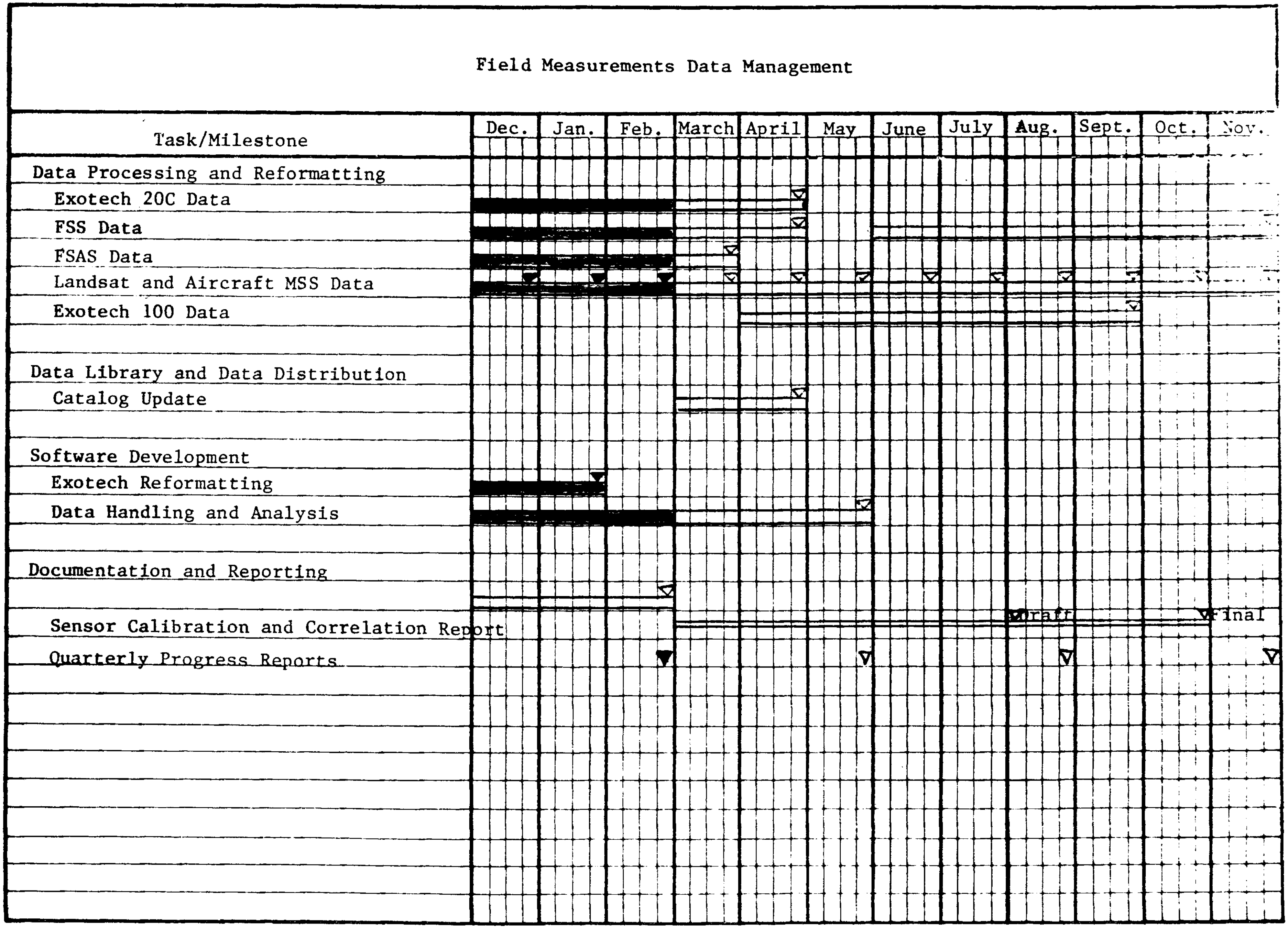
Software to increase graphics/plotting capability for spectrometer data should be online (on the LARS IBM 370/148 computer system) for all users by the end of February. It will be under EXOSYSDV. The new software has the capability to direct graphs to the terminal, line printer, or the varian plotter. The user can also use this software to plot the information in the header record in addition to the reflectance data directly from the tape it is stored in. Also, reformatters can use the new software to verify the processed spectrometer data much more quickly and conveniently.

The new software system used the Graphics Compatibility System (GCS) acquired from the U.S. Army Corps of Engineers a year ago to actually do the plotting (the GCS package of subroutines was free).

Next Quarter

The processing of the rest of 1976-77 spectrometer data should be completed during the next quarter (by April 30). Also, Volume 3 of the LACIE Field Measurements Data Library Catalog will be updated and published.

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

Although a great body of knowledge has been accumulated about the physical and chemical characteristics of soils as they are influenced by the soil forming factors of climate, parent material, relief, biological activity, and time, there is very limited knowledge about how these factors relate to the reflected radiation from surface soils. Preliminary studies show that information about the spectral properties of soils may be useful in their identification and characterization (1,2,3,4).

If present satellite sensors and the much improved sensor systems planned for future satellites are to be used most effectively in the preparation of land use capability maps and soil productivity ratings as these relate to food production, it is crucial to define quantitatively the soil variables related to productivity which can be measured by or correlated with multispectral radiation from the surface soil. This research approach seeks to contribute significantly to the understanding of the multispectral reflectance of soils as it relates to climate, physical properties of soils, chemical properties of soils, engineering aspects of soil use and potential agricultural productivity.

a. Selection of Soils to Be Studied

i. Climatic Zones

The continental United States was divided according to soil temperature regimes and moisture regimes for the purpose of statistical stratification of soil sampling. An adequate number of soil samples was desired to represent each climatic region approximately in proportion to the geographic extent of that region.

The temperature of a soil is one of its important properties. Soil temperature has an important influence on biological, chemical, and physical processes in the soil and on the adaptation of introduced plants. Each individual soil has a characteristic temperature regime that can be measured and described. For practical reasons, the soil temperature regime can be described by the mean annual soil temperature and the average seasonal fluctuations from that mean at a depth of 50 cm (5). The mean annual soil temperature is related most closely to the mean annual air temperature, and can be estimated for much of the United States by adding 1°C to the mean annual air temperature (6).

Classes of soil temperature regimes occurring in the continental United States are defined in the U.S. Soil Taxonomy (5) as follows:

1) Frigid - The mean annual soil temperature is lower than 8°C (47°F).
2) Mesic - The mean annual soil temperature is 8°C (47°F) or higher but lower than 15°C (59°F).
3) Thermic - The mean annual soil temperature is 15°C (59°F) or higher but lower than 22°C (72°F).
4) Hyperthermic - The mean annual soil temperature is 22°C (72°F) or higher.

For all these classes, the difference between mean summer and mean winter soil temperature is more than 5°C (9°F) at a depth of 50 cm. The distribution of soil temperature regimes (7) is indicated in Figure 1C-1.

Climate classification according to moisture regime is not as straightforward as soil temperature classification, but many authors have proposed and modified systems to describe the water balance adequately at the earth's surface. Thornthwaite (8) modified his 1931 "precipitation effectiveness" classification in 1948 by calculating the potential evapotranspiration and comparing it with precipitation to develop measures of water surplus and water deficiency. Thornthwaite's basis for climatic classification consisted of a moisture stress index dependent only on potential evapotranspiration and precipitation. The five main moisture regions in the continental United States are identified as follows:

A) Perhumid - moisture index 100 and above
B) Humid - moisture index 20 to 100
C) Subhumid - moisture index -20 to 20
D) Semiarid - moisture index -40 to -20
E) Arid - moisture index -60 to -40

The distribution of these moisture regimes is shown in Figure 1C-1.

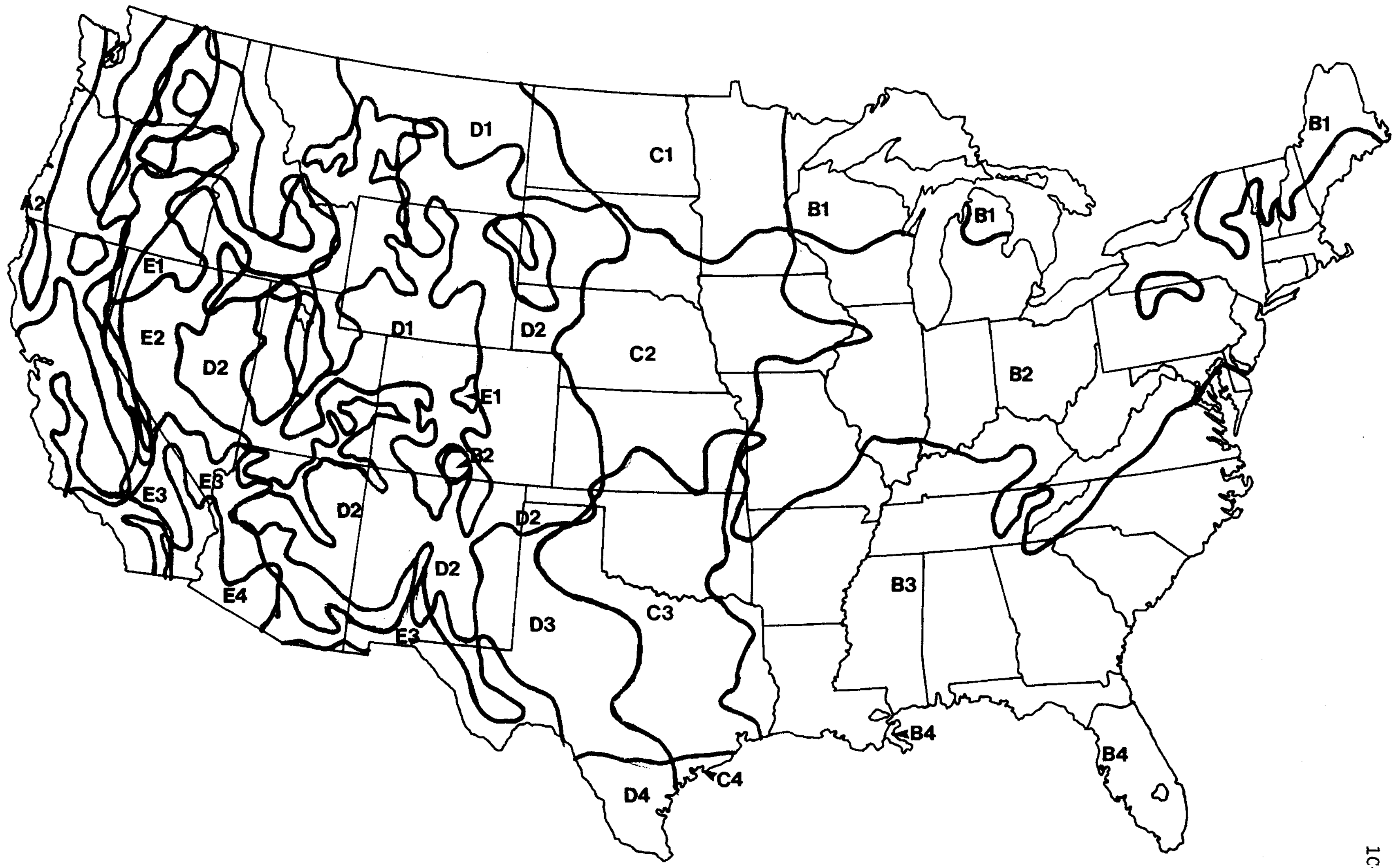


Figure 1C-1. Climatic zones in the continental United States as identified by soil temperature regime (5,6,7) and Thornthwaite's 1948 moisture index (8).

ii. Stratified Sampling of Soils

Of the more than 10,000 soil series in the United States a list of over 1300 Benchmark Soil Series was prepared by the four regional soil survey work planning committees to represent those soils with a large geographic extent. Benchmark soils are key soils selected to represent an important part of a state or resource area. They are important soils to study because the range of soil characteristics they represent renders the data so widely applicable.

The type locations for all of the Benchmark Soils in the continental United States were obtained from the National Cooperative Soil Survey's established series descriptive sheets for each soil. Only those soils whose type locations were at least one county away from a climatic zone boundary were considered for this study.

The number of soils chosen for study from each climatic zone was determined primarily by the proportional geographic extent of each climatic zone, keeping in mind the overall study limitation of about 250 soils (Table 1C-1). Climatic zones with few Benchmark Soils have all of these soils represented in the final list.

A random sampling procedure was used within each stratified climatic zone to select the desired number of soils for each climatic region. A complete listing of the soils chosen is presented in Table 1C-2. A total of 254 soils was obtained, representing 16 climatic regions in 42 states.

b. Soil Field Sampling Guidelines

Because of the crucial need for a measure of the variability between different samples of the same soil series, a set of guidelines was prepared outlining the procedure to be followed in the collection of duplicate soil samples for each soil to be studied. These guidelines will be followed by personnel of the Soil Conservation Service in field collection of all soil samples:

Table 1C-1. Summary of climatic regions, map codes, and number of soil series from each region.

Climatic Region	Map Code	Number of Soil Series Requested
Perhumic Mesic	A2	6
Humid Frigid	B1	20
Humid Mesic	B2	40
Humid Thermic	B3	30
Humid Hyperthermic	B4	6
Subhumid Frigid	C1	20
Subhumid Mesic	C2	25
Subhumid Thermic	C3	20
Semiarid Frigid	D1	14
Semiarid Mesic	D2	19
Semiarid Thermic	D3	14
Semiarid Hyperthermic	D4	6
Arid Frigid	E1	1
Arid Mesic	E2	10
Arid Thermic	E3	4
Arid Hyperthermic	E4	2
Arid - temperature regime not certain		17
	TOTAL	254

1) Soils should be sampled at sites that represent the dominant use of the Benchmark Soil to be studied. Samples should be collected in cultivated sites if this is the dominant use. These sites should be near the type location for the current official series to assure conformity to the central concept of the Benchmark Soil Series. Care should be taken to avoid areas next to gravel roads, fence rows, old farmsteads and any other areas of undesirable chemical or physical alternation of the soil profile.

2) A duplicate profile should be located at a site one to twenty miles from the first site and in a different mapping delineation. Sampling sites should be investigated to verify the similarity of profile characteristics at the two locations before collecting duplicate soil samples. Specifically, surface texture should not vary.

3) Samples should represent the surface soil and should contain material from 0 to 15 cm (0-6 inches), if depth to B horizon permits.

4) Two kilograms (5 pounds) of soil should be sampled at each site and placed in 9 in x 20 in heavy vinyl plastic sample bags. This amount of soil will fill the bags about halfway.

5) Sample bags should have soil series name, county, and soil survey sample number (SSSN) identified in indelible ink or pencil on tags inside and outside the bags.

6) Additional information on each soil should be provided as follows:

   a) Date of sampling
   b) County, state and location of sampling site
   c) Phase name of soil (ex. Miami silty clay loam)
   d) Physiographic position
   e) Topography
   f) Drainage
   g) Vegetation
   h) Parent material
   i) Sampled by:
   j) Remarks (peculiar sampling conditions, etc.)

c. Acquisition of Soil Samples

Preparation for acquisition of soil samples is underway at present. The Soil Survey Investigation Division of the Soil Conservation Service has informed each state involved in sample collection as to the procedures to be used in soil sampling. Weather permitting, soil samples will be taken in conjunction with the regular field work of Soil Conservation Service personnel.

References

1. Bowers, S. A., and R. J. Hanks, "Reflectance of Radiant Energy from Soils," Soil Sci. 100:130-138, 1965.
2. Cipra, J. E., M. F. Baumgardner, E. R. Stoner, and R. B. MacDonald, "Measuring Radiance Characteristics of Soil with a Field Spectroradiometer," Soil Sci. Soc. Amer. Proc. 35:1014-1017, 1971.
3. Condit, H. R., "The Spectral Reflectance of American Soils," Photogrammetric Eng. 36:955-966, 1970.
4. Montgomery, O. L., "An Investigation of the Relationship between Spectral Reflectance and the Chemical, Physical and Genetic Characteristics of Soils," Ph.D. Thesis, Purdue University, 1976.
5. Soil Survey Staff, "Soil Taxonomy--a Basic System of Soil Classification for Making and Interpreting Soil Surveys," Soil Conservation Service, U.S. Dept. of Ag., Agriculture Handbook No. 436, Washington, D.C., 1975.
6. Smith, Guy D., Franklin Newhall, and Luther H. Robinson, "Soil Temperature Regimes, Their Characteristics and Predictability," SCS-TP-144, Soil Conserv. Serv., U.S. Dept. of Ag., Washington, D.C., 1964.
7. FAO-UNESCO, "Soil Map of the World, Vol. II: North America," United Nations Educational, Scientific, and Cultural Organization, Paris, 1975.
8. Thornthwaite, C. W., "An Approach toward a Rational Classification of Climate," Geograph. Rev. 38:55-94, 1948.

Table 1C-2. Complete listing of Benchmark Soil Series, their location, and climatic region.

Climatic Region	State	County	Soil Series
Perhumid Mesic	Oregon	Tillamook	Astoria
			Brenner
			Hebo
			Nehalem
		Curry	Blacklock
			Orford
Humid Frigid	Maine	Aroostook	Caribou
			Plaisted
	Michigan	Baraga	Iron River
			Munising
		Chippewa	Ontonagon
			Pickford
		Delta	Angelinca
			Grayling
			Onaway
			Rifle
		Emmet	Emmet
		Sheboygan	Casco
	New York	Lewis	Adams
	Wisconsin	Bayfield	Vilas
		Florence	Pence
		Langlade	Antigo
		Marathon	Fenwood
		Polk	Campia
			Cushing
		Price	Goodman
Humid Mesic	Colorado	Alamosa	La Jara
			Mosca
	Connecticut	New Haven	Charlton
		New London	Ninigret
		Tolland	Hollis
	Illinois	Champaign	Drummer
			Flanagan
		Iroquois	Ridgeville
	Indiana	Clark	Haymond
		Decatur	Russell
		Fayette	Genesee
		Knox	Alford
		Porter	Door
		Vigo	Iva
	Iowa	Clayton	Downs
		Dubuque	Dubuque
		Howard	Waukee

	Massachusetts	Essex	Sudbury
		Franklin	Winooski
			Berkshire
		Hampden	Agawam
			Ridgebury
		Hampshire	Hadley
		Worcester	Hinckley
	Michigan	Livingston	Hillsdale
	Missouri	Moniteau	Union
		Scotland	Kilwinning
	New Hampshire	Hillsboro	Acton
	New Jersey	Monmouth	Collington
	New York	Chenango	Norwich
	Ohio	Highland	Cincinnati
		Summit	Holly
		Tuscarawas	Keene
		Wayne	Canfield
	Pennsylvania	Lancaster	Duffield
			Edgemont
		Perry	Elliber
	Virginia	Augusta	Frederick
	West Virginia	Monroe	Murrill
	Wisconsin	Ozaukee	Fox
Humid Thermic	**Alabama**	Houston	Red Bay
	Arkansas	Franklin	Enders
		Ouachita	Saffell
		Pope	Linker
	Florida	Bay	Leon
	Georgia	Irwin	Ocilla
	Kentucky	Daviess	Newark
		Laurel	Whitley
	Louisiana	Acadia	Midland
		E. Baton Rouge	Calhoun
		Jefferson	Kenner
		Ouachita	Rilla
		Tensas	Commerce
		Union	Ruston

	Maryland	Dorchester	Elkton
	Mississippi	George	Susquehanna
		Grenada	Grenada
	North Carolina	Alamance	Appling
		Cabarrus	Mecklenburg
		Catawba	Cecil
		Craven	Craven
		Scotland	Wagram
		Washington	Ponzer
	South Carolina	Florence	Rains
		Spartanburg	Pacolet
	Tennessee	Coffee	Dickson
			Mountview
		Humphreys	Bodine
		Rutherford	Cumberland
			Talbott
Humid Hyperthermic	Florida	Lake	Myakka
		Okeechobee	Basinger
			Pompano
			Wabasso
		Palm Beach	Terra Ceia
		Seminole	Paola
Subhumid Frigid	Minnesota	Beltrami	Taylor
		Cass	Warba
		Grant	Roliss
		Isanti	Anoka
		Kittson	Grygla
			Redby
		Lake of the Woods	Cormant
		Ottertail	Buse
		Pope	Langhei
		Stevens	Flom
	Montana	Missoula	Greenough
			Tarkio
	North Dakota	LaMoure	Svea
		Ransom	Tonka
		Wells	Divide
	South Dakota	Brown	Beotia
			Exline
		Codington	Fordville
			Renshaw
		Roberts	Peever

Subhumid Mesic	**South Dakota**	Davison	Betts
			Stickney
			Tetonka
		Gregory	Boyd
		Todd	Tuthill
	Minnesota	Martin	Nicollet
		Steele	Canisted
			Glencoe
		Rice	Hayden
		Waseca	Cordova
	Nebraska	Buffalo	Hord
		Clay	Hastings
		Dawes	Alliance
		Holt	Jansen
		Thomas	Loup
		Thurston	Crofton
		Webster	Gibbon
	Iowa	Clay	Sac
		Crawford	Ida
		Harrison	Monona
		Monona	Haynie
	Kansas	Cloud	Hedville
		Geary	Irwin
		McPherson	Goessel
		Saline	Lancaster
Subhumid Thermic	**Kansas**	Montgomery	Verdigris
		Pratt	Pratt
	Oklahoma	Cotton	Foard
		Grady	Port
		Lincoln	Darnell
		Kay	Renfrow
		Oklahoma	Bethany
			Canadian
			Zaneis
		Payne	Dougherty
		Roger Mills	St. Paul
		Tulsa	Newtonia
		Washita	Dill
	Texas	Bell	Brackett
		Anderson	Elrose
		Coryell	Denton
			Frio
		Kaufman	Trinity
		Parker	Windthorst
		Smith	Kirvin

Semiarid Frigid	Montana	Hill	Chinook Elloam
		Liberty	Ethridge
		Roosevelt	Lihen
		Toole	Joplin
		Valley	Marias
	Nevada	Douglass	Indian Creek Mottsville Ophir Ormsby Reno Toiyabe Turria
	North Dakota	Bowman	Ekalaka
Semiarid Mesic	Colorado	Arapahoe	Blakeland Bresser Fondis
		Crowley	Glenberg
		Elbert	Kutch
		Morgan	Vona
		Prowers	Apishapa Haverson Kornman Minnequa Rocky Ford Wiley
	Kansas	Grant	Richfield
		Hamilton	Colby
	Montana	Yellowstone	Absarokee Hesper Keiser
	New Mexico	McKinley	Fortwingate
	Texas	Sherman	Sherm
Semiarid Thermic	Arizona	Graham	Gila Glendale
	New Mexico	Lea	Jal Kimbrough
		Roosevelt	Portales

	Texas	Andrews	Triomas
		Haskell	Abilene
		Kent	Miles
		Kinney	Montell
		Lamb	Amarillo
		Lubbock	Acuff
		Lynn	Patricia
		Menard	Tarrant
		Upton	Reagan
Semiarid Hyperthermic	Texas	Cameron	Willacy
		Hidalgo	Hidalgo
			Sarita
		Jim Wells	Clareville
		Nueces	Victoria
		Zavala	Uvalde
Arid Frigid	Colorado	Clearcreek	Vasquez
Arid Mesic	Nevada	Churchill	Appian
			Carson
			Dia
			Pirouette
		Pershing	Blackhawk
			Humboldt
			Lovelock
			Placeritos
			Ryepatch
			Sonoma
Arid Thermic	Arizona	Santa Cruz	Continental
			Pima
			White House
	Texas	Pecos	Hodgins
Arid (Temperature Regime Not Certain)	Arizona	Yuma	Superstition
	California	San Bernardino	Adelanto
	Nevada	Clark	Bitterspring
			Calico
			Land
			McCarran
			Morman Mesa
			Overton
			Toquop
			Virgin River
		Eureka	Cortez
		Humboldt	Bloor
			Ninch
			Rio King
			Valmy

Utah	**Millard**	**Abbott** **Harding** **Palisade** **Pharo**

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

Task/Milestone	1977 DEC	1978 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Selection of soils to be studied	▽											
Acquisition of soil samples						▽						
Preparation of soils for analysis							▽					
Checking out analytical techniques				▽								
Spectral analysis					▽					▽		
Physical/chemical analysis								▽				
Determining engineering properties								▽				
Statistical analysis											▽	
Interpretation of results												▽
Preparation of report												▽

JSC Form 1956C (Rev Jun 66) NASA-JSC

TASK 2A. APPLICATION OF STATISTICAL PATTERN RECOGNITION TO IMAGE INTERPRETATION.

I. Introduction

A. Rationale

In large scale Landsat agricultural crop surveys, samples used to train the classifier cannot be labelled solely by ground observation, either due to the great expense or to inaccessibility as in foreign countries. The ability to accurately and reliably label training samples from the Landsat imagery and easily accessible ancillary data is crucial to the application of remote sensing technology to global crop inventory systems. Current image interpretation techniques involve a great deal of subjective judgment and so vary in accuracy and repeatability among analyst-interpreters.

B. Objectives and Approach

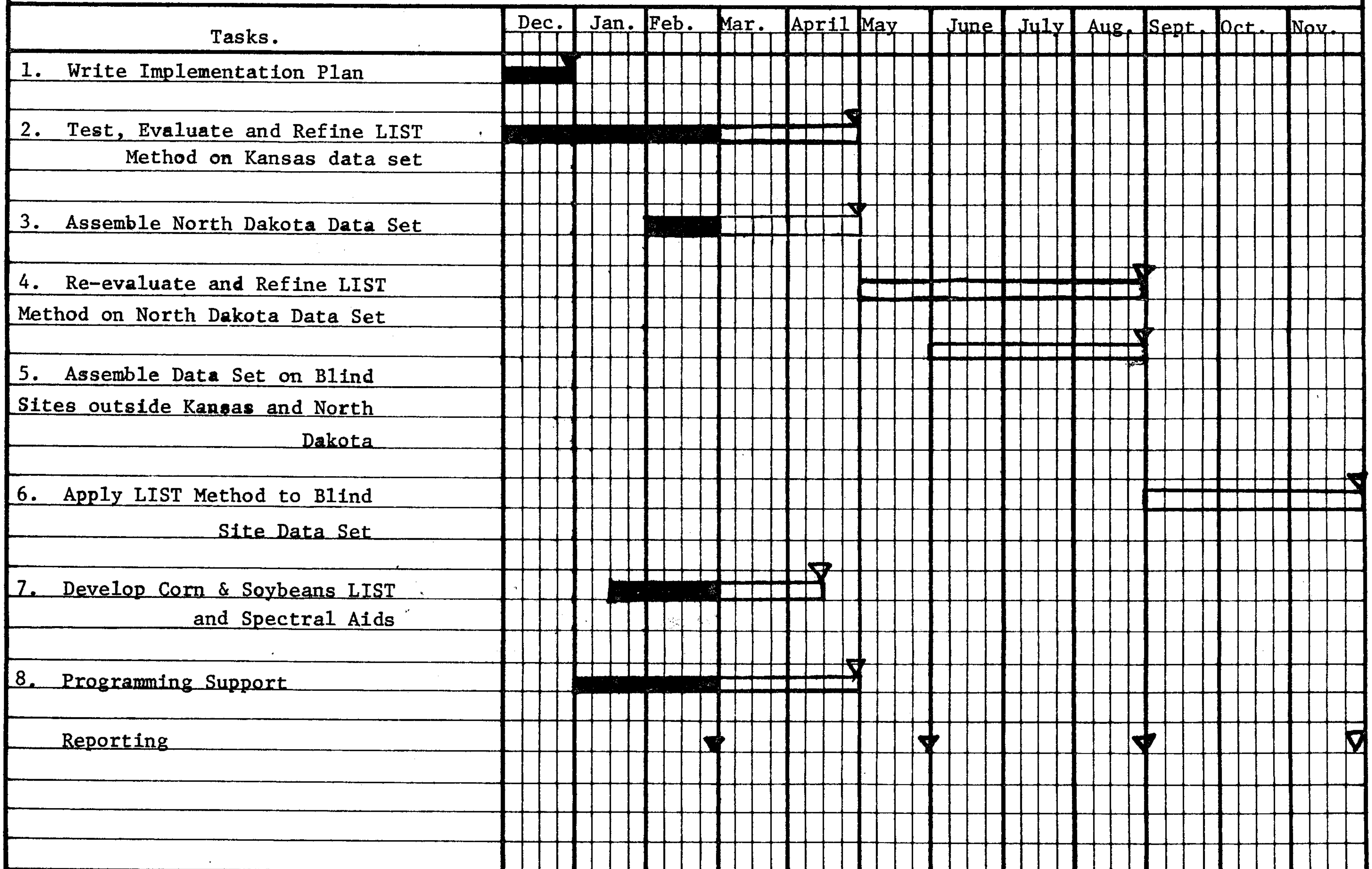
This task seeks to upgrade the reliability and objectivity brought to the sample labelling process and so improve conventional image interpretation techniques. The sample labelling problem will be addressed in the context of the wheat/nonwheat classification problem of LACIE, and as a secondary priority, the corn/soybeans/other classification problem.

The attributes which an analyst uses in labelling wheat in Landsat data will be identified and measured for known wheat and nonwheat pixels. The extent to which the recognition attributes used by the analyst-interpreter in labelling wheat can be stated in more objective and quantitative terms amenable to machine implementation will be determined. Statistical pattern recognition techniques will be applied to determine what specific attributes can be used to distinguish one crop from another and devise strategies for the optimal labelling of training samples.

II. Activities During Quarter

During the quarter, work has progressed on subtasks 1, 2, 3, 7, and 8 as given in the Implementation Plan and shown in Detailed Implementation Schedule (Figure 2A).

Figure 2A. Detailed Implementation Schedule



JSC Form 1956C (Rev Jun 66)

NASA-JSC

1. Write Implementation Plan. The implementation plan was completed and sent to NASA/JSC for approval in early January. No notice of approval has been received.

2. Test, Evaluate, and Refine LIST method on Kansas Data Set. Under this task several activities are taking place. The LIST method is being applied to segments 1857, 1860, and 1865, and will be applied to segments 1163, 1165, 1852, and 1855. To aid in this application of the LIST method, samples of spectral trajectory plots and greenness and brightness numbers have been generated from other LACIE segments. This will aid the analysts in answering questions about "typical" wheat responses and in developing quantitative measures of such responses. A third activity has been the programming needed to support this effort. (See task 8).

3. Assemble North Dakota Data Set. The supporting ancillary data and full-frame imagery for segments 1660, 1661, 1633, and 1637 are being assembled. The samples of spectral trajectory plots and greenness and brightness numbers will be generated from other segments in North Dakota.

7. Develop Corn and Soybeans LIST and Spectral Aids. The CITARS data set is being reassembled. (See Task 2B. Application and Evaluation of Landsat Training Classification and Area Estimation Procedures for Crop Inventory). The registered and geometrically corrected digital data were delivered to NASA/JSC on February 14. At this time, it is not known how soon the PFC products will be available. Work in the next quarter will emphasize the development of quantitative spectral aids.

8. Programming Support. Some problems in the programs to produce spectral plots were corrected. However, this slowed the improved implementation of the UCB "wheat probability stratification" and of the ERIM improved data screening. These algorithms will be implemented in the next quarter.

Personnel from this task attended the SR&T quarterly review during December 13 - 16. In addition, B. Davis participated in the Multicrop meetings held January 25 - 26 and February 14 - 15.

The Multicrop meetings have had an impact on this task. In addition to the time spent on travel and meetings, effort has been directed at the stratification needed by Multicrop for the 1978 crop year data acquisition. This has not been easy to do nor could it be done as quickly as was first thought. This, and the writing of the corresponding data set design, has drained some effort off the image labelling task.

The Multicrop meetings have also led to a discussion of the possibility of modifying the emphasis of this task to include more corn and soybeans and less wheat work. This should be resolved at the next SR&T quarterly review, March 13 - 16.

B. Application and Evaluation of Landsat Training Classification and Area Estimation Procedures for Crop Inventory

I. Introduction

The need for accurate and timely crop information on a global basis is increasing each year as the world's growing population increases the demand for food. Considerable evidence has developed that multispectral remote sensing from satellites combined with computer-aided data analysis can provide the information necessary to monitor the world's croplands.

The Large Area Crop Inventory Experiment (LACIE) which was initiated in 1974 has sought to estimate wheat production in several important wheat growing regions of the world. Area estimates for wheat were made by aggregating the proportion of wheat in individual 5x6 nm segments which together represented about two percent of the total land area. Since the estimates were based on a relatively small number of segments, the sampling errors associated with the estimates were quite large (more than 4%).

Since the LACIE system was designed, new information has been acquired on scene stratification, training sample selection, classification algorithms, and area estimation methods. This research task will build upon these recent developments and extend them to a multicrop inventory system.

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 primary objectives during the first year are acquisition, documentation, and initial processing of an extensive data set with several types of agricultural scenes in the Corn Belt. Secondary objectives include a pilot study which will use currently available data to develop and refine multicrop inventory techniques. The second year will extend the results of the pilot study to assess scene dependent differences in optimal choices of training, classification, and area estimation.

III. Approach

This investigation will be conducted in two phases: a pilot study and a major study. The pilot study will pursue objectives related to establishing spectral crop calendars for corn, soybeans, and "other" and to evaluating the LACIE Procedure 1 (P-1) for multicrop identifications using currently available Landsat MSS, aerial photography, and ground observations acquired over Indiana and Illinois in 1973 during the Crop Identification Technology Assessment for Remote Sensing (CITARS) project. Spectral aids, such as plots of greenness and brightness numbers and infrared/red ratios, which may enhance the separability of these crops will be evaluated.

The major study, which includes both data collection and analysis, will begin in the first year and will extend through the second year of this investigation. The specific objectives of the major study include:

a. Data Acquisition

- to define data requirements and to design experiments for assessing choices of training, classification, and area estimation procedures.
- to collect, correlate, and document Landsat data and imagery, aerial photography, and ground observations for the major study.

b. Training

- to evaluate and extend procedures for training area selection including factors such as size, number and geographic location of the training areas.
- to refine procedures for obtaining class statistics from multiple training areas.

c. Classification

- to assess the accuracy, compared to USDA/SRS estimates, of the area estimates of corn and soybeans obtained by two classification algorithms: per point maximum likelihood classification and ECHO classification.

- to assess the accuracy of multitemporal classification as compared to the unitemporal classifications.

d. Area Estimation

- to compare the accuracy and precision of area estimates for corn and soybeans obtained by different estimation methods; specifically, to compare estimates obtained by classification and aggregation of a systematic sample of pixels with estimates made from a sample segment approach.

The major study will build upon the training procedures developed in the pilot study and will extend its investigation to include other aspects of training area selection such as size and geographic location of training areas. In addition, classification and area estimation procedures will be studied. Finally, differences in the optimal procedures for the different test sites in the Corn Belt will be assessed.

IV. Accomplishments this Quarter

The primary activity during this quarter has been to develop and refine the objectives and specific approach to be followed. As a result of this process, the implementation plan was written and forwarded to NASA/JSC in early January. The process has continued during the "multicrop survey" discussions held at JSC on January 23-24 and February 13-14. The overall result of these discussions in relation to this task are that the LARS task will comprise the most intensive sampling rate of three levels of sampling intensity to be used in the multicrop effort.

Data and maps to be used in the selection of test areas and for stratification have been obtained for Indiana and Iowa. The initial stratification is now being performed utilizing county acreage, yield, and production estimates from 1972 to 1976, along with soil and climatic information. Eighty segments will be allocated to four test areas in Indiana and Iowa. Landsat MSS data, aerial photography and ground observation will be obtained for these segments for the major study.

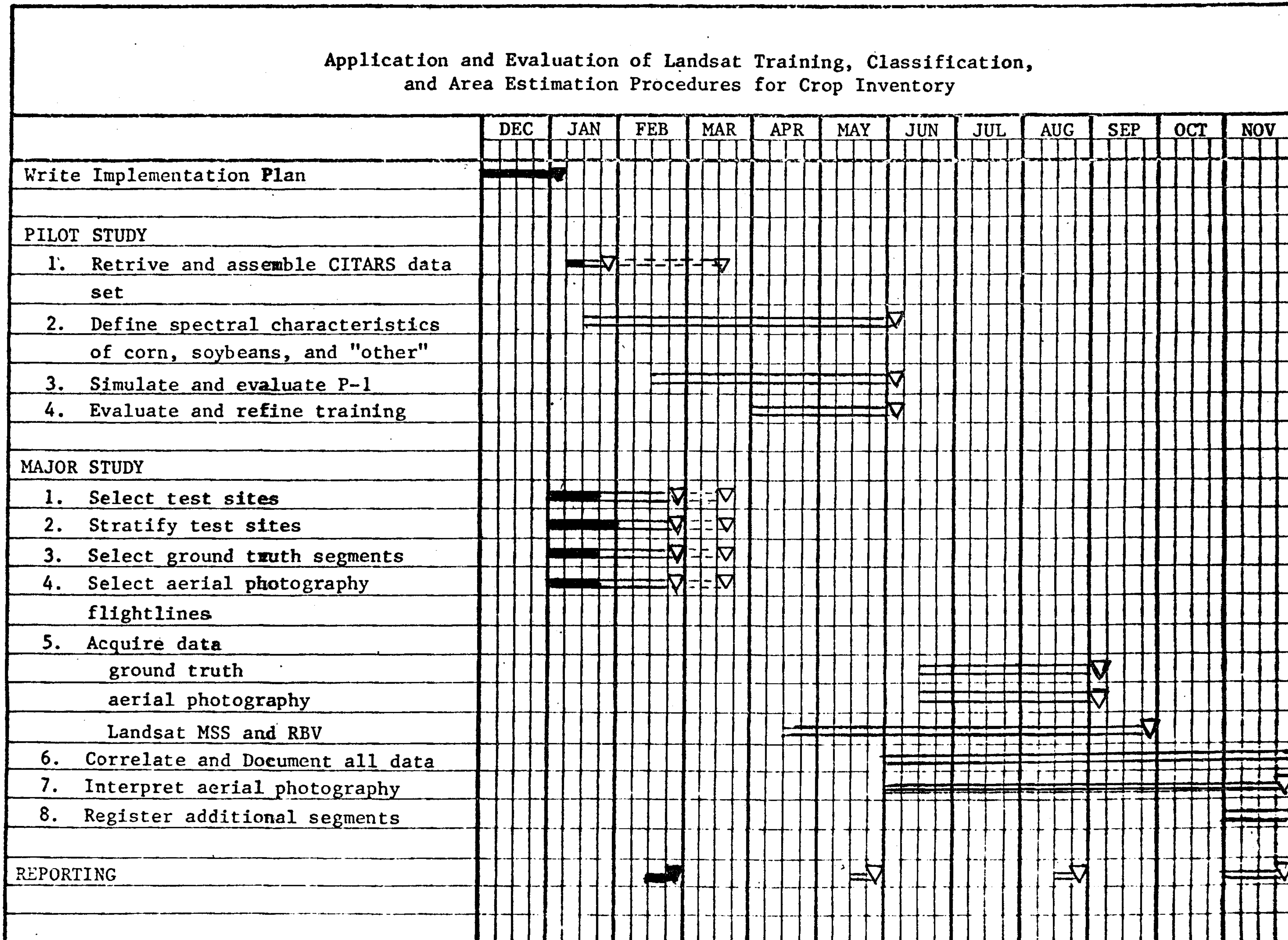
Secondly, we have started to retrieve and assemble the available Landsat data sets at LARS (i.e., CITARS data) for use in the pilot study. The primary use of these data will be to determine the spectral characteristics and variability of corn, soybeans, and other cover types as a function of crop calendar and location.

Thirdly, we have formulated plans for the collection of aerial photography and ground observations for the major study. The ground observations are to be acquired in conjunction with the JSC multicrop effort and will consist of "wall-to-wall" crop identification on all segments and periodic observations of other agronomic variables including height and maturity for a subset of segments and fields within the selected segments.

V. Plans for Next Quarter

During the second quarter, the analysis of the pilot study data will begin and the stratification/sample allocation completed. Initial data collection is planned for May.

Figure 1. Detailed Implementation Schedule.



JSC Form 1550C (Rev Jun 66)

NASA-JSC

2C. MULTISENSOR RADIOMETRIC CORRECTION CORRELATION AND APPLICATIONS ANALYSIS

The objective of this subtask 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. Progress on the two parts of the project during the quarter are discussed below:

2C1. Multisensor Parametric Evaluation and Radiometric Correction Model

Three activities were pursued during the quarter:

I. Develop and Test Scanner Spatial Model

The spatial model represents the effect of the IFOV of the sensor in the reflected energy measurement process carried out by the scanner. The objective is to enable study of the interactive relationship among the scanner IFOV, spectral bands, signal-to-noise ratio, and classification accuracy by relating the statistics of the data at the scanner output to the corresponding quantity at the input. In order to proceed with the formulation of the problem a spatial model for the multispectral data was developed.

a. Scene Spatial Model

By scene spatial model, specifically is meant a spatial correlation structure. Relatively little attention has been paid to this topic partly because spectral classifiers are more widespread than spatial classifiers. It has been frequently suggested, however, that the correlation function associated with the multispectral data closely follows an experential shape.

Let $\underline{S}_k$ be the spatial correlation matrix associated with the kth spectral band;

$$\underline{S}_k = [s_{ij}] \quad i,j = 0,1,\ldots,N-1$$

where: N is the size of the data array being considered

Under two assumptions, (a): Markov correlation structure and (b): separability of it along the cross-track and down track directions, $\underline{S}_k$ can be specified as follows

$$\underline{S}_k = [s_{ij}] = [s_i s_j] = [\rho^i_{x_k} \rho^j_{y_k}] \quad i,j = 0,1,\ldots,N-1$$

where ρ_{x_k} and ρ_{y_k} are the adjacent pixel correlation along the respective directions given by

$$\rho_{x_k} = e^{-a_{kk}}$$

$$\rho_{y_k} = e^{-b_{kk}}$$

Similarly the spatial cross-correlation matrix between the two bands p and q is defined

$$\underline{S}_{pq} = [\rho^i_{x_{pq}} \rho^j_{y_{pq}}] \quad i,j = 0,1,..,N-1$$

where

$$\rho_{x_{pq}} = e^{-a_{pq}}$$

$$\rho_{y_{pq}} = e^{-b_{pq}}$$

In order to examine the validity of the Markov model and the separability property of the correlation functions, a sample NASA aircraft 24 channel MSS data set was selected and the estimate of the auto and cross-correlation functions obtained using the following estimator

$$s_{\tau,\eta} = \frac{1}{N} \sum_{i=0}^{N-\tau-1} \sum_{j=0}^{N-\eta-1} f(i,j)f(i+\tau,j+\eta) \quad \tau,\eta = 0,1,\ldots,N-1$$

where f(i,j) is the test data. Plots of $s_{\tau,o}$, $s_{o,\eta}$ and the corresponding cross-correlation functions for channels 2 and 8 are shown in Fig. 2C1-1 thru 2C1-3.

Although the shape of the correlation curves themselves indicate an approximate exponential decay, a quantitive least-square fit shows that this assumption does indeed hold. The unusually high cross-track pixel-to-pixel correlation is attributed to the very high resolution aircraft data, for

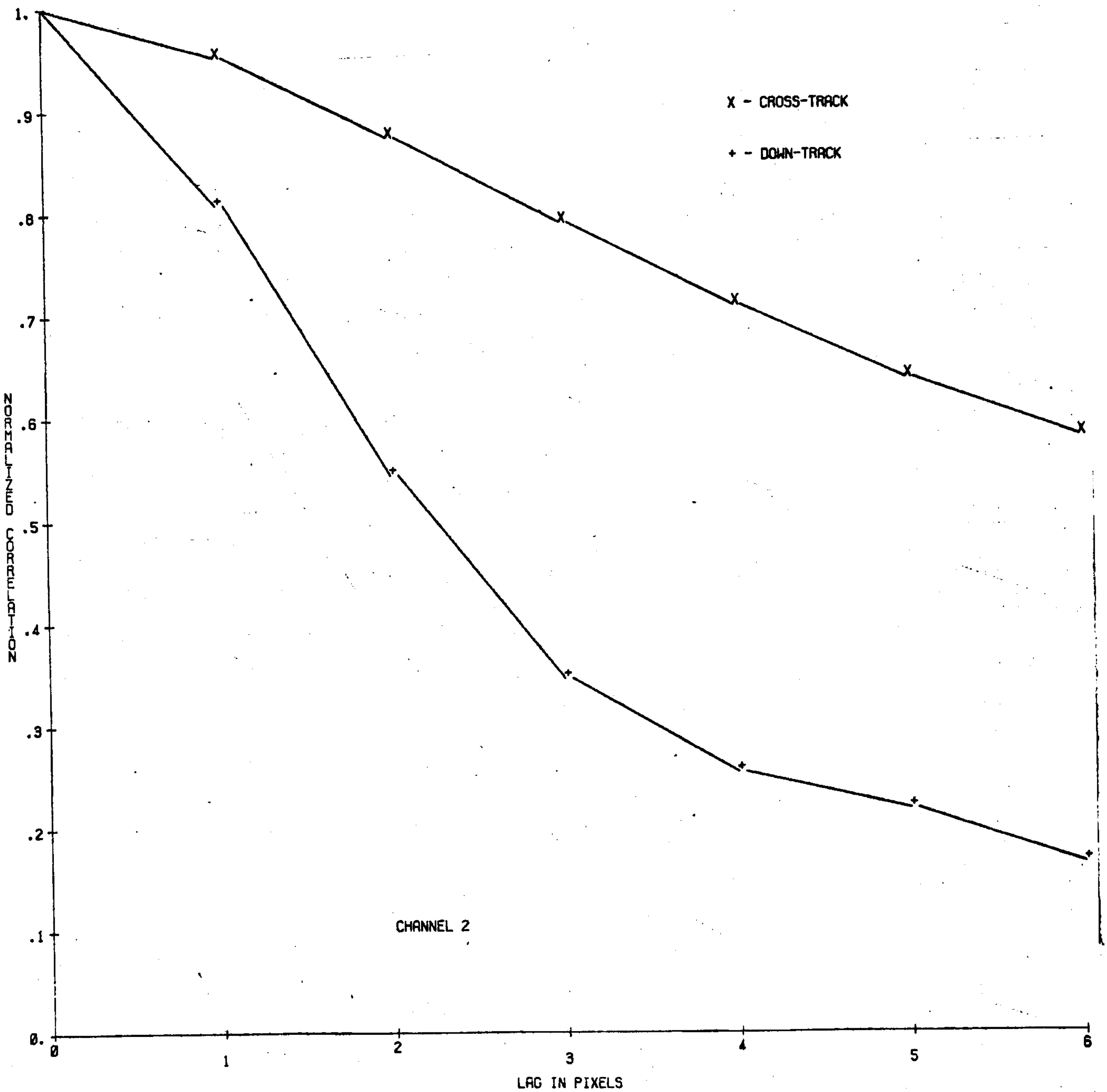


Figure 2C1-1 Along and Across Track Correlation Functions for Channel 2.

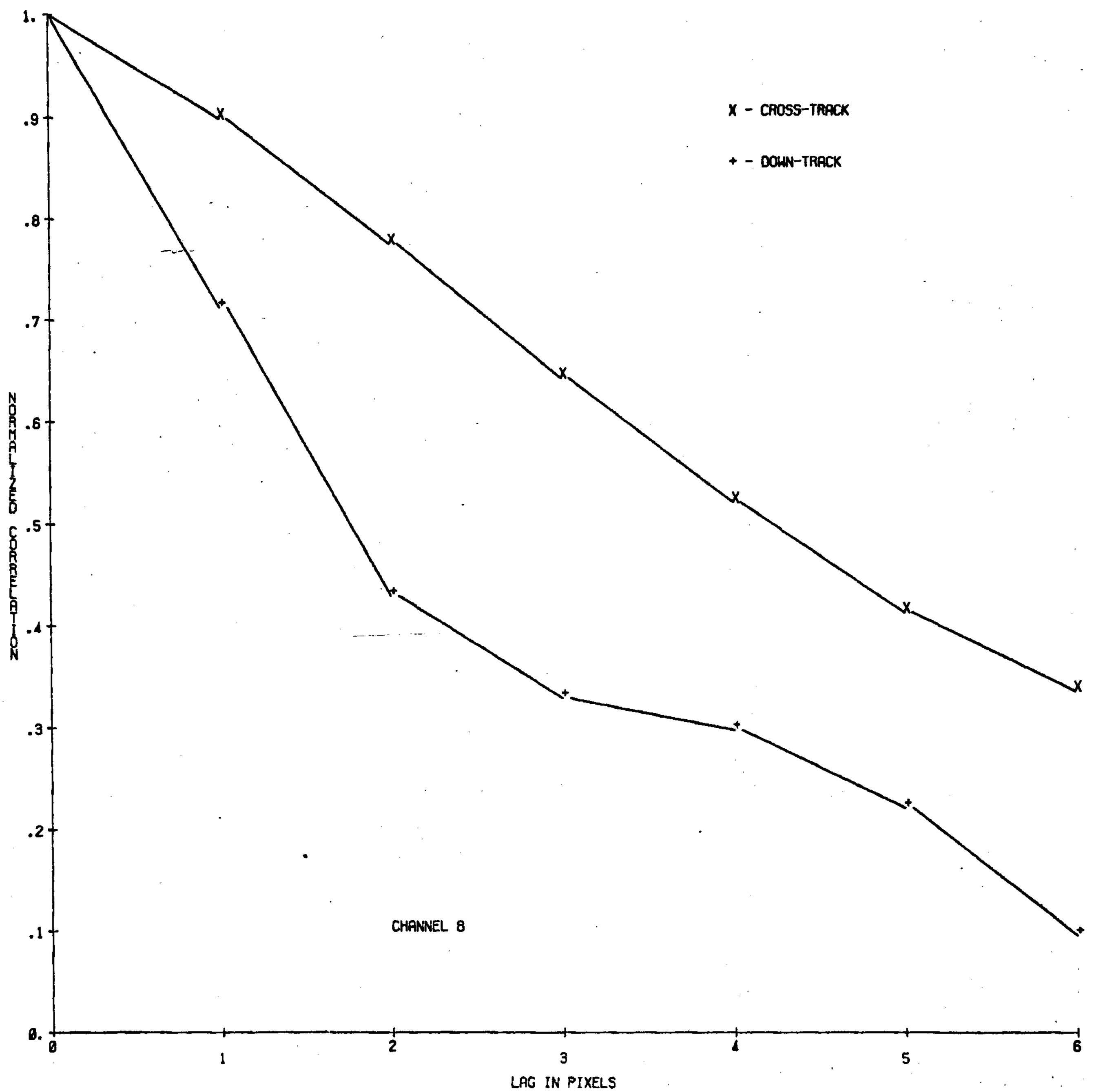


Figure 2C1-2 Along and Across Track Correlation Functions for Channel 8.

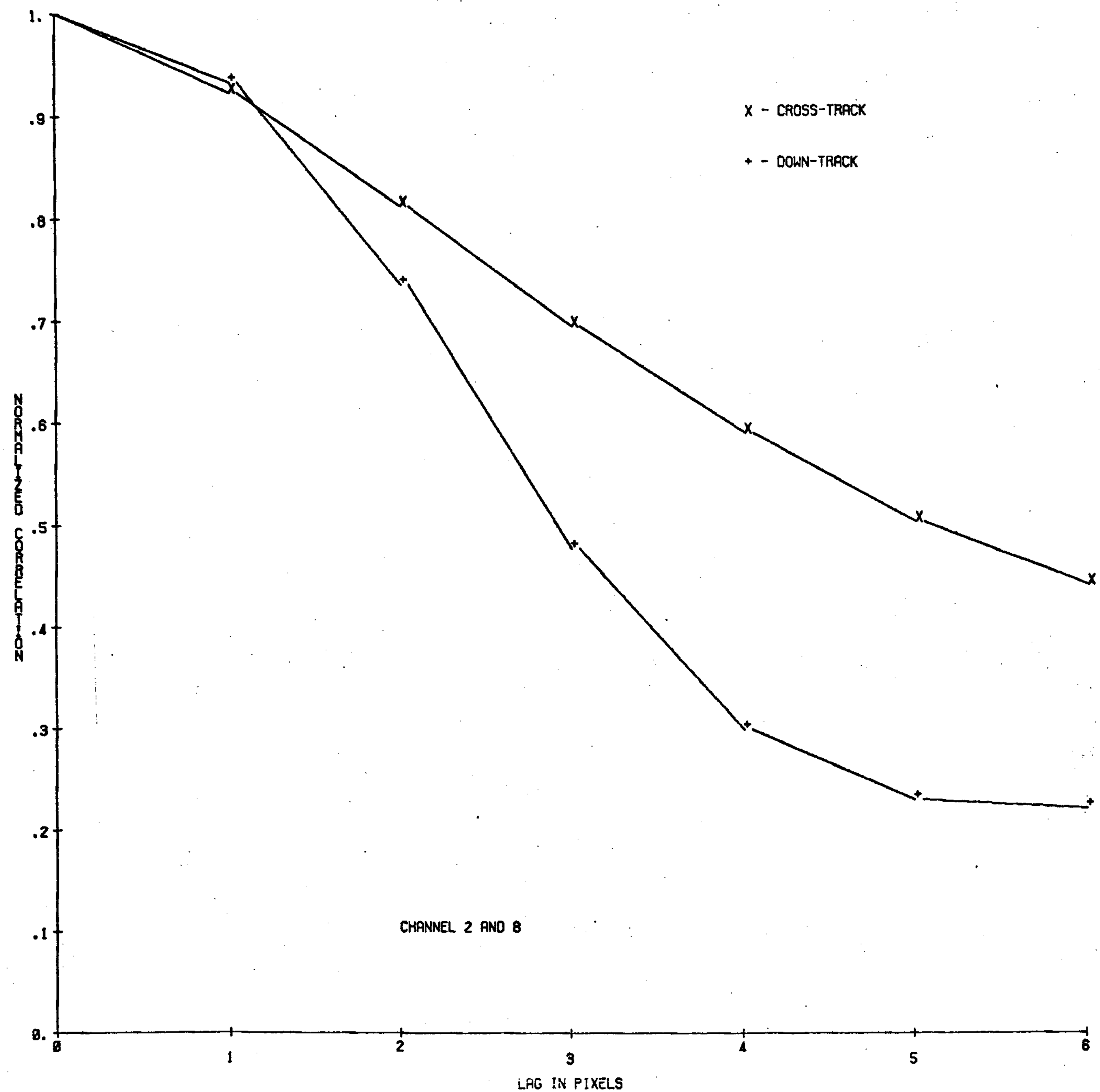


Figure 2C1-3 Along and Across Track Cross-Correlation Functions for Channels 2 and 8.

satellite imagery a $\rho_{x_k} = 0.8$ is a more common value.

In order to check the separability assumption, an error matrix is defined as follows

$$\underline{E}_k = |[s_{ij}] - [s_i s_j]|$$

and expressed as a percentage of the experimentally obtained values, shown in Tables 2C1-1 thru 2C1-3. It can be observed that the error is smallest for low correlation lags and progressively gets worse around the tails of the correlation function. It is important to note that although the absolute value of the error for high lags is rather large, the magnitude of the correlation function is itself small and thus carries little weight in influencing the final results.

b. IFOV Modeling:

The MSS point spread function (PSF) has been generally modeled by a Gaussian shaped function defined by

$$h(x,y) = C_1 \exp(-x^2/r_o^2)\exp(-y^2/r_o^2)$$

where r_o is the PSF's "characteristic length" and C_1, a constant providing unity filter gain. The scanner IFOV and r_o are related by the following relationship

$$\text{IFOV} = 2\sqrt{\ln 2}\; r_o$$

In order to obtain the data statistics at the scanner output in terms of the input statistics, it is necessary to have a relationship between the input and output correlation functions. This task can be accomplished by applying linear system theory techniques to the MSS for a specified PSF. Let $s_{\tau,\eta}$ and $s'_{\tau,\eta}$ be the input and output correlation functions respectively, then

$$s'_{\tau,\eta} = s_{\tau,\eta} * m_{\tau,\eta}$$

where

Table 2C1-1 Error Matrix for Correlation Function Approximation for Channel 2.

$\underline{S}_2$ =

1.00	0.95	0.87	0.79	0.71	0.64	0.58
0.81	0.79	0.74	0.67	0.60	0.53	0.48
0.54	0.55	0.52	0.48	0.42	0.31	0.32
0.34	0.36	0.35	0.33	0.29	0.25	0.21
0.25	0.27	0.28	0.27	0.25	0.21	0.18
0.22	0.24	0.25	0.25	0.23	0.21	0.18
0.16	0.19	0.20	0.21	0.20	0.19	0.16

$\hat{\underline{S}}_2$ =

1.00	0.95	0.87	0.79	0.71	0.64	0.58
0.81	0.77	0.70	0.63	0.57	0.51	.47
0.54	.51	.47	.42	.38	.34	.31
0.34	.32	.3	.27	.24	.21	.2
0.75	.23	.21	.19	.17	.16	.14
0.22	.2	.19	.17	.15	.14	.12
0.16	.25	.13	.12	.11	.1	.09

$\underline{E}_2$ =

0	0	0	0	0	0	0
0	2.6	5.4	5.9	5	3.7	.2
0	7.2	9.6	12.5	9.5	8.1	3.1
0	11.1	14.2	18.1	17.2	16	4.7
0	14.8	25	29.6	32	23.8	22.2
0	16.6	24	32	34.7	33.3	33.3
0	24	35	42.8	45	47.3	43.7

Table 2C1-2 Error Matrix for Correlation Function Approximation for Channel 8.

$$\underline{S}_8 = \begin{bmatrix} 1.00 & .9 & .77 & .64 & .52 & .41 & .33 \\ .71 & .68 & .59 & .48 & .37 & .28 & .20 \\ .43 & .43 & .38 & .3 & .21 & .12 & .06 \\ .33 & .35 & .33 & .27 & .19 & .12 & .06 \\ .30 & .32 & .31 & .28 & .23 & .17 & .12 \\ .22 & .75 & .26 & .24 & .20 & .15 & .11 \\ .10 & .13 & .14 & .13 & .11 & .08 & .05 \end{bmatrix}$$

$$\hat{S}_8 = \begin{bmatrix} 1.00 & .9 & .77 & .64 & .52 & .41 & .33 \\ .71 & .64 & .55 & .45 & .37 & .3 & .11 \\ .43 & .39 & .33 & .27 & .22 & .17 & .14 \\ .33 & .3 & .25 & .21 & .17 & .14 & .11 \\ .30 & .27 & .23 & .2 & .15 & .12 & .09 \\ .22 & .2 & .17 & .14 & .11 & .09 & .07 \\ .1 & .9 & .07 & .06 & .05 & .04 & .03 \end{bmatrix}$$

$$\underline{E}_8 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 5.8 & 6.7 & 6.2 & 0 & 6.6 & 45 \\ 0 & 9.3 & 13.1 & 10 & 4.5 & 30 & 57 \\ 0 & 14.2 & 24.2 & 22.2 & 10.5 & 14.2 & 45.4 \\ 0 & 15.6 & 25.8 & 28.5 & 34.7 & 29.4 & 25 \\ 0 & 20 & 34.6 & 41.6 & 45 & 40 & 36.3 \\ 0 & 30.7 & 50 & 53.8 & 54.5 & 50 & 40 \end{bmatrix}$$

Table 2C1-3 Error Matrix for Cross Correlation Function Approximation Between Channels 2 and 8.

S_{28} =

1.00	.92	.81	.69	.59	.50	.44
.93	.88	.78	.67	.56	.48	.41
.73	.71	.64	.54	.44	.36	.3
.48	.47	.43	.36	.28	.21	.16
.30	.31	.29	.24	.18	.12	.08
.23	.25	.24	.21	.16	.12	.08
.22	.24	.24	.22	.19	.15	.12

$\hat{S}_{28}$ =

1.00	.92	.81	.69	.59	.50	.44
.93	.86	.75	.64	.55	.46	.4
.73	.67	.6	.5	.43	.36	.32
.48	.44	.38	.33	.28	.24	.71
.30	.27	.24	.2	.17	.15	.13
.23	.21	.18	.16	.13	.11	.1
.22	.2	.18	.15	.13	.11	.1

$\underline{E}_{28}$ =

0	0	0	0	0	0	0
0	2.2	3.8	4.5	1.8	4.16	2.43
0	5.6	6.2	7.4	2.3	0	6.75
0	6.4	11.6	8.3	0	17.5	23.8
0	13.0	17.2	16.6	5.5	20	38.4
0	16	25	23.8	18.7	8.3	20
0	16.6	25	31.8	31.6	26.6	16.6

$$m_{\tau,\eta} = F^{-1}\{|H(u,\nu)|^2\}$$

A comment is in order here. Although the above relationship supplies $s'_{\tau,\eta}$ for all values of τ and η, the required quantity, spectral covariance matrix, is only a function of zero lag values of the spatial covariance matrix, therefore once the output auto and cross-correlation functions have been derived they need be evaluated only for $\tau=\eta=0$.

Carrying out the mathematics, there emerges a function of central role which uniquely controls the entire transformation of the data through the scanner, calling it the scanner characteristic function, it has the following representation

$$W_s(0,0,a,b) = 4 \exp(\frac{a^2+b^2}{2} r_o)Q(ar_o)Q(br_o)$$

where a and b are the parameters of the input correlation function and Q is the complementary error function. For example, the output channel variances, σ'^2, are given by

$$\sigma'^2 = W_s(0,0,a,b)\sigma^{2'}$$

therefore once W_s is specified, so will the data statistics at the scanner output, thus accomplishing the objective initially outlined.

The variation of W_s vs. a, b and r_o can be very illuminating. Fig. 2C1-4 shows a plot of W_s vs. the pixel-to-pixel correlation decided by a (here for the sake of illustration a=b) with r_o, or effectively the IFOV, as the running parameter. The following can be observed from Fig. 2C1-4. (a): W_s has 0 and 1 as the lower and upper bound therefore assuring that the output variances are always smaller than the input variances (an expected result due to averaging operation of the scanner PSF). (b): For a fixed pixel-to-pixel correlation the ratio σ'/σ decreases with increasing IFOV. (c): For a fixed IFOV, σ'/σ increases with increasing pixel-to-pixel correlation.

All of the aforementioned comments have been experimentally observed. In particular, (c) has an interesting interpretation, i.e., for a fixed scanner, the output classification accuracy decreases with increasing scene correlation due to smaller variance reduction.

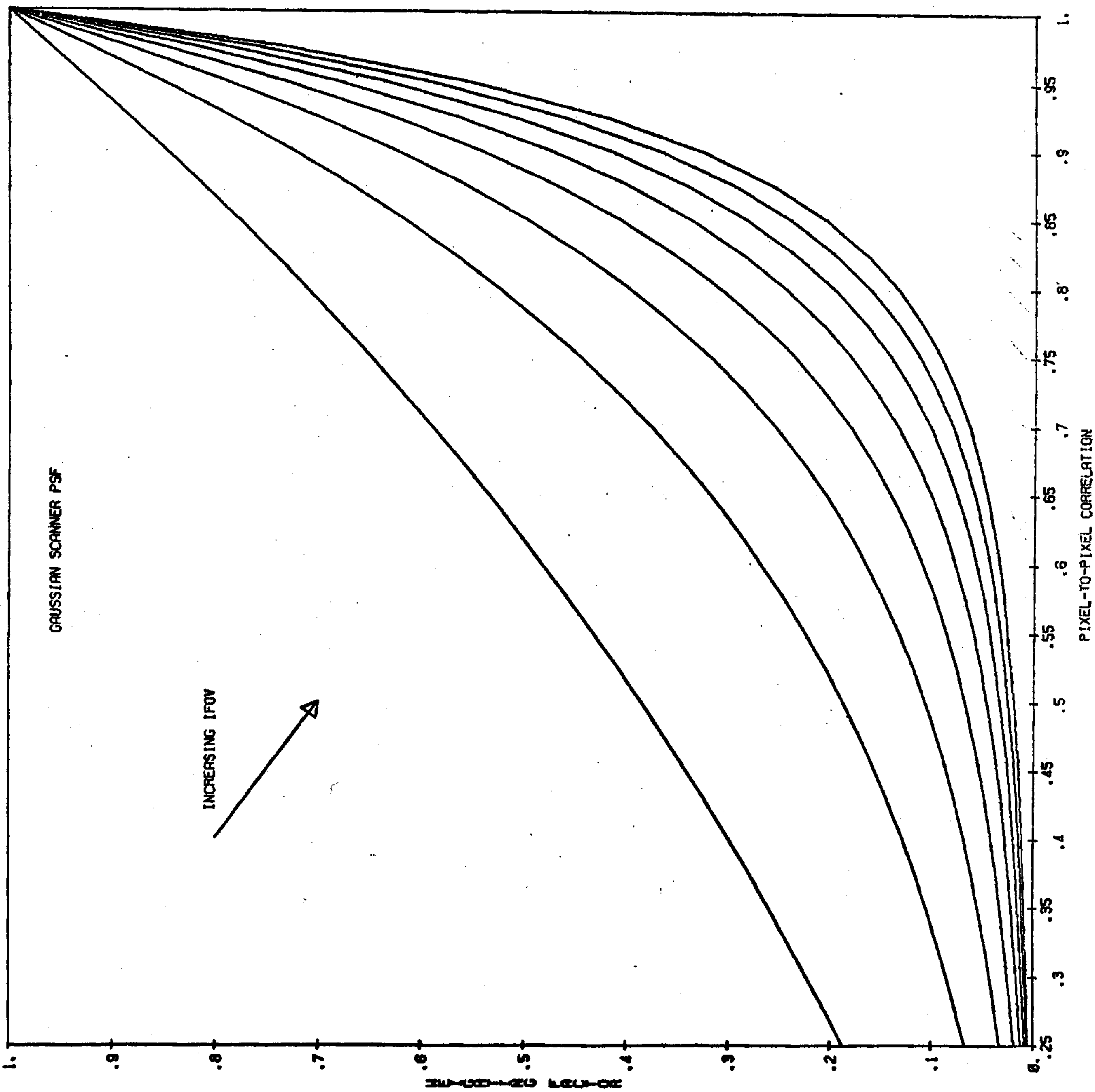


Figure 2C1-4 Plot of Scanner Characteristic W_s vs. Pixel-to-Pixel Correlation for a Gaussian Point Spread Function.

The same technique explained here can be applied to scanner systems with other forms of specified PSF. One example is the rectangular aperture function which is constant over a predefined interval and zero outside that interval. The corresponding W_s is shown in Fig. 2C1-5 exhibiting properties similar to the Gaussian PSF.

II. Develop and Test K-L and I-T Spectral Models

The spectral modeling activities seek optimum solutions for wavelength sampling functions. Generalized basis function (K-L) and information theory (I-T) approaches are being investigated. Progress on these two distinct approaches is as follows:

a. K-L Model

This optimum sensor characterization utilizes the Karhunen-Loeve expansion and is optimal in the sense of minimum mean-square representation error. The performance in terms of mean-square error is evaluated. Suboptimum practical systems are simulated and their performance is evaluated over the same set of data. This evaluation and comparison of optimum and suboptimum systems is repeated over several scenes.

At this point a software system for designing the optimal sensor from a finite data set has been developed and tested. The output of this system lists the mean-square error as a function of the terms used in the K-L expansion and a set of basis functions for transforming the data for evaluation of classification performance.

This past quarter a software system for simulating several practical systems was developed. The mean-square error for each suboptimal system is listed with the output. Both the optimum system and the suboptimum systems have been tried on a test data set.

In the coming quarter the optimum and suboptimum sensors will be evaluated in terms of classification performance. It is proposed to generate a set of statistics from the output of the sensors and evaluate performance using an algorithm that was developed as another portion of this task. Also, it is planned to assemble a variety of data sets to further evaluate the procedure.

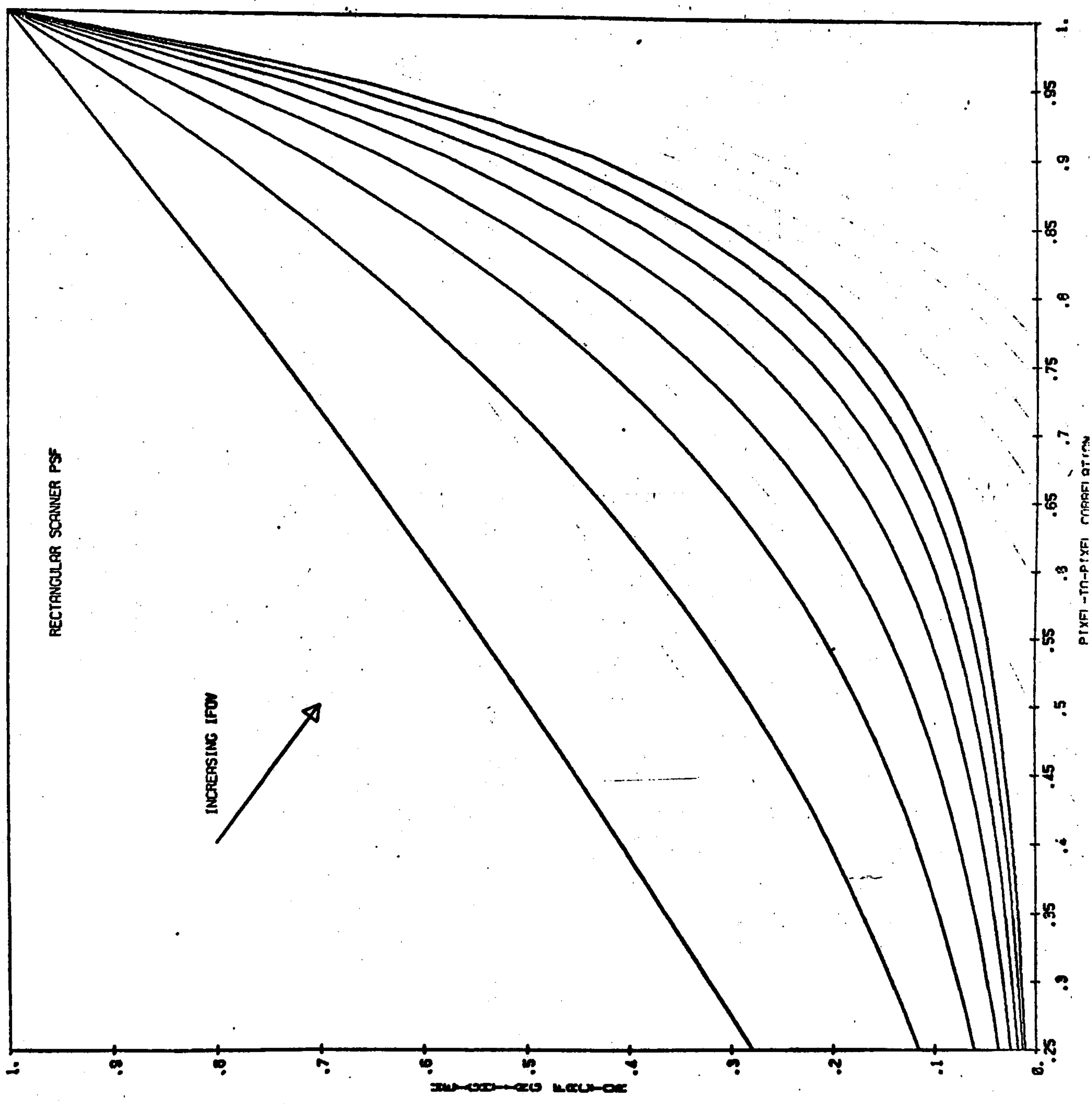


Figure 2C1-5 Plot of a Scanner Characteristic W_s vs. Pixel-to-Pixel Correlation for a Rectangular Point Spread Function.

b. I-T Model

The previous quarterly reports discussed the information theoretic approach to studying parameters of multispectral scanner systems. The spectral response process is divided into convenient spectral bands. These bands are then characterized by dynamic models. These models are chosen to provide a good fit to the empirical data and also to adequately account for statistical characteristics of the empirical data. The models are then used to compute the average information in a received spectral band about the corresponding band of the spectral reflectance process. Advantages of this technique include the ability to study average information as a function of spectral bandwidth and as a function of the noise level of the disturbance between the spectral scene and the multispectral scanner. These studies have continued during the current quarter.

When a subset of spectral bands is chosen using the average information criterion the question arises as to how well a classification algorithm would perform using these spectral bands. An attempt is currently being made to provide an estimate of classification performance for the two scene types (wheat and a combined scene of several agricultural vegetation types other than wheat) studied in this research. The estimates of classification performance assumes a Bayes classifier and gaussian statistics. The estimate is computed by the technique developed by Lissack and Fu [1]. This estimate is only an initial investigation and should not be construed as a complete characterization of classification schemes using multispectral scanner bands chosen on the basis of the information theoretic criterion.

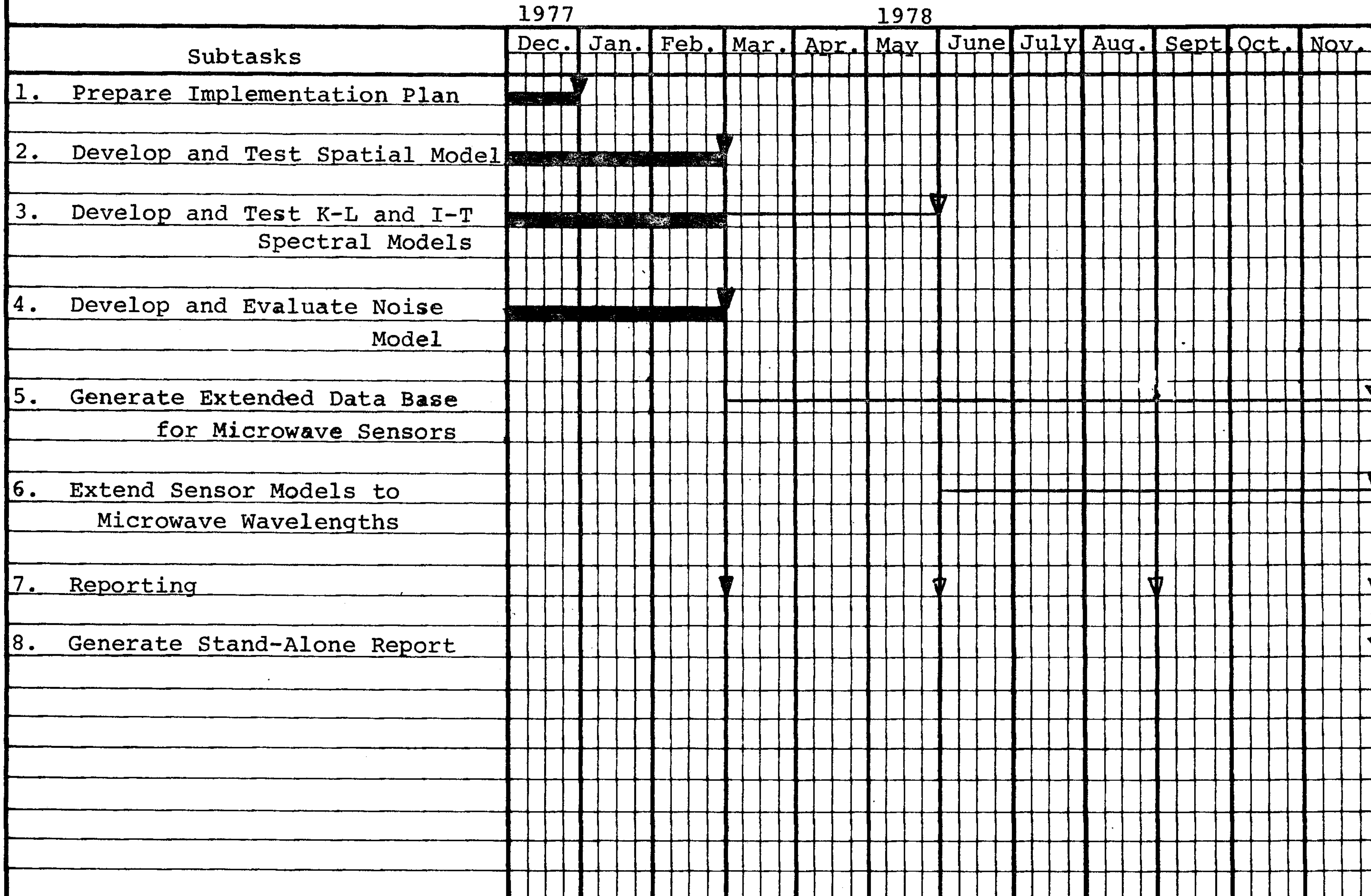
III. Develop and Evaluate Noise Model

No contributions were made on this item during the quarter. The noise addition software was completed in the last contract and noise addition can be made to the statistics for any class. The intent of the milestone is thus achieved and final stand-alone report due November 30, 1978.

REFERENCES

[1]. T. Lissack and K. S. Fu, "Error Estimation in Pattern Recognition via L^{α} - Distance Between Posterior Density Functions," IEEE Trans. Information Theory, Vol. It-22 No. 1, Jan. 1976, p. 34-45.

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



JSC Form 1956C (Rev Jun 68) NASA-JSC

2C2. Multisensor Information Extraction

Two activities were scheduled during the first quarter to begin study of information extraction techniques for Landsat data combined with other data types. The additional data type to be studied initially in this task is synthetic aperture radar imagery.

I. Data Set Survey and Acquisition

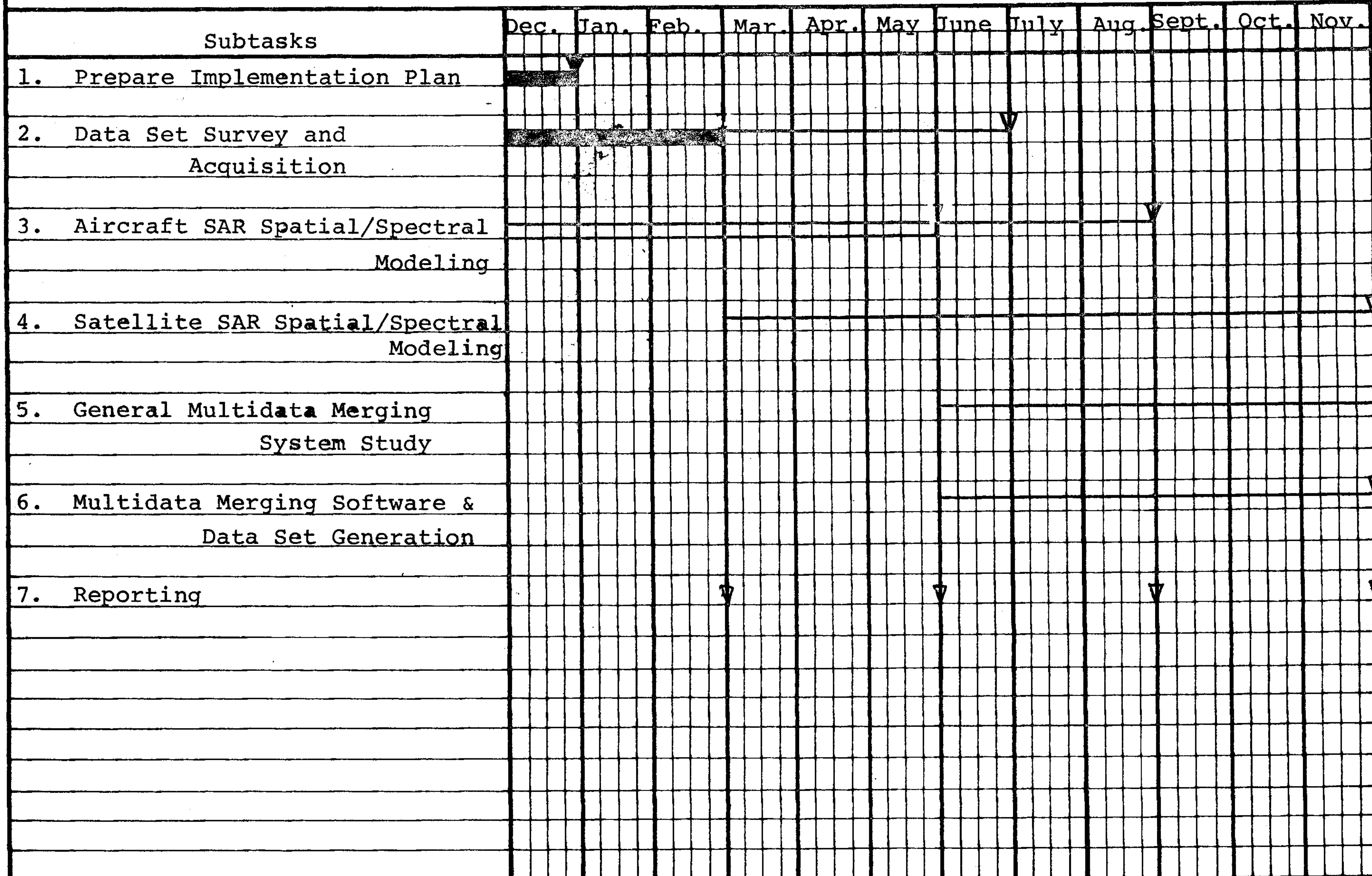
The basic data set to be considered in this study is a set of aircraft SAR flights over the Maryland eastern shore area in August, 1976. This data is on hand and ready to use in the study. Near time coincident Landsat data and ground truth is also on hand at LARS. A second SAR data set was acquired from Goodyear Aerospace Croporation which images the Phoenix, Arizona area in June 1977. Photographic processing was carried out in preparation for film digitizing. Landsat data search and ground truth inquiries are in progress to complete a data set for western agriculture and land use. It is expected that a south central SAR data set will be obtained from NASA from a flight early in 1978 flown by ERL. It is expected that an eastern, central and western SAR data set with near time Landsat data with some ground truth will be assembled in the second quarter. The remainder of the study will be primarily based on these data sets.

Also, Goodyear was consulted with regard to the U.S. Air Force radar imagery repository which they maintain. Accessing information was obtained and considerations made of what data will be requested. Over 6 million square miles of radar image are available at resolutions for 10 to 50 ft. Test sites and times of data could change depending on what is found in this repository.

II. Aircraft SAR Spatial/Spectral Modeling

This activity has the objective of determining the corrections and transformations of SAR data needed to optimally combine this data type with Landsat for information extraction. Due to a number of environmental and attendent personnel problems no progress was made on this activity in the quarter.

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



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

I. Introduction

a. Rationale

The growing concern over the world food situation has indicated the necessity to determine the availability and quality of resources to meet demands for food. While the global market demand depends on world population, income and national food preferences, food production relies on availability of cultivatable land, variability in weather patterns, level of technology and economic and governmental policies (1). Current endeavors call for stockpiling surplus grain production to deter food deficits in the near future, technological development of new and better varieties of food crops (e.g., triticale), and research on the use of resources and patterns of consumption. In general, estimates of potential food needs and potential food production are the focal points of the world food problem.

b. Objective

To assess potential food production adequately, an accurate estimate of current yield is necessary. Present-day production statistics are a conglomeration of yield and area figures acquired by objective methods in a limited number of countries while a major portion of the data is subjective in nature and frequently politically influenced. In order to estimate production accurately, a unified approach to the problem is needed.

A global crop inventory system would afford such an approach. The overall objective is to formulate guidelines for research and development of such an information system for wheat. More specifically, a global information system would provide an accounting of available resources as well as monitoring fluctuations in production caused by natural variability such as the weather.

II. Activity During Quarter

a. Primary Objective

Our principal interests in this quarter focused on describing and documenting existing statistical methodologies used in the United States, Indiana and India. Also included in the study were agricultural and economic influences on the acquisition and reporting of wheat statistics. Primarily, sampling practices and procedures were investigated as well as relevant sources of background information.

b. Approach

The basic plan concentrated on acquiring sources of information relevant to the task. This was mainly carried out in the form of an extensive literature search of material available in the Purdue University libraries. A preliminary bibliography detailing acquired materials is attached as Section VI. The major sources of information appear in publications of the Economic Research Service (USDA), the Food and Agriculture Organization (UN) and nonclassified reports of the CIA. Overall, much of the information is of a qualitative nature describing sampling practices in general. Information from the Journal of the Indian Society of Agricultural Statistics should provide more insight into the quantitative aspects of the sampling problem in India.

Within the Purdue community, several professionals were contacted and interviewed. Mr. Earl Park, Agricultural Statistician-in-Charge, State Statistical Office, Indiana, Statistical Reporting Service (SRS), USDA, discussed some of the finer points of the sampling and analysis procedures used within the state. Dr. Jerry Sharples, economist with the Economic Research Service (ERS), USDA and assigned to the Purdue Agricultural Economics Department, described the long term forecasting system used for U.S. wheat production. Dr. K. C. S. Pillai, Professor, Department of Statistics, Purdue University, obtained a number of government publications and final reports related to crop inventories and yields during a recent trip to India. Several contacts for follow up on national and foreign estimation procedures have been established:

1. Joseph Whillett, Director
   Foreign Demand and Competitor Division (USDA)
2. Bruce Meek, Assistant Administrator
   Foreign Commodity Analysis (USDA)
3. J. W. Kirkbride, Director, Estimates Division
   Crop Reporting Board (USDA)

Meetings with Larry Thomasson of the World Food and Agricultural Outlook and Situation Board and William Wigton, SRS, USDA, have also been scheduled.

During this quarter emphasis has been placed on an overview of sampling and estimation procedures in effect in the USA and Indiana. An investigation of wheat reporting practices in India has just begun. In the next section, a discussion follows with findings to date.

c. Findings

i. United States

Overview. The U.S. ranks fourth in land area and population with a temperate climate having four seasons with hot summers and cold winters. Forty-seven percent of the continental land area is developed for agriculture with 17% in use as cropland. Wheat is grown on 16.5% of the cropland with the major wheat producing area in the "Great Plains."

The area in use for crops has been decreasing while production has been increasing since the 1960's. In general, the number of farms has been decreasing as the average size has increased, with urbanization the contributing cause of the decreasing land in agricultural use.

Of major concern to the government are agricultural policies dealing with price supports in the form of direct payments to farmers and the storage and marketing of goods. Assurance of adequate supplies at reasonable prices to consumers while avoiding production resulting in burdensome surpluses are the objectives of major importance established in the national grain policy (2). These two objectives should be achieved at minimal government cost while maintaining farmer's income. Other objectives include guaranteed prices and voluntary set aside programs which would guard against an excessive total supply as well as having an adequate carryover to maintain prices.

Existing Information Systems. There are several federal agencies which are involved in collecting agricultural and related statistics. The principal agency involved in data collection and reporting is the Statistical Reporting Service (SRS) of the U.S. Department of Agriculture. The Census Bureau of the Department of Commerce is responsible for summarizing and publishing data collected in the 5-year agricultural census. Separate agencies handle weather information and reports and marketing information. The Economic Research Service of the USDA is responsible for analyzing the available information from the agencies mentioned and issuing analytic forecasts and describing trends. The primary goal of the ERS is long range planning and policy decisions.

This study will focus primarily on documenting the methods used by the SRS in sampling and estimating yield and area. Analytic procedures of the ERS should provide insight on factors which may affect the scope of, or applicability of, ground measures.

Domestic Crop Reporting. Official U.S. estimates are prepared and published by the Statistical Reporting Service. Organizationally, the agency consists of three divisions (Research, Survey and Estimates), forty-four State Statistical Offices and the Crop Reporting Board. Methods of collecting, estimating and forecasting are developed and improved by the Research Division. Procedures and forms for data collection are designed within the Survey Division while the Estimates Division acts as the main user contact specifying sampling units and implementing statistical methods to be used by the individual state statistical offices through a computerized network.

The Crop Reporting Board issues two types of statistics: forecasts and estimates. Forecasts are issued during the growing season and are a prediction of expected crop yield, assuming average weather patterns. No similar assumptions are made in the case of estimates which are issued at the end of the growing season and therefore rely on actual production figures.

Methods. Initially, a random sample of farmers is interviewed to obtain information regarding planting intentions and is followed with surveys to obtain estimates of actual area planted. Yield and production forecasts are made during the growing season, and finally, estimates of harvested area, production, and disposition of the crop. There are three basic methods used to obtain this information: mail surveys (voluntary), enumerative surveys, and objective measurements of sample plots (3).

Mail surveys are inexpensive but cannot be considered at all random and often produce about a 30% return thus giving a nonrepresentative sample. Their chief utility is to provide indications of the current crop status which might signal certain agricultural influences which would otherwise go undetected.

Enumerative surveys are constructed on the basis of a national sample of area segments. Interviews are conducted in June and December (December segments are a subsample of those selected the previous June) to obtain estimates of planting intentions and actual area planted. The state estimates are less precise than the overall national estimate but are used in conjunction with estimates from mail surveys.

Objective measurements are taken during the growing season for randomly chosen plots within the fields selected from the same population used in the enumerative surveys. These measurements consist of actual counts and clippings of number of heads, stalks, kernels, etc.

The methods of collecting, analyzing and reporting agriculture information are prescribed by the SRS and carried out by the state statistical offices. The Crop Reporting Board receives the individual state summaries and releases the official national estimates.

Recently, the USDA has come under attack from the climatologists who claim that crop yields are overestimated. This is a result of data interpretation based on a prediction system which incorporates data from the past 10 to 20 years (the 1950's and 1960's). In that time period, the prevailing weather conditions were good in general while in the present decade, the overall weather picture has not been as good as anticipated. Thus, timeliness of information is seen to be an important factor affecting forecasts.

Foreign Crop Estimation. The main source of agricultural information for foreign countries is the network of agricultural attachés stationed abroad. While much of the data they pass on to the ERS in Washington are based upon subjective observations and reports, they do provide commodity analysts here with timely indications of the existing trade situation. This information system is limited by the subjective nature of reports and by lack of a centralized framework to use as a base of operations. Currently, agricultural attachés are assigned to countries with which we have import/export relations.

ii. Indiana

This section focuses on the procedures of the SRS carried out by the State Statistical Office in Indiana concentrating on the collection and analysis of information pertinent to wheat production statistics.

Overview. Although Indiana's main crops are corn, soybeans and popcorn, it ranks tenth in the U.S. in terms of winter wheat production. While Indiana may not be a prototype of a typical wheat producing state, proximity to the State Statistical Office on the Purdue campus afforded convenience and opportunities for in-depth study.

Seventy-six percent of the total land area is agricultural with farm numbers and size following the national trend. The state itself is divided into 92 counties forming nine crop reporting districts.

Acquiring and Analyzing Wheat Statistics. Figure 3-1 gives an overview of the type of information collected under the direct supervision of the State Statistical Office. Enumerative and objective yield surveys use statistically selected national samples while mail surveys sample non-randomly from a fixed state pool.

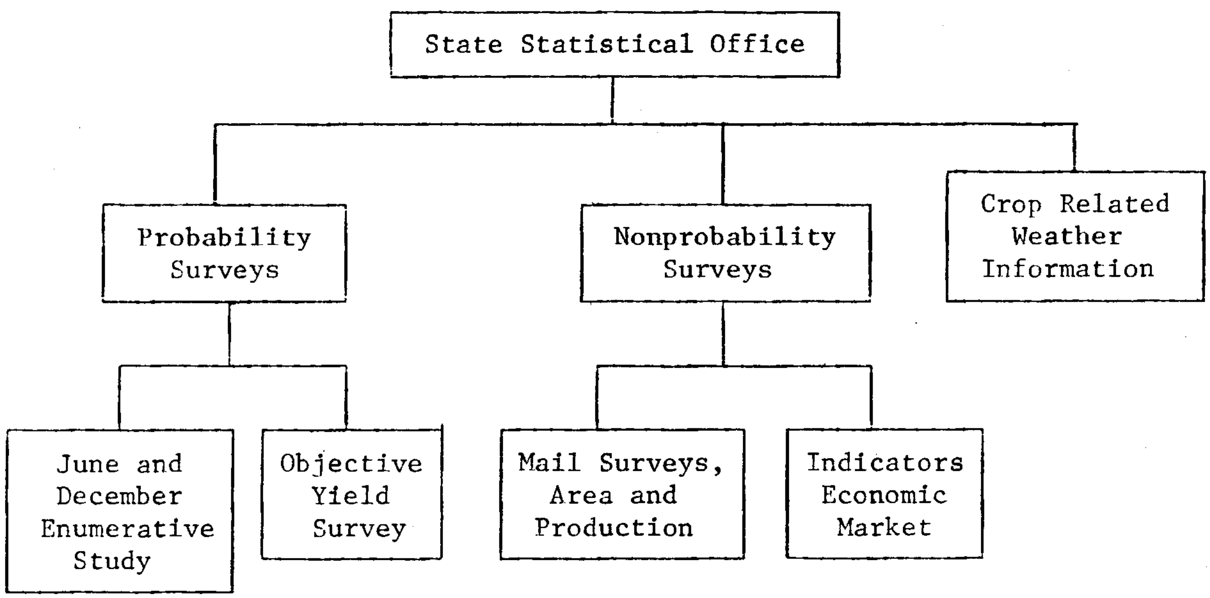


Figure 3-1. Overview of information collected by State Statistical Office.

State indications from acreage and production mail surveys are reported in terms of ratios and percentages, e.g., ratio of planted area to crop land and percentage change in planted area from the previous year. Regression charts are used to evaluate these indications using reported condition or probable yield and precipitation during growing season as predictions of yield per acre. Rainfall is included so that the forecasts would be sensitive to both deficiencies in moisture during growth as well as the amount of excess rainfall the crops could withstand. For any given date on which a forecast is issued, weather conditions are assumed to be normal for the remainder of the growing season. The major functions of acreage and production surveys include the planning of farm operations and measuring land utilization.

Figures 3-2 and 3-3 give a breakdown of the activities included in the two probability surveys carried out in Indiana. In the enumerative study (Figure 3-2) area samples are selected and farm operators in each sample are interviewed for information regarding area planted, crop condition, expected yield, etc. One survey is conducted in June for the entire sample and in December on a subsample.

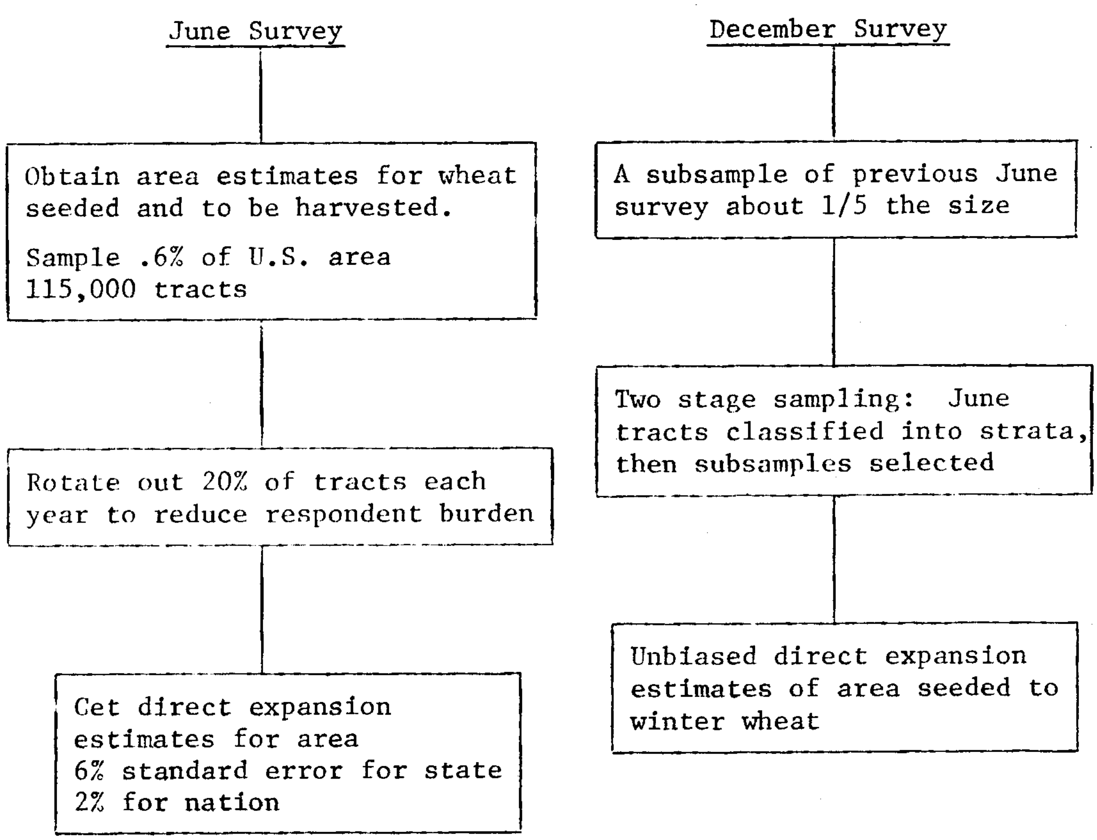


Figure 3-2. Enumerative Survey.

The December survey emphasizes acreage estimates of fall seeded crops such as winter wheat. Specifically, a stratified two-sample design is used with tracts classified in strata and a subsample chosen from selected strata. Direct expansion estimates are obtained by associating a probability of selection with each tract sampled with this probability being a product of the sampling probabilities at each stage. Sampling errors are determined from variation between segments.

The objective yield survey (Figure 3-3) provides crop yield information for forecasts and estimates based directly on counts and measurements of wheat. A systematic sampling scheme is used for selection based on a geographical arrangement of tracts. Fields are selected from chosen tracts based on probabilities proportional to area. Observations are then made on two randomly selected plots (the smallest sampling unit) in each of these selected fields.

Counts and measurements are conducted on a month to month basis and focus on the crop development stages. Forecasts are made on the basis of a regression procedure using a pre-established set of predictors such as weight, moisture content, precipitation, number of heads, number of kernels, number of stalks, height of stalks and others. When data are not available early in the growing season, the number of heads, for example, average data for the last three years are substituted. In states other than Indiana, separate estimates are derived for irrigated and nonirrigated fields and a weighted average is computed. There are two models which have been derived with the significant difference between the two being the rainfall period. Model A includes rainfall from previous August to present while model B uses the period from February to present.

Harvest losses are estimated at the end of the growing season by measuring gleanings after harvest for a sample plot and determining net yield for each sample.

Overall state indications take into account the results of both the objective yield survey and mail survey results. The following information is reported directly to the Crop Reporting Board:

1. Results of nonprobability mail survey

   number of respondents
   number of bushels expected
   regression estimate of yield

2. Objective yield results
3. Crop condition (100% = normal)
4. Precipitation

The USDA uses mail survey results to help interpret results from statistical models based on objective yield data.

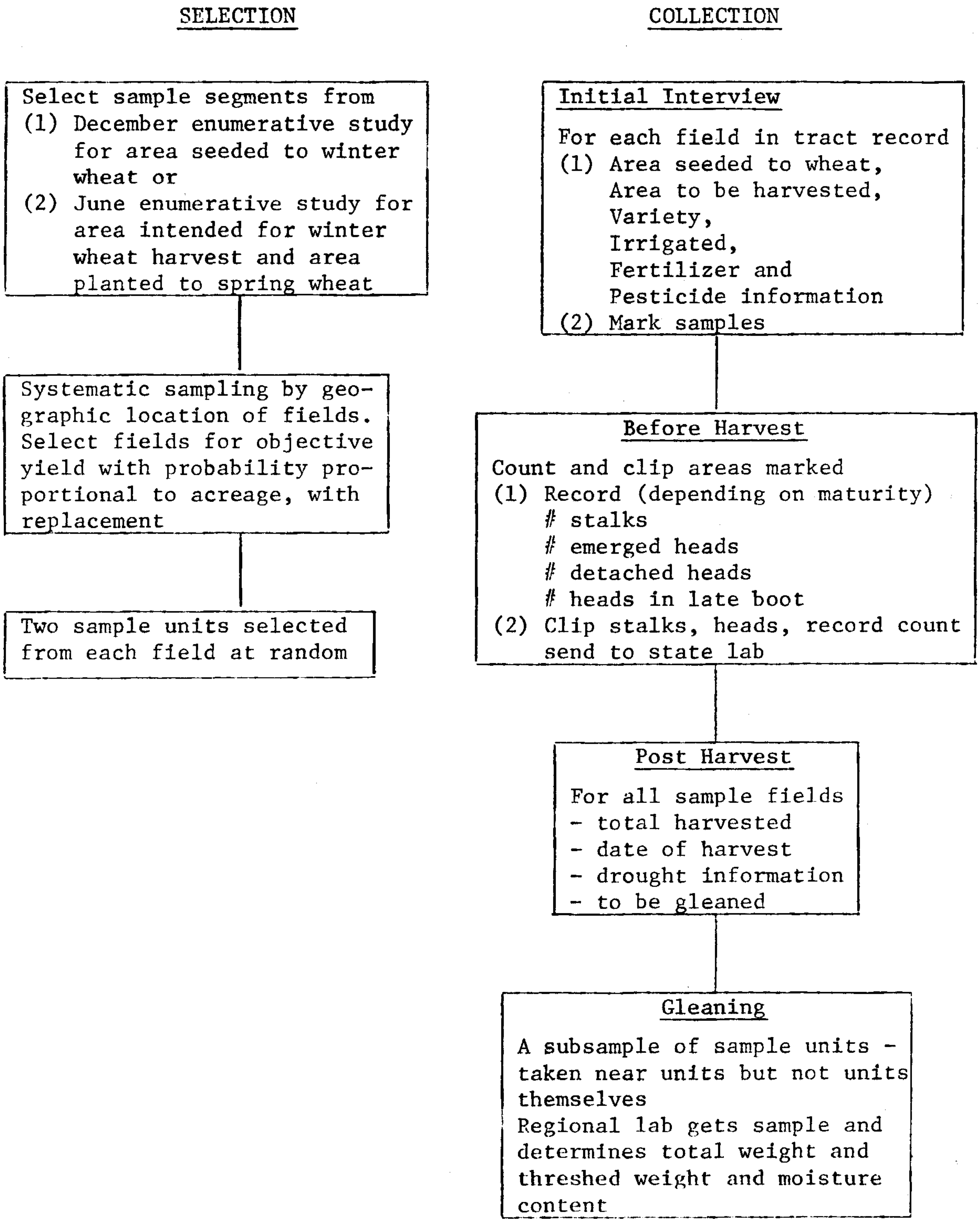


Figure 3-3. Objective yield survey selection of samples and data collection

iii. India

Overview. India's terrain and climate are varied. There are three seasons: cold (November to February), hot (March to June), and rainy (June to October). Heavy rainfall predominates in the northeast and along the western coast; minimal rainfall occurs in the northwest and Rajasthan desert; moderate rainfall of 750-1500 mm (30-60 inches) occurs in the north central and agricultural area of the Indogangetic Plain. Mountains border the north and west and inscribe a triangle in the bottom half of the country. The predominant soil is alluvial and is found in most states and territories.

The main wheat and grain producing area is located in the Indogangetic Plain, the most populated and cultivated area, along with coastal areas and plateaus in the southern half of the country. Fifty percent of the total land area is cultivated. The primary crops are rice and wheat followed by other small grains. Rice and wheat constitute 33 percent and 15 percent, respectively, of the cultivated grain area. Seventy percent of the labor force is in agriculture, with the individual landholdings being less than 2 hectares (5 acres). Technology and irrigation are helping to remedy physical obstacles to agriculture such as drought, floods and poor water holding characteristics of the land.

The Union of India is a federal republic and is structured much like the British and United States governments. The country is divided into 22 states and 9 territories. The states are in theory self-governing, but in practice are highly influenced by the Union. Their governing structures are similar to the Union with elected legislatures and governors appointed by the national president. Legislative responsibilities are divided into three categories with Union subjects, state subjects and the concurrent list of subjects of concern to both the Union and states. Agriculture is a concurrent list subject.

India's economic plans and development have been stated in a series of five year plans. The current plan is for 1974-79, along with a "20 point program." Emphasis is on agricultural production, meeting domestic needs of its massive population, land reform, elimination of foreign aid and maintaining an annual economic growth of 6 percent.

Land reform is an important phase of agricultural development. The main concerns are abolishing bonded labor, establishing land ownership rights for tenant farmers, breaking up large holdings, redistributing land to the landless and establishing land ceilings. The 1976-77 growing seasons have moved India in a positive direction with record grain crops and creation of buffer stocks.

Methods. Collection and distribution of agricultural statistics is under the domain of the Directorate of Economics and Statistics in the Ministry of Food and Agriculture. In all states, except Kerala, Orissa and West Bengal, land use and crop statistics are enumerated on a field to field basis. The three states of Kerala, Orissa and West Bengal obtain statistics on the basis of sample surveys.

Three forecasts are issued annually for wheat detailing: first, planted area and seedling condition; second, expected yield and additional planted area; and third, estimated harvest. Area and yield estimates are used by the Ministry of Food and Agriculture to formulate crop prices and export policies.

Area estimates are obtained from revenue agents in settled areas and primary reporters in temporarily settled areas. Yield estimates are obtained by one of three methods: (1) a percentage method where yield is the product of average yield and a crop condition factor; both are measured subjectively, (2) direct estimation by revenue officers, and (3) random sample crop cutting surveys which are the most prevalent.

On the whole, statistical forecasting in India is characterized by lateness in the reporting of area and production of crops. This may be attributed to the small farm size with a typical farm being two hectares. Usually, villages are taken as segment units and all farms within the village are enumerated. Eliminating complete enumerations of small farms may lead to faster turn around in reporting results but some way of assessing the contribution of the small land units is necessary under the existing landholding practices.

III. Progress

Much of the information received has been of a qualitative nature. This has afforded the opportunity of obtaining an overview of current crop inventory systems and noting some existing limitations. Overall, sufficient information is available in the U.S., Indiana and India to evaluate present reporting methods.

In summary, a global system must provide crop information that is both timely and thorough and also incorporate individual differences between countries of varying geographic and climatological characteristics. These are the major factors which will be focused on in the course of study: timeliness and thoroughness of reports and weather and surface condition.

IV. Plans for Next Quarter

A major thrust for the next quarter will be to focus on quantifying our current qualitative findings. This will be accomplished through meetings with officials of the ERS and SRS of the USDA, representatives of the International Food Policy Research Institute and the Agricultural Attaché from Argentina. Information gathering on the methodologies of Canada and the Soviet Union will be started. Additionally, a description of the goals to be incorporated into a global crop system will be pursued.

V. Cited References

1. Agricultural Research Policy Advisory Committee, "Research to Meet U.S. and World Food Needs," Vol. I and II, Report of a Working Conference held in Kansas City, MO, July 9-11, 1975.

2. Food and Agriculture Organization, "National Grain Policies, 1975," (Rome, Italy), 1976.

3. Statistical Reporting Service, USDA, "Scope and Methods of the SRS," USDA Misc. Publ. 1308, 1975.

4. Shapley, D., "Crops and Climatic Change: USDA's Forecasts Criticized," Science 193:1222-1225, 1976.

VI. Bibliography

a. Global

Agricultural Research Policy Advisory Committee. 1975. Research to meet U.S. and world food needs, Vol. I and II. Report of a Working Conference held in Kansas City, MO. (July 9-11).

Economic Research Service, USDA. 1977. Western hemisphere agricultural situation: review of 1976 and outlook for 1977. For. Agr. Econ. Report #136. 41 pp.

---------------. 1977. World agricultural situation. WAS #14. 43 pp.

Food and Agricultural Organization, United Nations. 1976. National grain policies, 1975. (Rome, Italy.) 271 pp.

---------------. 1974. National methods of collecting agricultural statistics: Asia, Far East, European and North American regions, Vol. I. (Rome, Italy.) 375 pp.

---------------. 1975. National methods of collecting agricultural statistics: African, Latin American and Near East regions, Vol. II. (Rome, Italy.) 234 pp.

---------------. 1948. Program for the 1950 world census of agriculture. (Washington, D.C.) 96 pp.

---------------. 1968. Program for the 1970 world census of agriculture. (Rome, Italy.) 82 pp.

---------------. 1958. Report on the 1950 world census of agriculture, Vol. II, Census Methods. (Rome, Italy.) 168 pp.

---------------. 1966. World crop statistics, area production and yield 1948-1964. 458 pp.

---------------. Estimation of areas in agricultural statistics. (ed., S. S. Zackovich). (Rome, Italy.) 203 pp.

Panse, V. G. 1954. Estimation of crop yields. Food and Agricultural Organization, United Nations. (Rome, Italy.) 61 pp.

b. United States

Dunn, D. M. and J. M. Landwehar. 1976. Graphical displays for analyzing aggregation effects from clustering time periods. Proceedings American Statistical Association. Statistical Computing Section. 6 pp.

Economic Research Service, USDA. 1977. The U.S. cash grain trade in 1974: participants, transactions and information sources. Agricultural Economics Report #386. 73 pp.

---------------. 1977. Wheat situation. WS-242. 31 pp.

Haun, J. R. 1974. Prediction of spring wheat yields from temperature and precipitation data. Agronomy Journal 66:

Heady, E. O. 1975. A world food analysis: grain and export capacity of American agriculture under various production and consumption alternatives. Card Report #60. The Center for Agricultural and Rural Development, Iowa State University. 83 pp.

Houck, J. P. and D. Pearson. 1976. Official production estimates for corn and soybeans: preparation and accuracy. Ag. Ext. Service, Univ. of Minnesota. Bull. #578. 6 pp.

Houseman, E. E. 1975. Area frame sampling in agriculture. Statistical Reporting Service, USDA. SRS #20. 79 pp.

Kirkbride, J. W. 1977. Domestic agricultural information systems. Economic Research Service, USDA. Presented at Workshop on Global Information Systems for Food and Fiber, Purdue University, W. Lafayette, Indiana. 4 pp.

Miller, T. A. 1977. Observations on the 1978 economic evaluation of LACIE. Economic Research Service, USDA. Commodity Economics Division. 40 pp.

Shapley, D. 1976. Crops and climatic change: USDA's forecasts criticized. Science 193:1222-1225.

Statistical Reporting Service, USDA. 1975. Scope and methods of the SRS. USDA Misc. Publ. 1308.

Thomasson, L. 1977. Agricultural information systems in the U.S. World Food and Agriculture Outlook and Situation Board, USDA. Presented at Workshop on Global Information Systems for Food and Fiber, Purdue University, W. Lafayette, Indiana. 16 pp.

Vermeer, J. 1976. A summary of the study: the use of value of foreign wheat production information to USDA programs and activities. The Futures Group, Glastonbury, Connecticut. 13 pp.

c. Indiana

Bureau of Census, U. S. Department of Commerce. 1977. 1974 census of agriculture--Indiana. Vol. 1.

Indiana Department of Commerce. 1970-71. Indiana economic report and forecast. Economic Research Division. 39 pp.

Indiana Crop and Livestock Reporting Service. 1977. Monthly crop statistics--Indiana: Small grain summary 1977. #M77-9. Purdue University, West Lafayette, Indiana.

Indiana Crop and Livestock Reporting Service. 1977. Field crops. Agricultural Experiment Station, Dept. of Agricultural Statistics, Purdue University, West Lafayette, Indiana.

Kreider, L. E. 1972. Indiana economic trends of national policy. State of Indiana Economic Research Division. 28 pp.

State Planning Services Agency. Indiana Facts Book 1976: Planning Information System #1.

d. India

Bureau on Agricultural Statistics, Kerala. Kerala--Collection on agricultural statistics 1976-1977--instructions for field work. 20 pp.

Bureau of Economics and Statistics, Agricultural Division. 1977. Instructions for field staff on area and yield estimation surveys. SGP Govt. Press Trivandrum. 34 pp.

----------------. 1975. Report on the crop cutting survey on winter and summer crop of paddy 1974. SGP Govt. Press. 45 pp.

----------------. 1976. Report on the crop cutting survey on winter and summer crop of paddy 1975. SGP Govt. Press. 51 pp.

----------------. 1977. Report on crop cutting survey on autumn crop of paddy 1976. SGP Govt. Press. 27 pp.

----------------. 1976. Season and crop report for Kerala State 1974-75. SGP Govt. Press, Trivandrum. 89 pp.

Bureau of Economics and Statistics Trivandrum. 1977. Report of the timely reporting survey of agricultural statistics 1975-1976, Kerala State. 48 pp.

Chandraskhar, S. A. 1972. Population growth and agricultural development in India. Journal of the Indian Socity of Agricultural Statistics 25:63-74.

Directorate of Economics and Statistics. Crop forecasts in India. Ministry of Agriculture and Irrigation. 10 pp.

Directorate of National Sample Survey. 1964. Crop estimation surveys (State series). Report on type-2 study on maize in Bihar 1963-64. Agricultural Statistics Division. 19 pp.

-----------------. 1966. Report on type-2 study on Jowar (Kharif) Mysore, 1965-66. Agricultural Statistics Division. 40 pp.

Economics Research Service, USDA. 1973. Agricultural development and employment in India. 109 pp.

National Sample Survey Organization. 1975. Estimation surveys on principal crops, 1971-72. Ministry of Planning, Field Operations Division. 63 pp.

-----------------. 1975. Consolidated results of crop estimation on principal crops 1972-73. Ministry of Planning. 61 pp.

-----------------. 1975. Consolidated results of crop estimation surveys on principal crops 1970-71. Ministry of Planning, Field Observations Division. 60 pp.

Panse, V. G. and P. V. Suktatme. 1957. Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi, India. 361 pp.

Rao, J. N. K. 1971. Some thoughts on the foundations of survey sampling. Journal of the Indian Society of Agricultural Statistics 23(2):69-82.

Rao, V. K. R. V. 1974. New challenges before the Indian agriculture. Journal of Indian Society of Agricultural Statistics 26(1):33-56.

Subramaniam, C. 1971. The story of the green revolution in India. Journal of Indian Society of Agricultural Statistics 23(1):1-10.

e. Argentina

Papadakis, J. 1970. Agricultural research: principles, methodology, suggestions. 88 pp.

f. Canada

Canada Department of Agriculture. 1974. Guide to federal agricultural services. Publ. #1262. 40 pp.

Canada Department of Agriculture. 1974. Winter wheat production in western Canada. Information Division, Ottawa, Canada. 17 pp.

Information Division of Canada. 1970. Organization and activities of the Canada Department of Agriculture. Publ. #1123. Department of Agriculture, Ottawa, Canada.

g. Union of Soviet Socialists Republic

Economic Research Service, USDA. 1977. Agriculture in the U.S. and the Soviet Union. Econ. Report #92. 18 pp.

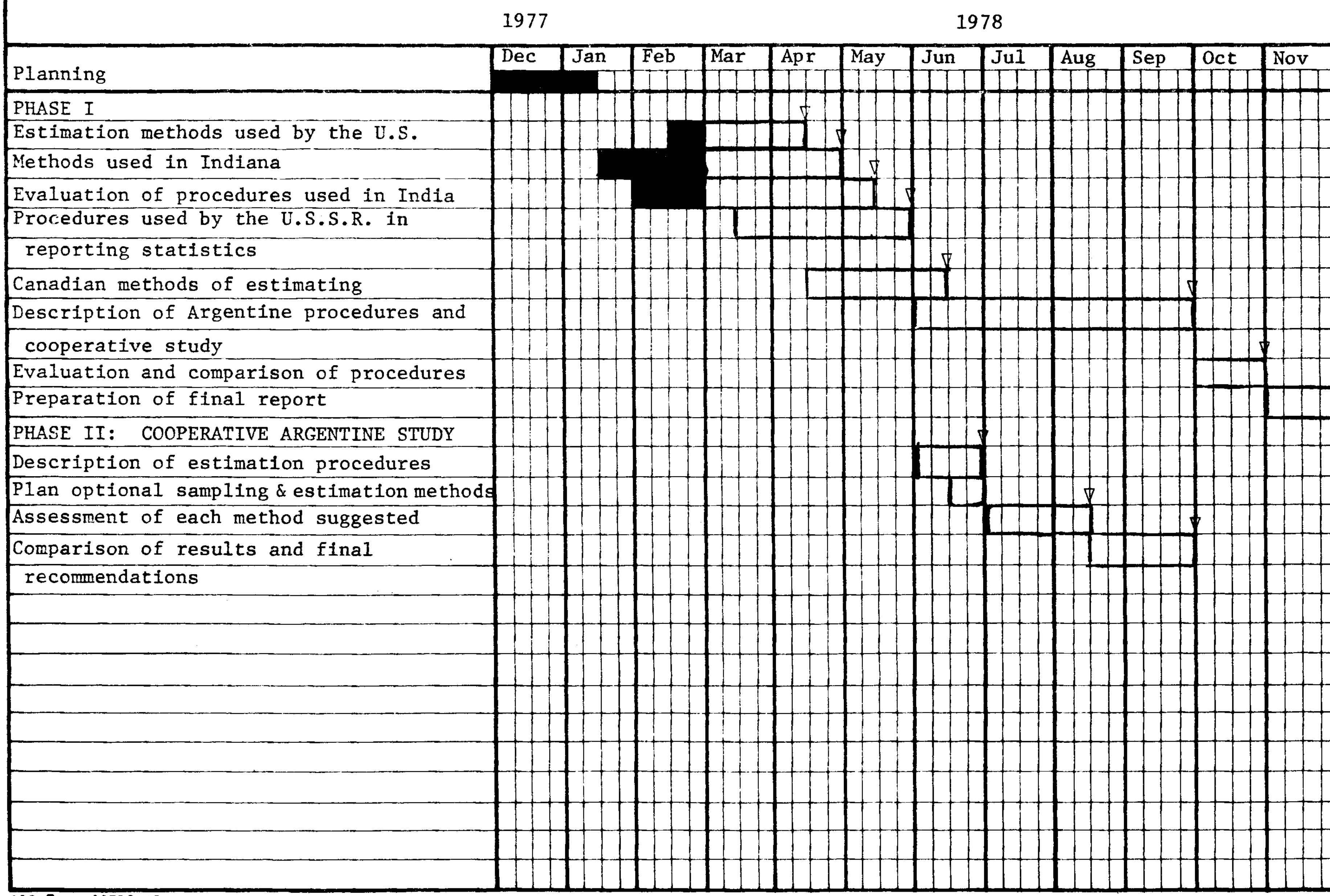
----------------. 1975. Collecting agricultural statistics in the Soviet Union. Econ. Report #112. Report of forecasting project on cooperation in the field of agriculture. 23 pp.

----------------. 1977. USSR agricultural situation review of 1976 and outlook for 1977. Agr. Econ. Report. #132. 47 pp.

Office of Economic Research, CIA. 1975. Research aid--the Soviet grain balance, 1960-73. 34 pp.

Schoonover, D. M. 1976. Agricultural trade implications of the 1976-80 Soviet economic plan. Economic Research Service, USDA. Presented at Annual Meeting of Washington Chapter of the Amer. Assoc. for Advancement of Slavic Studies. 15 pp.

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



2.4 COMPUTER PROCESSING SUPPORT

I. Introduction

a. Background

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 user's location, to data and the 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 January 1980 timeframe. The ERDS system must be designed to support world wide coverage for the multi-crop food and fiber program while allowing the processing freedom 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 development and expansion purposes. 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 for both organizations access to useful resources (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 is being pursued during this contract period.

b. Objective

The objective of this task is to provide to EOD and LARS a shared data processing environment designed for the support of remote sensing technology through a facility including computer and related hardware, software, data, personnel, and procedures.

During this contract period, LARS will continue to support JSC's 2780 terminal while it continues to be used. LARS will provide support to the JSC software conversion and hardware implementation tasks and will provide computer support for the conversion and testing of programs. Subtasks which are to be pursued include:

*Hardware installation

*Software support

*Systems consulting

*Techniques exchange

*Software conversion support

Additional subtasks may be defined and pursued at some future date including:

*CMS/370 support

*LARSYSP1/LARSYS integration

*Statistical package support

*Ancillary LARS Systems capability transfer (LARSYSDV, LARSYSXP, EXOSYS, Registration System, etc.)

*RT&E data base support

*ERDS design and concept testing

II. Subtask Report

During the first quarter, an implementation plan was written and transmitted to JSC. The tasks outlined in that plan were categorized into four general areas, responsibilities were assigned for those areas and the areas were prioritized:

Priority	Area
1	Hardware Installation
2	Software Support
3	Systems Consulting
4	Techniques Exchange

The thrust of the work performed during the quarter was to provide JSC with the hardware, software, and knowledge necessary for greatly expanded usage of the LARS computer by JSC personnel.

In early February, Jim Kast and Terry Phillips journeyed to Houston to make an informal progress report, investigate additional projects and services LARS might provide, review EOD concerns and priorities with respect to this task, and seek direction for future work.

a. Hardware Installation

The objective of this subtask is to provide the computer and related hardware necessary for the support of JSC terminal facilities and users.

i. Work Accomplished

Phone Line. In order to accomodate the Data 100 Batch Terminal at JSC, an order has been placed for a 4-wire, full-duplex, voice grade channel AT&T type 3002, with D1 conditioning. We expect this line to be installed by March 15, 1978. Phone line installation will be necessary for the full support of the JSC tapecopy capability.

IBM 3705 Communications Controller. The addition of six lines to the JSC remote site (five additional keyboard terminals and one Data 100) will exceed the capabilities of the 3705 as presently configured at LARS. To facilitate the installation of the additional lines, parts have been ordered to reconfigure the 3705. Because of the reconfiguration of the 3705, it was also necessary to place orders for additional cables and short-haul modems.

Tape Racks. The expansion of the JSC tape library at LARS exceeds the amount of storage space currently available on the LARS tape racks. To meet the increased demand for storage space, a tape rack has been ordered. The additional tape rack will provide 700 tape storage slots.

ii. Work in Progress

3705 Communications Controller. To support the reconfiguration of the 3705, software modifications are necessary. Modifications will be made to CP, the 3705 Emulator Program, and to RSCS. In addition to the software modifications, it will be necessary to install additional cables and modems.

Data 100 Installation. The test procedures for the installation of the Modem Selection Switching System will be reviewed and comments and/or suggestions will be tendered. The abilities and deficiencies of the RSCS IBM 360/20 emulator program will be reviewed. If the review proves favorable, the modifications necessary to bring the program to the current level of support will be studied.

Disk Space. The major unresolved hardware issue is that of disk space. There currently is not enough space on the 2314 disk drives to meet the increased demand. Some room does remain on the two 3350 disk drives at the Laboratory. The 3350 drives may be accessed only by ID's which use CMS/370 exclusively. The CMS/360 operating system, which most LARS and JSC programs are currently running under, will not support access of the 3350 drives. Both JSC and LARS personnel are looking for solutions to this problem. One solution under consideration is the purchase of several relatively inexpensive 2314 disk packs. This solution would inconvenience users whose disks are not mounted when they log in.

iii. Future Work

A price/performance/feasibility investigation of placing an IBM 3705 Communications Controller at JSC will be undertaken during the next quarter.

This remote device could possibly be connected to LARS via a single high-rate line. Such an arrangement might greatly enhance both data transfer rates between the organizations and give JSC greatly expanded terminal and hardware flexibility. The cost of the high rate line and 3705 and the system's software involved in such an arrangement are possible constraints.

The actual installation of cables, modems, switching mechanisms, phone lines, 3705 parts and tape racks should take place during the next quarter. Additional disk storage and other hardware modifications may be necessary beyond the second quarter.

b. Software Support

The objective of this subtask is to provide the EOD user community with system and other software support, necessary maintenance and implementation of earth resources processing capabilities.

i. Work Accomplished

IMSL Installation. International Mathematical and Statistical Libraries (IMSL), Inc. was contacted concerning the installation of the IMSL library on an IBM 370/148 running VM. The library is not available in CMS tape dump/load format, but is available in card image format which could be used to install the library. IMSL is in a combination of Fortran and IBM Assembler. To implement IMSL, we will need to receive the tape, split the card files into programs, build a TXTLIB and construct supporting EXEC files. Since IMSL will be implemented in CMS/370, disk space should not be a problem. The next step at LARS is to receive the IMSL source tape.

Tape Transfer Software. Data 100 tape drive documentation has been procured and a test tape has been delivered to JSC. A plan for the implementation of a tape transfer capability has been drafted and distributed.

ii. Work in Progress

IMSL. It appears that IMSL can be installed within a short while after the arrival of the library tape. There are no test procedures supplied on the library tape. Testing will be accomplished with the assistance of JSC.

Tape Transfer Software. Programming and testing are in progress on the tapecopy routines which will allow the transfer of specified files from a tape at either site to a tape at the other site. In addition, batch tapecopy operator procedures for JSC Data 100 operators are being developed. More detailed and complex tapecopy capabilities need to be developed to reduce complexity for JSC users and operators.

iii. Future Work

A tapecopy capability must be installed, tested, documented, and knowledge of its use transferred to JSC. After an initial capability is on-line, refined and expanded tapecopy procedures should be developed.

IMSL remains to be received at LARS, implemented and tested. Software to support JSC's Data 100 in 360/20 emulator mode will be investigated, as will the effect such a change would have on the tape transfer software.

Software support for additional conversion or development efforts may be of value. These efforts must first be identified and plans devised, however. Certain candidate conversion or development efforts have been discussed as possibilities:

*Additional statistical package implementations,

*Implementation of Building 30 processing on the LARS computer,

*Development of an integrated EOD-LARS processing system as an ERDS prototype,

*Implementing a registration system useful to both sites.

c. System Consulting

The objective of the systems consulting subtask is to provide assistance in the use of any software facilities available at LARS and to obtain computer resources, preprocessing products or programming support as required for JSC remote terminal users.

i. Work Accomplished

Six new computer ID's were requested and made available, tapes were reassigned to ID's as requested, and a number of computer ID's received increased disk space. One user wanted to be able to determine which port he was using and distribute output accordingly. He was advised to look at the WHERE EXEC routine. An SPSS user with a large data file was unable to complete execution due to filling the largest (25 cyl) temporary disks. The problem appeared to be solved when the output file was placed directly on tape (with the appropriate FILEDEF command).

ii. Problems Encountered

Several requests for increased disk space have not been filled due to a shortage of disk space. The expanded use by an increased number of people at Houston has led to an increase in demand for systems consulting. Part of this increase probably stems from the number of new JSC users with little LARS experience, part from the new equipment (Data 100) which is becoming available, and part directly from the increased usage.

The LARS Computer Operations group has complained about users at JSC who ask the computer operators questions they are not trained to answer or report equipment problems which resulted from improper use of the equipment by the user. In general, JSC user problems should, in most instances, be referred to the JSC site specialists.

The shortage of disk space will continue to be a problem until more disk drives can be obtained. In the interim, both LARS and JSC are assessing the use of their ID's and disk space to locate unused storage. The complaint from the Computer Operations group about the number of questions they receive is being handled in a number of ways. The computer operators have been asked to just tell users they are not trained in CMS (or LARSYS or...) and that the user should see his site specialist. The operator may also call Susan Schwingendorf or Jeanne Etheridge to assist. The course scheduled at JSC this month will also inform a number of users on the structure of LARS Computer Facility and how they can get questions answered.

iii. Work in Progress and Future Work

Purdue/LARS will continue to provide consultants to respond to requests and questions from the JSC remote site specialists about system use and access to computer resources. We will try to make the communications as efficient and effective as possible by encouraging users at JSC to consult their site specialists before calling LARS.

d. Techniques Exchange

The objective of this subtask is to mutually exchange the experience and expertise resident at JSC and LARS. Installation of JSC software on the LARS computer system has created a unique opportunity for both LARS and JSC to share and gain insight and experience related to data processing, data analysis, and software design. In response to this opportunity, the need for a formally administered activity to insure orderly exchange of information was recognized. As a result, initial steps toward development of an ongoing technique interchange were taken during the last contract period. Ogranizational counterparts at LARS and JSC have been established to summarize and share the information needs of their sites.

i. Work Accomplished

During this quarter, the fundamental requirements of this subtask were assessed and plans to meet those needs outlined. Discussions among the organizational counterparts resulted in two short courses being designed and scheduled. The first, presented during this quarter at JSC, covered use of the LARS computer system. The schedule for that course is presented on the succeeding pages. The second, to be presented at LARS by JSC personnel during the first part of the second quarter, will provide an overview and detailed instruction on the use of Procedure 1 algorithms.

ii. Problems Encountered

At this point, the only problems encountered with this subtask are related to the interest, excitement and participation expected in the techniques interchange programs by personnel at both sites. If participation is at the level of current expectations, class sizes may press the upper edge of manageability. A concern of LARS is that exchanging techniques be visualized as a continuous activity in which two-way communication between LARS and JSC would become spontaneous. Maximum efficiency will be realized by both organizations if this goal is realized.

iii. Future Work

Currently, a technique exchange session is planned upon installation of the Data 100, associated phone line and modem, and completion of the tapecopy software. This session will contain instruction for both users and operators. JSC will present LARS with course requirements for this session.

In the remaining three quarters, LARS hopes interest will develop for the specification and scheduling of additional two-three day reciprocal workshops. Potential topics would include details of Procedure 1 Software Design, description and demonstration of algorithms adjunctive to Procedure 1, Procedure 1 subroutine documentation, LARSYS, LARSYSXP and LARSYSDV, description of Field Measurements data and use of EXOSYS, use of the Graphics Compatibility System (GCS), and pre- and post- processing capabilities (LARS and JSC). Judging by the interest

SCHEDULE FOR THE SHORT COURSE ON THE LARS COMPUTER SYSTEM

DAY 1

9:30 I. INTRODUCTION

II. OVERVIEW OF LARS COMPUTER SYSTEM
- A. MACHINE TYPE
- B. STORAGE CAPABILITIES
  - 1. DISK
  - 2. TAPE
- C. OPERATING SYSTEM
- D. AVAILABLE ENVIRONMENTS
- E. VIRTUAL MACHINES

10:30 III. CMS370 EDITOR
- A. COMMANDS
- B. TABSET PROCEDURES
- C. CMS SUBSET

11:30 LUNCH

1:30 IV. OPERATING SYSTEM: CP/CMS370
- A. ASSESSING SYSTEM STATUS
- B. MANIPULATING FILES
- C. RECONFIGURING VIRTUAL MACHINES
- D. OTHER COMMANDS
- E. LARS SUPPLIED COMMANDS
- F. DOCUMENTATION

3:00 BREAK

SCHEDULE FOR THE SHORT COURSE
ON THE LARS COMPUTER SYSTEM
(CONT)

3:15	V.	STATISTICAL PACKAGES UNDER CMS370
		A. DOCUMENTATION
		B. INCREASING SPSS WORKSPACE
		C. USING BMD
		D. USING SSP
		E. OTHER AVAILABLE PROGRAMS
4:00	VI.	OPTIONAL TIME
		A. QUESTION/ANSWER PERIOD
		B. HANDS-ON
		C. DEMONSTRATIONS

DAY 2

8:30	I.	EXECS
		A. PROGRAM EXECUTIVE
		B. UTILITY
		C. EDIT MACROS
		D. ADDITIONAL EXEC WORDS
9:30	BREAK	
9:45	II.	ALGORITHM IMPLEMENTATION
		A. SPECIAL FILETYPES
		B. COMPILER AND DOCUMENTATION
		C. DEBUG
10:30	III.	BATCH MACHINES

SCHEDULE FOR THE SHORT COURSE
ON THE LARS COMPUTER SYSTEM
(CONT)

11:00	IV.	UTILITY FUNCTIONS A. ACCOUNTING AND LABELING B. TAPE MANIPULATION C. RUNTABLE SEARCH
11:45	LUNCH	
1:30	V.	SYSTEM DESIGN CONSIDERATIONS A. SYSTEM DIAGRAM B. SIMPLIFICATION OF USE THROUGH EXECS C. IPL SYSTEMS D. MONITORING PROCESSOR REQUESTS E. UPDATING AND ACCOUNTING F. BATCH
3:30	BREAK	
3:45	VI.	SERVICES A. RESOURCE SUPPORT B. CONSULTING SUPPORT C. PREPROCESSING PRODUCTS D. OUTPUT PRODUCTS
4:15	VII.	OPTIONAL TIME A. QUESTION/ANSWER PERIOD B. HANDS-ON C. DEMONSTRATIONS

SCHEDULE FOR THE SHORT COURSE ON THE LARS COMPUTER SYSTEM (CONT)

DAY 3

8:30 I. OPTIONAL TIME

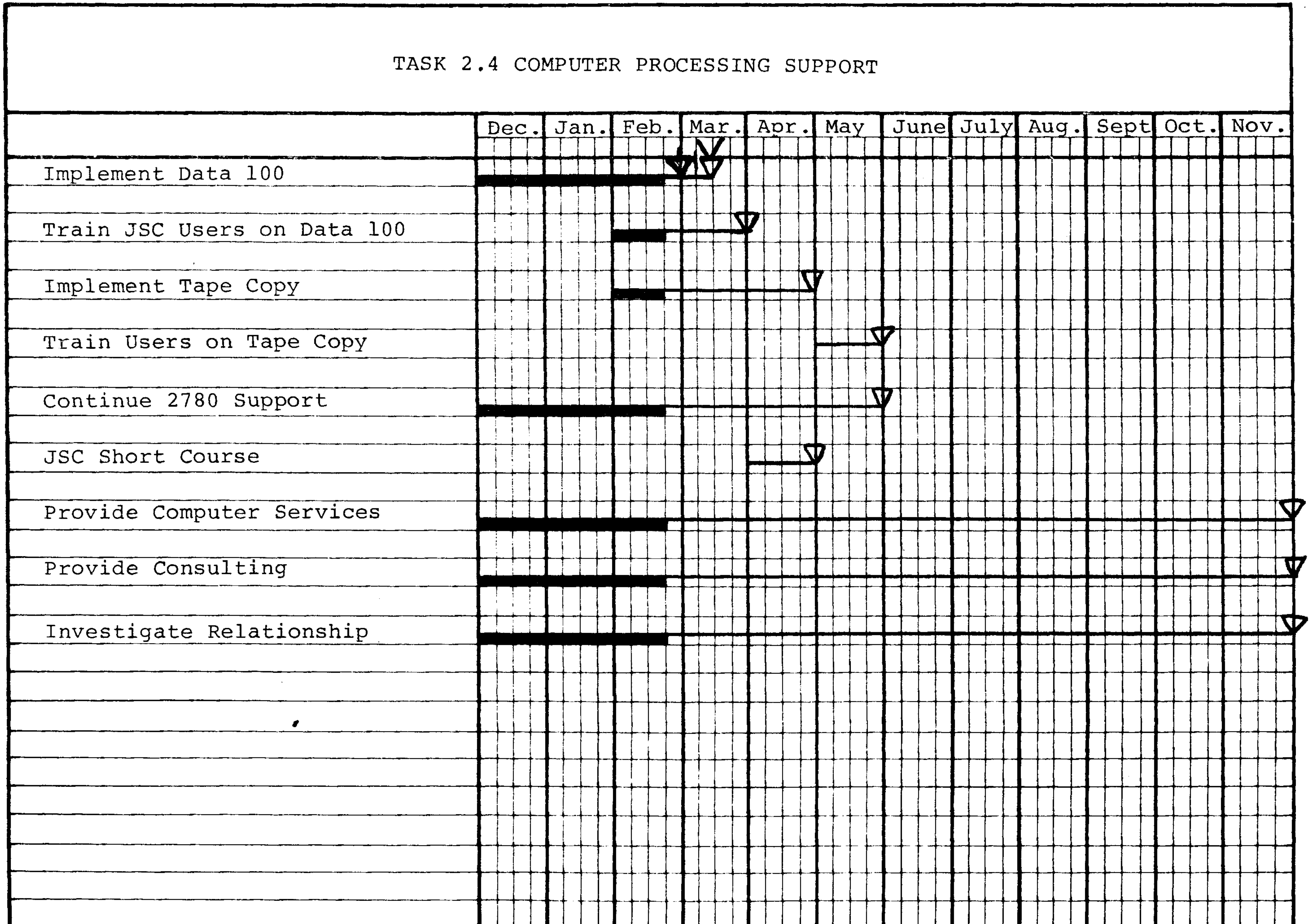
- A. HANDS-ON
- B. DEMONSTRATIONS

12:00 FINISH

generated at both sites for the initial sessions, these exchange sessions have broad appeal. If a marriage of the capabilities developed over the last five years at LARS and JSC is to be consummated, general knowledge of our joint capabilities must be accomplished.

In addition to formal workshops, there seems to be a need for communication among analysts from both sites. This might take several forms. Reciprocal one or two week visits by a small number of analysts or programmers would allow a much more thorough collective understanding of our mutual hardware/software complex. Exchange of monthly newsletters would keep personnel at both sites abreast of revisions, new documentation, and other current news pertinent to their daily activities. The latter should be considered a minimum requirement, similar in importance to the establishment of organizational counterparts. As the needs of each organization are communicated through the organizational counterparts, the needed activities will be specified and pursued.

A final consideration that should be given attention is specification of needed documentation. As outlined in "Technique Interchange Plan - Part II" by J.C. Lindenlaub, several parameters govern this need. It is apparent that we are currently operating under time constraints that do not allow preparation of formal documentation. However, the state of the technology and the potential number of users might suggest the need for some formal documentation. Therefore, a potential future part of this subtask might be the documentation of some portion of our collective hardware/software system. LARS software is certainly a potential for this activity. However, if only on the basis of the already existing material, JSC software might be a better choice for documenting. This issue must be defined shortly if such documentation is to take place in this contractual period.



JSC Form 1958C (Rev Jun 68) NASA-JSC

Technical Reports Issued
During December-February 1978
Funded by Contracts NAS9-14016 and NAS9-14970

110577 The LARSYS Educational Package: Instructor's Notes for Use with the Data 100 by J. C. Lindenlaub and J. D. Russell.

The LARSYS Educational Package is a set of instructional materials developed to train people to analyze remotely sensed multispectral data using LARSYS. A computer software system developed at LARS/Purdue. The materials included in this volume have been designed to assist LARSYS instructors as they guide students through the LARSYS Educational Package. All of the materials have been updated from the previous version (Information Note 110574) to reflect the use of a Data 100 Remote Terminal.

110677 Demonstration of LARSYS on a Data 100 Terminal - Student's Notes by John Lindenlaub and Staff.

This unit provides the student with an introduction to the remote terminal hardware he will be using and introduces him to some aspects of the LARSYS software system. The demonstration requires an instructor to present the material and guide the student. The students notes provides objectives and activities to reinforce the concepts presented.

110777 Data 100 Remote Terminal - A Hands-On Experience - Student's Notes by J. D. Russell.

In this unit the student is instructed in the use of the terminal by means of an audio-tape accompanied by these student notes. Details concerning interactive use of a CRT or typewriter console and a Data 100 Remote Terminal are presented.

011678 Optimum Filter for Minimization of Image Registration Error Variance by C. D. McGillem and M. Svedlow.

The problem discussed is the design of an optimum filter for registration of two images of the same scene. The optimum filter was previously shown to be a matched filter. This report shows that in addition to being optimum in the sense of maximum signal to noise ratio at the match position it also minimizes the variance of the registration error.

030178 Bayesian Classification in a Time-Varying Environment by Philip H. Swain.

This paper deals with the problem of classifying a pattern based on multiple observation made in a time-varying environment. The identity of the pattern may itself change. A Bayesian solution is derived, after which the conditions of the physical situation are invoked to produce a "Cascade" classifier model. Experimental results based on remote sensing data demonstrate the effectiveness of the classifier.