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Houston, Texas 77058

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15. Supplementary Notes

16 Abstract

This report summarizes progress for the current quarter on the three tasks of the subject contract which are:

1. Agricultural Scene Understanding and Supporting Field Research
2. Processing Techniques Development
3. Computer Processing and Data Base Services

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NASA - JSC

Task 1. Agricultural Scene Understanding and Supporting Field Research

A. Experiment Design and Data Analysis

The objectives of this task are (1) to design the Supporting Field Research program, including initial experiments to be conducted in 1979 and longer term experiments to be conducted during 1980-85, and (2) to conduct analyses of field research data on wheat, corn and soybean.

During this quarter, a draft of the project plan for the 1979 field research was completed and submitted to JSC. The plan describes the objectives and experimental approach to be followed in 1979. Secondly, analyses of corn and soybean spectral and agronomic data acquired in 1978 at the Purdue Agronomy Farm were initiated. Thirdly, in support of the data analysis, the documentation of the graphics and analysis system used for analyzing spectrometer and agronomic measurements is being upgraded. This latter activity will assist analysts at JSC, as well as at LARS.

PROJECT PLANNING AND EXPERIMENT DESIGN

Accomplishments this Quarter

- 1979 multicrop supporting field research project plan written and submitted to JSC for review
- Experiments to be conducted at Purdue on winter wheat, corn, and soybean designed

Plans for Next Quarter

- With JSC staff, plan 1980-85 supporting field research program

  Technical objectives
  Experimental approach
  Data requirements
  Data acquisition and preprocessing
  Data analysis
  Schedules, management

Data Analysis

Accomplishments this Quarter

- Analyses of corn and soybean data acquired in 1978 were begun
  - Data review and editing completed
  - Analysis objectives and approach defined
  - Initial analyses performed
- Analysis objectives
  - Temporal trajectory of spectral response and determination of maturity stage from reflectance measurements.
  - Relationship of spectral response to measures of amount of vegetation (LAI, biomass, % cover, etc.).
  - Effect of agronomic treatments (soybean cultivar and row width, corn fertilization) on spectral response.
- Analysis approach
  - Plots of agronomic-spectral measurements as function of date (maturity stage)
  - Regression analysis of relationships
  - Analysis of variance and multiple range tests to determine significant differences among treatments

Plans for Next Quarter

- Continue analysis of data for corn and soybeans

Documentation of Graphics and Analysis Software

In support of data analysis at LARS and JSC, documentation of LARSPEC (formerly called EXOSYS) is being upgraded, including

- complete descriptions of each processor
- control card dictionary
- user manual with example control card decks and output
- additional meterials for training and analyst

Accomplishments this Quarter

- Control card dictionary describing syntax, default parameters, and options available completed for DSEL and IDLIST

Plans for Next Quarter

- Control dictionary will be completed for GSPEC, descriptions of processors and user manual will be written

MULTICROP FIELD RESEARCH PROJECT PLAN, 1979

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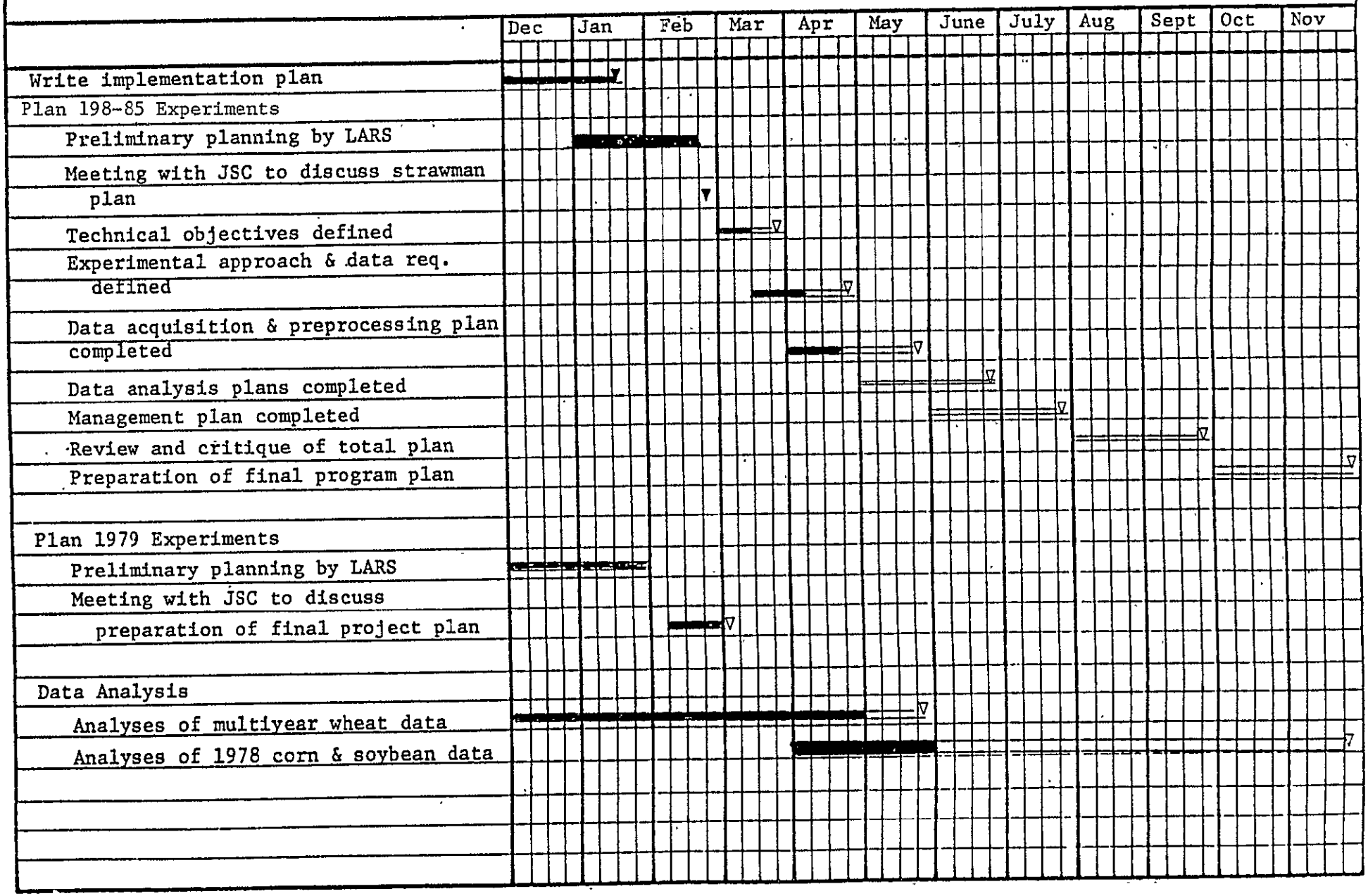
Implementation Schedule for Task 1A, Experiment Design and Data Analysis



1B. Field Research Data Acquisition and Preprocessing

The objectives of this task are to acquire and preprocess the data required to accomplish the objectives of the Multicrop Supporting Field Research project. The key accomplishments this quarter were the completion of the 1978 Exotech 20C processing and the preparation of the plots for the corn and soybean experiments to be conducted at the Purdue Agronomy Farm. Data collection at the Agronomy Farm on winter wheat experiments has begun with both the Exotech 20C field spectrometer system and the Exotech 100 field radiometer system.

During the next quarter the data collection on experiments at the Purdue Agronomy Farm will continue, preprocessing of 1979 data will begin, and 1978 Exotech 100 radiometer data preprocessing will be completed.

Accomplishments This Quarter

Processing of the 1978 Exotech 20C field spectrometer data collected at the Purdue Agronomy Farm was completed.

Processing of six dates of the 1978 Exotech 100 field radiometer data were completed.

Data collection began at the Purdue Agronomy farm for two experiments (5/1, 5/6, 5/16).

Field reflectance standards were prepared and calibrated.

Plots were prepared and planted for five corn and soybean experiments.

Spectral Measurements

Stress Experiments (nutrition, moisture, disease)

- Exotech 20C field spectrometer system
  - Bidirectional reflectance factor (0.4-2.4μm)
  - Radiant temperature
  - Color photographs

Cultural Practices Experiments

- Exotech 100 field radiometer system
  - Bidirectional reflectance factor (Landsat MSS spectral bands)
  - Radiant temperature
  - Color photographs

Each experiment will be measured at approximately weekly intervals from planting to maturity.

Agronomic Measurements

Crop Development Stage

Amount of Vegetation

- Plant height
- Percent soil cover
- Number of plants per square meter
- Number of leaves per plant
- Leaf area index
- Total fresh and dry biomass (g/m^2)
- Dry biomass of leaves, stems, and heads, ears or pods (g/m^2)

Crop Condition

- Percent leaves green, yellow, and brown
- Plant water content (g/m^2)
- Presence and severity of stress

Soil Background Condition

- Percent moisture
- Munsell color
- Roughness

Additional data for specific experiments

- Leaf nitrogen and chlorophyll concentrations (wheat and corn nitrogen fertilizer experiments)
- Leaf water potential (moisture stress experiments)
- Leaf blight infection levels (corn blight experiment)

Photography

- Overhead and ground level views of canopies

Grain Yield

Meteorological Measurements

On days spectral data are collected (continuosly)

- Total irradiance
- Termperature
- Relative humidity
- Barometric pressure
- Wind speed and direction
- Percent cloud cover and type

Daily, hourly records from Purdue Agronomy Farm Weather Station

Air temperature, relative humidity, precipitation, pan evaporation, dew, dew point, wind speed, solar radiation, net radiation

6. Corn and Soybeans: Moisture Stress

   3 Moisture levels

7. Corn: Soil Background

   2 Surface moisture levels (moist and dry)

   2 Surface tillage conditions (rough and smooth)

   2 Replications

Summary of Supporting Field Research Experiments
Purdue Agronomy Farm, 1979

1. Winter Wheat: Nitrogen Fertilization and Disease
   - 3 cultivars
   - 3 Nitrogen fertilizer rates (0, 60, and 120 kg/ha)
   - 3 Replications

2. Corn: Cultural Practices
   - 3 Planting Dates (May 2, 16, and 30)
   - 3 Plant populations (25, 50, and 75 thousand plants/ha)
   - 2 Soil types (Chalmers-dark and Fincastle-light)
   - 2 Replications

3. Soybeans: Cultural Practices
   - 3 Planting dates (May 10, 24 and June 7)
   - 2 Cultivars (Amsoy-narrow, group II maturity and Williams-bushy, group III maturity)
   - 2 Soil types (Chalmers-dark and Fincastle-light)
   - 2 Replications

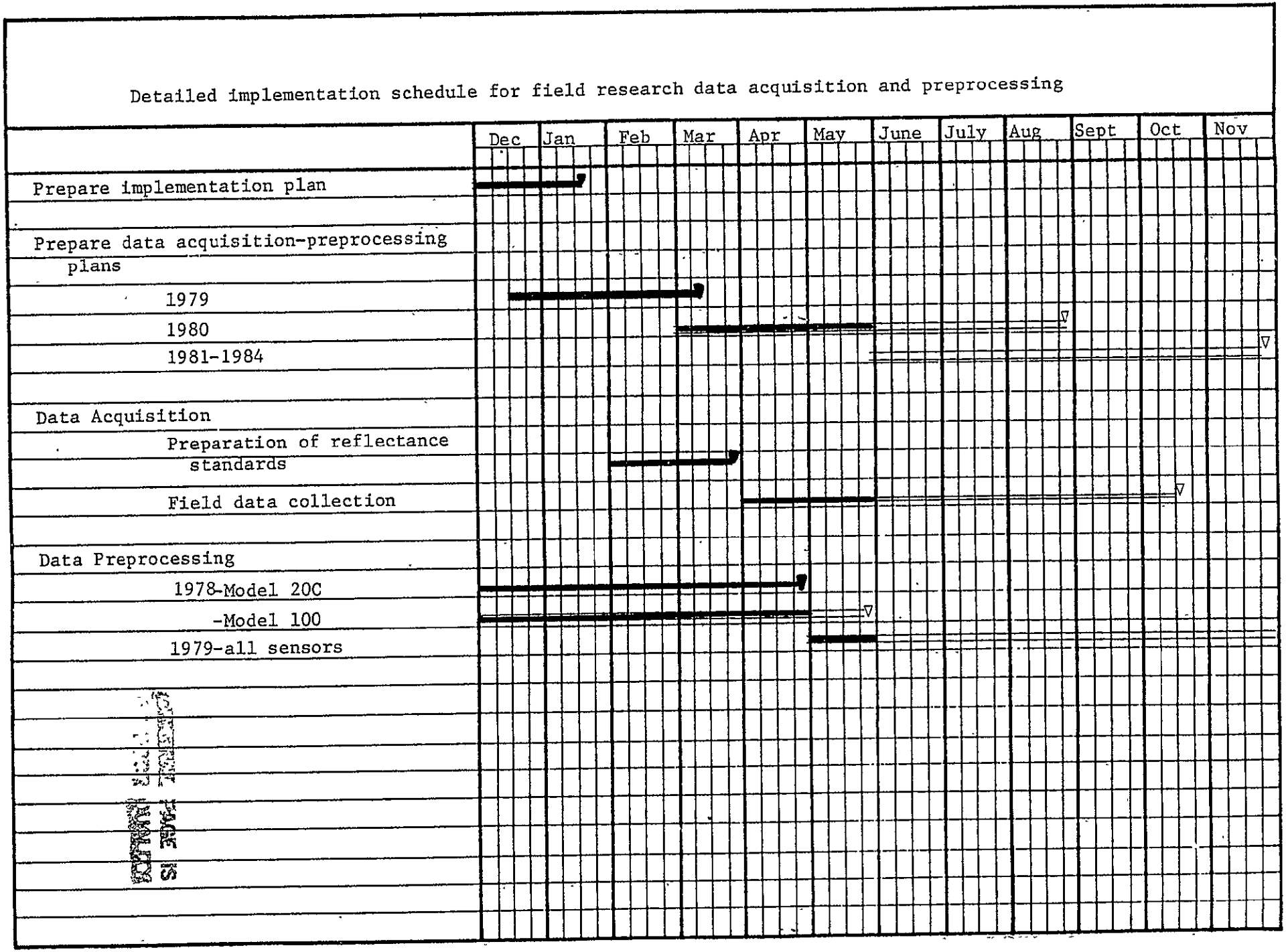
4. Corn: Nitrogen Fertilization
   - 4 Nitrogen fertilizer rates (0, 67, 134, 202 kg/ha)
   - 3 Replications

5. Corn: Disease (Leaf Blight)
   - 3 Leaf Blight Treatments (None-resistant, early and late infection)
   - 2 Hybrids (Pioneer 3545 and DeKalb XL43)
   - 2 Replications

Plans For Next Quarter

- The 1978 Exotech 100 Data Processing will be completed
- The 1979 data collection at the Purdue University Agronomy Farm will continue with both the Exotech 20C and Exotech 100 field systems
- Processing will begin on the 1979 data collected at the Purdue University Agronomy Farm

Figure 1.



1C. Development of Multiband Radiometer System

The overall objective of this task is to develop a multiband radiometer system for agricultural field research. The system is to be low-cost, simple to operate, and adaptable to a wide variety of platforms. The following pages contain the material presented in the oral briefing for this quarterly report.

Figures 2.1C-1 and 2.1C-2 summarize the objectives for this task.

Figure 2.1C-3 lists the accomplishments in this quarter. The major accomplishment of the quarter was the issuance of the Requests for Quotation for the Multiband Radiometer and Data Acquisition System on May 3, 1979 by Purdue University.

Figures 2.1C-4 through 7 specify the format of vendor proposals and list the deliverable items.

Figure 2.1C-8 summarizes the status of the subtasks.

Figure 2.1C-9 indicates the plans for next quarter.

TASK 2.1C DEVELOPMENT OF MULTIBAND RADIOMETER SYSTEM

OBJECTIVE:

DEVELOP A MULTIBAND RADIOMETER SYSTEM FOR AGRICULTURAL FIELD RESEARCH. THE SYSTEM IS TO BE LOW-COST, SIMPLE TO OPERATE, AND ADAPTABLE TO A VARIETY OF PLATFORMS.

Specific Objectives

- Specify, develop and test
  - A prototype multiband radiometer
  - A prototype data acquisition system

- Prepare a System Manual including
  - Description of system
  - Operating instructions
  - Data handling instructions
  - Inspection, test, maintenance and calibration procedures

- Prepare a manual describing the use of the instrument in agricultural remote sensing experiments

- Develop software for entry, storage, use and presentation of multiband data in concert with agronomic, meteorological, and ancillary data.

Accomplishments for the Quarter

Consultant Reports

- Gene D. Nutter, Assistant Director
  Instrumentation Systems Center
  University of Wisconsin - Madison

- Sy Coleman, President
  Bartlett Systems, Inc.
  Woody Creek, Colorado

- Preparation and Issuance of Requests for Quotation of Multiband Radiometer and Data Acquisition System
  - In concert with technical monitor
  - 15 vendors primarily for radiometer
  - 8 vendors primarily for D.A.S.

- Detailed outline of multiband radiometer system manual

- Preliminary outline of Field Measurements Experiment Design Manual

- Design begun for mounting hardware
  - First task: A pick-up truck mounted boom

- Initial version of software for reformatting of multiband radiometer data was completed and tested.

Requested Proposal Organization - Radiometer

1. Introduction and Summary

2. Description of Proposed Instrument
   - 2.1 Main Frame
   - 2.2 Channel Design 0.4 - 1.0 micrometers
   - 2.3 Channel Design 1.0 - 2.35 micrometers
   - 2.4 Channel Design 10.4 - 12.5 micrometers
   - 2.5 Field Standaridzation Source Design

3. Special Topics
   - 3.1 Radiometric Transfer Function
   - 3.2 Operating Ranges - Controls and Procedures
   - 3.3 Radiant Referencing for the Thermal Channel
   - 3.4 Alignment/Interchangeability
   - 3.5 Volume Production Suitability
   - 3.6 Power Dissipation and Battery Life

4. Test Plan

5. Price
   - 5.1 Main Frame, Field Standaridzation Source, Batteries, Charger, Shipping Container
   - 5.2 Channel 0.4 - 2.0 micrometers
   - 5.3 Channel 1.0 - 2.4 micrometers
   - 5.4 Channel 10.4 - 12.5 micrometers
   - 5.5 Repair Labor Rates
   - 5.6 Test Program

ITEMS TO BE DELIVERED

THE VENDOR OF THE MULTIBAND RADIOMETER SHALL DELIVER THE FOLLOWING ITEMS TO THE UNIVERSITY AS DESCRIBED IN PART I OF THE SPECIFICATIONS:

1. A MULTIBAND RADIOMETER WITH RECHARGEABLE BATTERY PACK.
2. ONE (1) EXTRA RECHARGEABLE BATTERY PACK FOR THE RADIOMETER.
3. ONE BATTERY CHARGER
4. CABLES - 10 METER AND 1.2 METER TO CONNECT TO LOGGER.
5. DOCUMENTATION.

THE VENDOR OF THE FIELD STANDARDIZATION UNIT SHALL DELIVER THE FOLLOWING ITEMS TO THE UNIVERSITY AS DESCRIBED IN PART I OF THE SPECIFICATIONS.

1. A FIELD STANDARDIZATION SOURCE.
2. A POWER SUPPLY FOR THE FIELD STANDARIDZATION SOURCE.
3. DOCUMENTATION.

Requested Proposal Organization - DH-DR/PM

1. Introduction and Summary

2. Description of the Proposed Instrument
   - 2.1 Analog Section and Multiplexer Design
   - 2.2 A/D Converter Design
   - 2.3 Data Memory Design
   - 2.4 Microprocessor Design
   - 2.5 Control Panel Design
   - 2.6 Data Interface Design
   - 2.7 Main Frame Design

3. Special Topics
   - 3.1 Microprocessor Software Description
   - 3.2 Maintenance Schedule
   - 3.3 Recommended Spare Parts
   - 3.4 Environmental Design
   - 3.5 Volume Production Suitability
   - 3.6 Power Dissipation and Battery Life

4. Test Plan

5. Price
   - 5.1 Instrument, Charger, Batteries, Data Memories, Shipping Container
   - 5.2 Repair Labor Rates
   - 5.3 Test Program

ITEMS TO BE DELIVERED

THE VENDOR OF THE DATA HANDLING-DATA RECORDING/PLAYBACK MODULE SHALL DELIVER THE FOLLOWING ITEMS TO THE UNIVERSITY AS DESCRIBED IN PART II OF THE SPECIFICATIONS.

1. ONE (1) DH-DR/PM WITH RECHARGEABLE BATTERY PACK.
2. ONE EXTRA DATA MEMORY FOR DH-DR/PM.
3. ONE (1) EXTRA RECHARGEABLE BATTERY PACK FOR THE DH-DR/PM.
4. ONE PLUG TO CONNECT TO EXTERNAL POWER CONNECTOR.
5. ONE BATTERY CHARGER.
6. CONTROL CABLE FOR REMOTE PUSHBUTTON.
7. DOCUMENTATION

STATUS

- VENDOR RESPONSES ARE DUE JUNE 15, 1979
- DRAFTS OF DOCUMENTATION HAVE BEGUN
- THE SOFTWARE FOR REFORMATTING IS COMPLETED AND SOFTWARE FOR ENTRY OF DATA FROM THE LOGGER WILL BE BEGUN

PLANS FOR THIRD QUARTER

Prototype Radiometer and Logger

- Select vendor
- Prepare and issue purchase order
- Prepare preliminary design report
- First draft of system manual

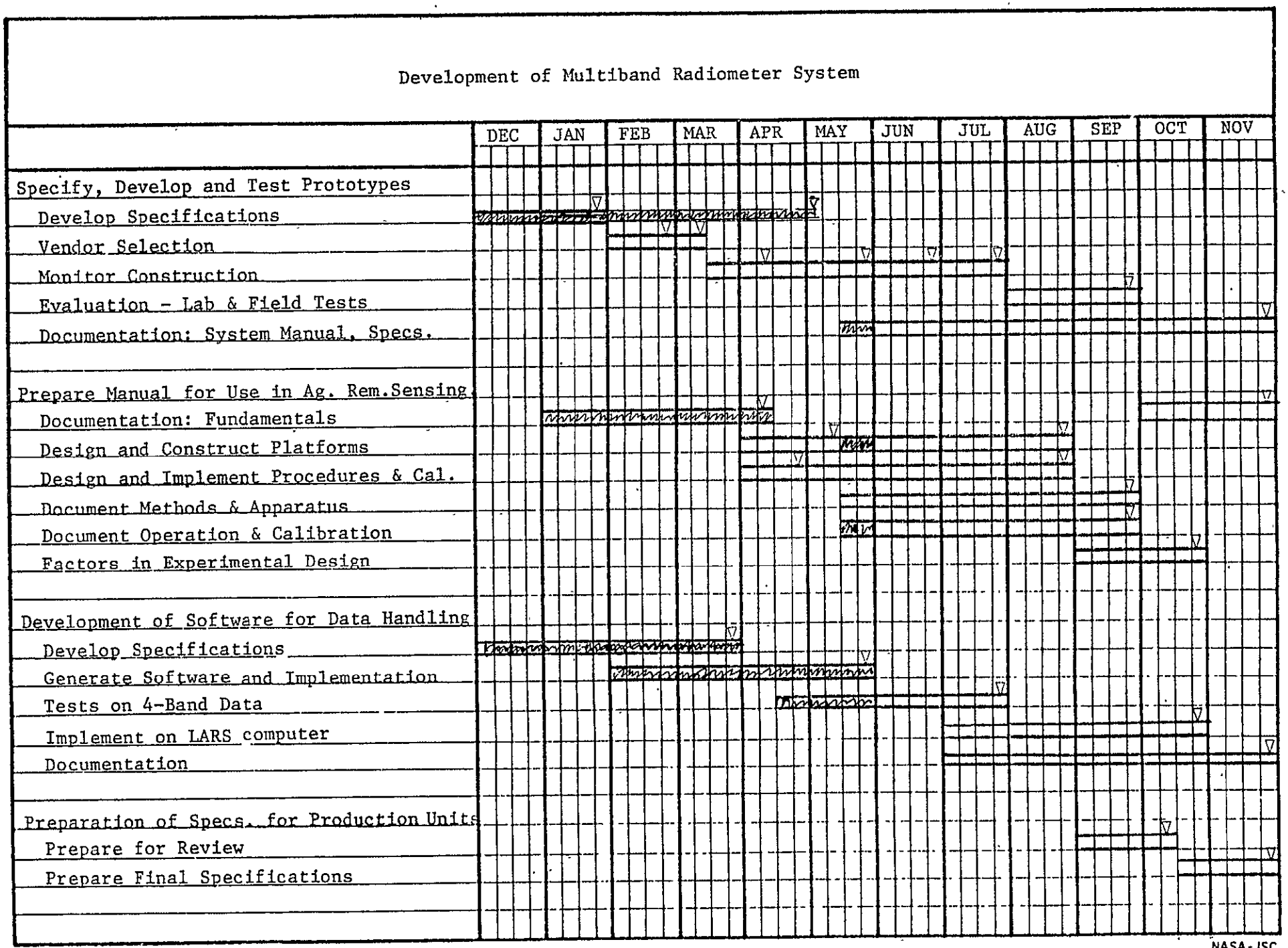
Field Measurements Experiment Design Manual

- Further work on fundamentals section
- Completion and testing of boom - draft documentation
- Field testing of procedures and calibration with draft documentation

Development of Software for Data Handling

- Continued tests of software system with 4 band data
- Design of data entry procedures - software begun

B. Detailed Implementation Schedule



JSC Form 1858C (Rev Jun 86)

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1D. Soils Data Base

A. Work Accomplished During the Reporting Period

Data base coding continued during this quarter, with over two-thirds of the 480 iron oxide analysis results being entered into the computer soils record. About one-third of the soil samples remain to be analyzed for iron oxide content and work is continuing towards completion of this final phase of laboratory soil analysis during the next quarter.

A format for the proposed Atlas of Soil Spectra was developed (Figure 1-D). The very large quantity of data that has been stored in the soils data base for each soil (100 items of information) has been reduced to include essential soil parameters that may be helpful in understanding the reflectance properties of that soil. Four Benchmark soils are displayed on each sheet, and each soil series contains chemical, physical, spectral and site information specific for one of two duplicate soil samples taken in the field. Following the soil series name in large letters is the state abbreviation. This is followed by the soil taxonomic name at the family level, according to the U.S. Soil Taxonomy. Climatic moisture zone, parent material, and county where sampled follow. Then for each of the two duplicate samples these items are listed: soil horizon sampled, slope class, internal drainage, textural class name, percent sand, silt, and clay, moist and dry Munsell colors, percent organic matter, cation exchange capacity, iron oxide content (%), and moisture percentage by weight (MW%). The corresponding spectral curves are displayed as a plot of bidirectional reflectance factor (BRF%) versus wavelength from about 0.52-2.32 μm.

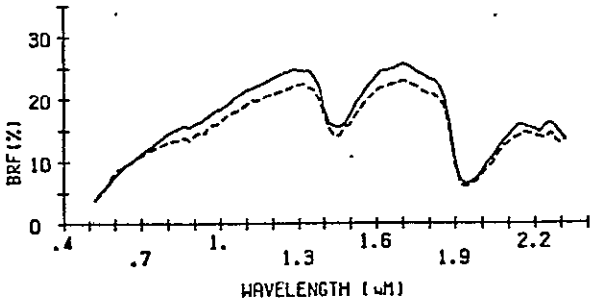
Graphic display of duplicate soil curves has been completed for all 242 Benchmark soil series, and work is in progress to transfer the remaining chemical, physical and site information from the soils header record to the

RED BAY(AL)

Rhodic Paleudult, fine-loamy, siliceous, thermic
humid zone
marine sediments
Houston Co.

____	____
Ap horizon	Ap horizon
B slope	B slope
well drained	well drained
loamy sand	sandy loam
83%S 7%Si 10%C	76%S 11%Si 13%C
5YR 3/4 (moist)	5YR 3/4 (moist)
(dry)	(dry)
0.58% O.M.	0.91% O.M.
10.8 meq/100g CEC	7.1 meq/100g CEC
0.80% Fe_2O_3	1.32% Fe_2O_3

12.8 MW%·____ 15.2 MW%·----

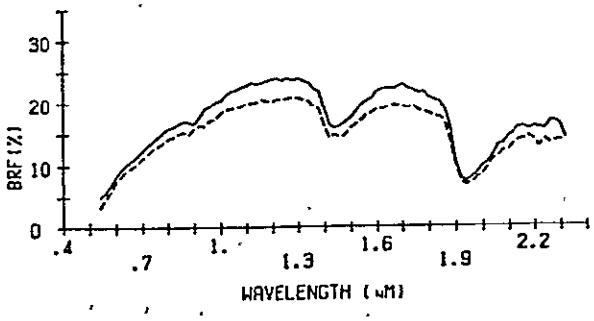


CONTINENTAL(AZ)

Typic Haplargid, fine, mixed, thermic
arid zone
acid rock alluvium
Santa Cruz Co.

____	____
All horizon	All horizon
A slope	A slope
well drained	well drained
c. sandy loam	f. sandy loam
70%S 20%Si 9%C	53%S 35%Si 11%C
5YR 3/4 (moist)	5YR 3/3 (moist)
(dry)	(dry)
0.48% O.M.	0.71% O.M.
6.0 meq/100g CEC	15.7 meq/100g CEC
% Fe_2O_3	% Fe_2O_3

12.6 MW%·____ 17.2 MW%·----

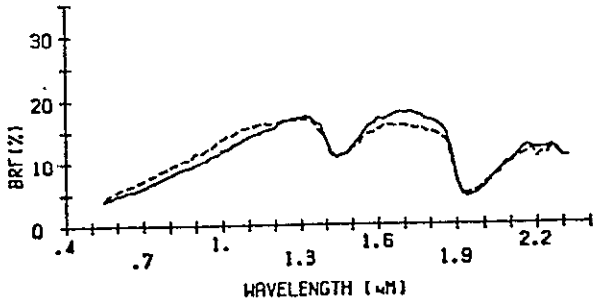


PIMA(AZ)

Cumulic Haplustoll, fine-silty, mixed, thermic
arid zone
mixed alluvium
Santa Cruz Co.

____	____
Ap horizon	Ap horizon
A slope	A slope
well drained	well drained
silty clay	silty clay loam
8%S 48%Si 44%C	9%S 52%Si 39%C
7.5YR 3/2 (moist)	7.5YR 3/2 (moist)
(dry)	(dry)
3.66% O.M.	1.86% O.M.
52.6 meq/100g CEC	44.8 meq/100g CEC
0.94% Fe_2O_3	1.25% Fe_2O_3

50.9 MW%·____ 55.9 MW%·----



WHITE HOUSE(AZ)

Ustollic Haplargid, fine, mixed, thermic
arid zone
mixed alluvium
Santa Cruz Co.

____	____
Al horizon	Al horizon
A slope	B slope
well drained	well drained
f. sandy loam	sandy loam
52%S 34%Si 14%C	62%S 26%Si 12%C
5YR 3/3 (moist)	5YR 3/3 (moist)
(dry)	(dry)
1.68% O.M.	1.70% O.M.
15.7 meq/100g CEC	10.6 meq/100g CEC
1.84% Fe_2O_3	1.85% Fe_2O_3

21.8 MW%·____ 18.8 MW%·----

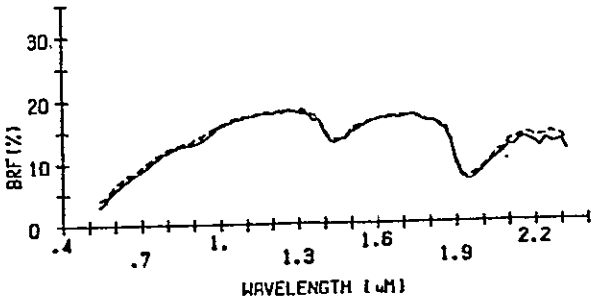


Figure 1-D. Example of sheet from proposed Atlas of Soil Spectra.

format shown in Figure 1-D. The Purdue University Agriculture Experiment Station has agreed to publish this Atlas of Soil Spectra as a research bulletin after appropriate clearance is received from the contractor.

B. Statistical Correlation Studies

For the purpose of statistical correlation all soil spectral curves were represented by ten spectral bands (Table 1-D). Bands 1-8 all have bandwidths of 0.1 μm. Bands 1 and 2 are visible bands. Bands 2 and 4 are centered on the regions of known ferric iron absorption. Most of bands 1-8 resemble, but may not coincide exactly with existing bands on Landsat or Skylab S192. Bands 9 and 10 are proposed Thematic Mapper bands with band 10 being slightly altered by the cutoff of spectroradiometric data at 2.32 μm.

Table 1-D. Soil Spectral Bands for Correlation Analysis

Band	Wavelength (μm)	Band	Wavelength (μm)
1	0.52-0.62	6	1.02-1.12
2	0.62-0.72	7	1.12-1.22
3	0.72-0.82	8	1.22-1.32
4	0.82-0.92	9	1.55-1.75
5	0.92-1.02	10	2.08-2.32

Scattergrams of reflectance versus important laboratory-measured soil parameters for specific bands are shown in Figure 2-D. These scattergrams contain all data points for all Benchmark soils within the ranges of the soil parameters exhibited. The best overall band correlating with organic matter is band 1 in the visible. A definite curvilinear relationship can be seen between organic matter and reflectance. Band 10 in the middle infrared correlates most highly with water content, clay content, and cation exchange capacity.

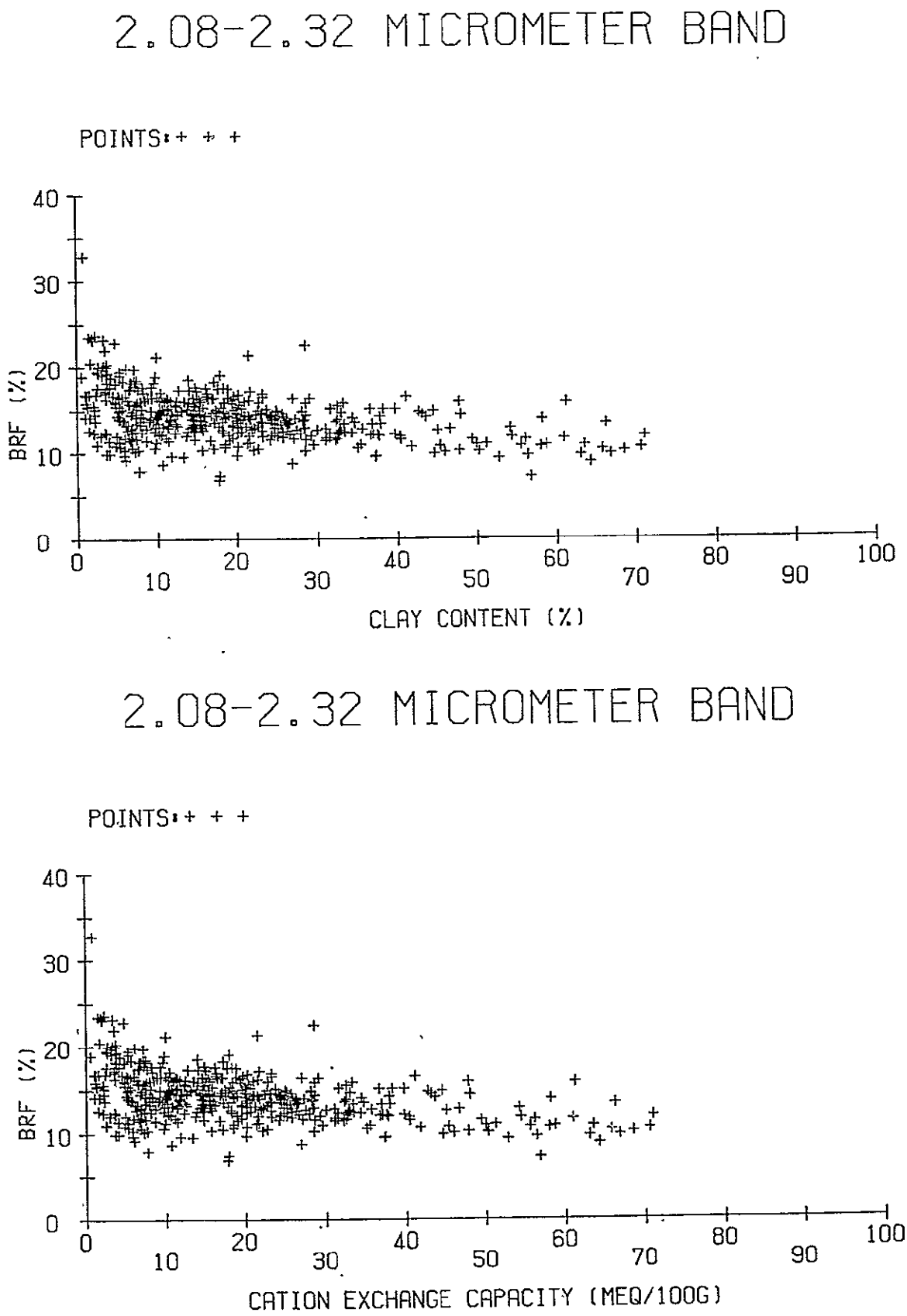
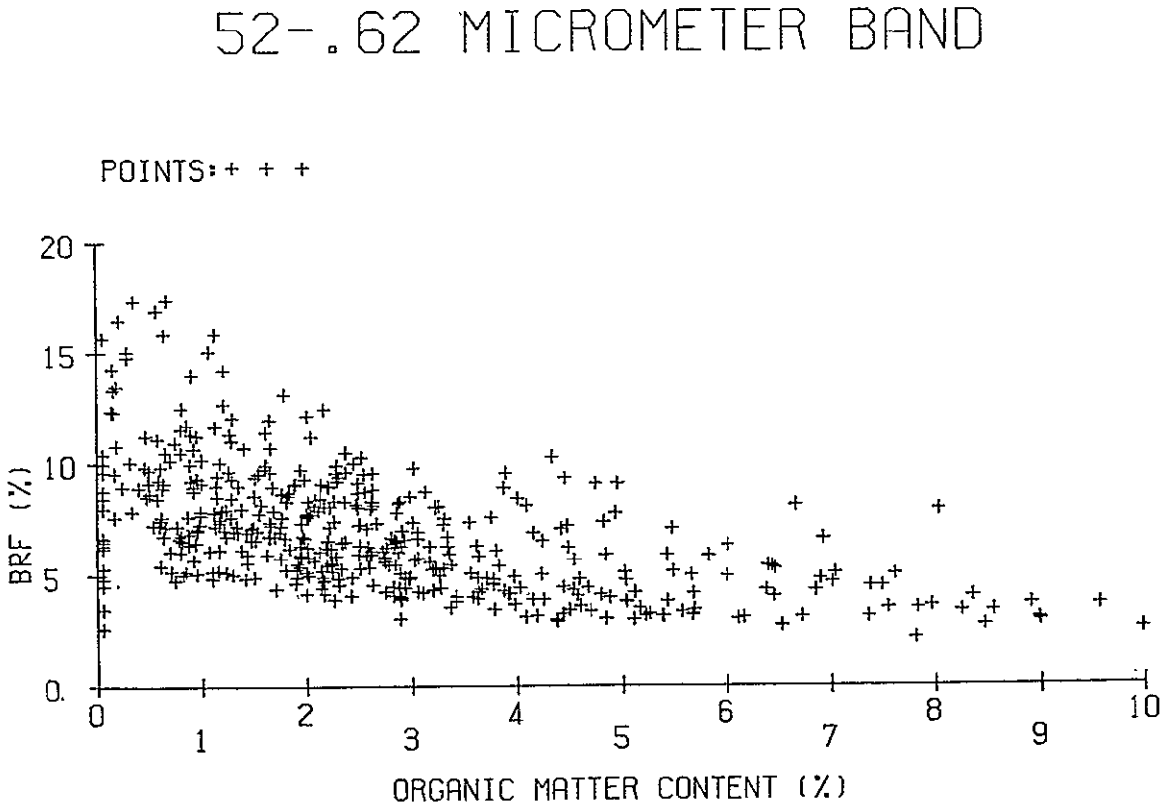


Figure 2-D. Scattergrams of reflectance in band 1 vs. organic matter, and in band 10 vs. moisture percentage by weight, clay content, and cation exchange capacity.



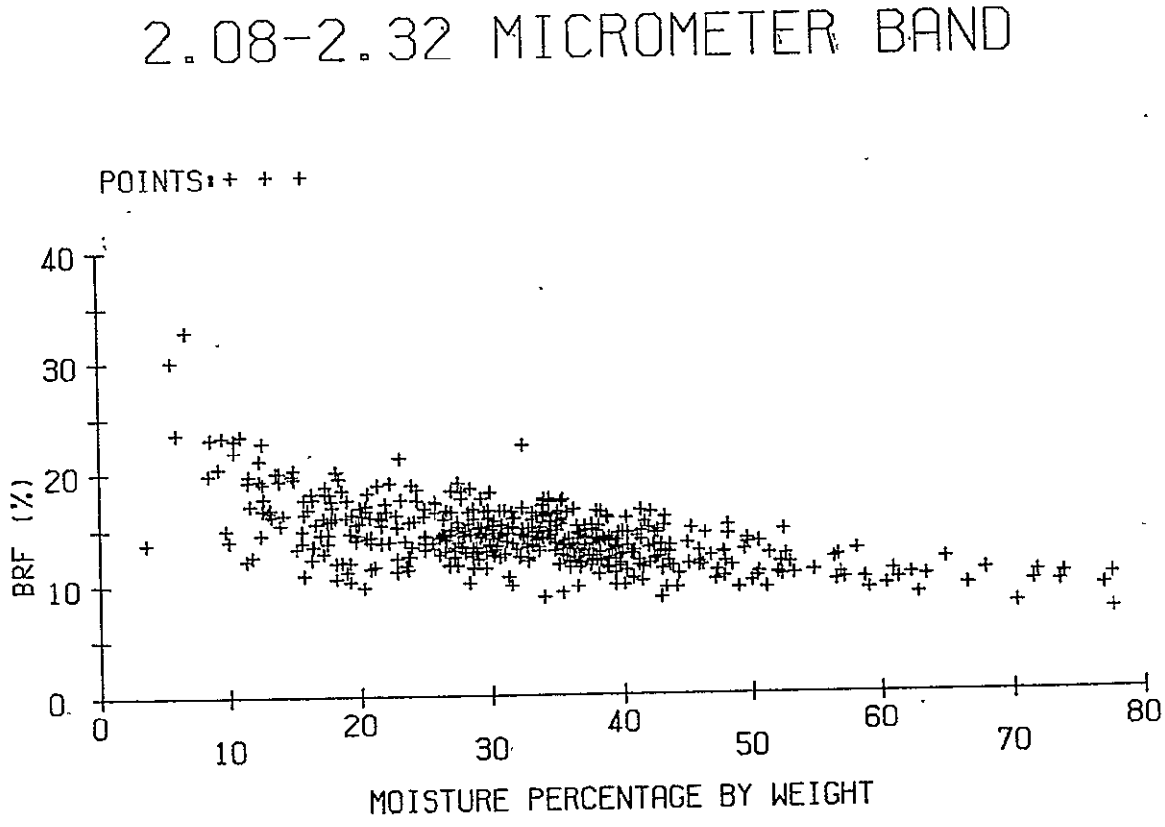


Figure 2-D. (Continued).

Correlation coefficients between these four soil parameters and spectral bands can be seen in Tables 2-D and 3-D. A natural logarithmic transformation of organic matter values resulted in generally improved correlations because of the previously mentioned curvilinear relationship. Improved correlation is seen to occur in most cases as the climatic region in which the soils occur becomes more specific. Whereas some specific climatic zones do not show improved correlations from the more general climatic regions, most of the specific climatic zones show much improved correlations. These results are an indication of the extent to which spectral data can be used to predict certain soil properties within known climatic regions.

C. Plans for Next Reporting Period

Statistical analysis will be completed as results from iron oxide determinations become available. Completion of the Atlas of Soil Spectra is anticipated at the end of the period.

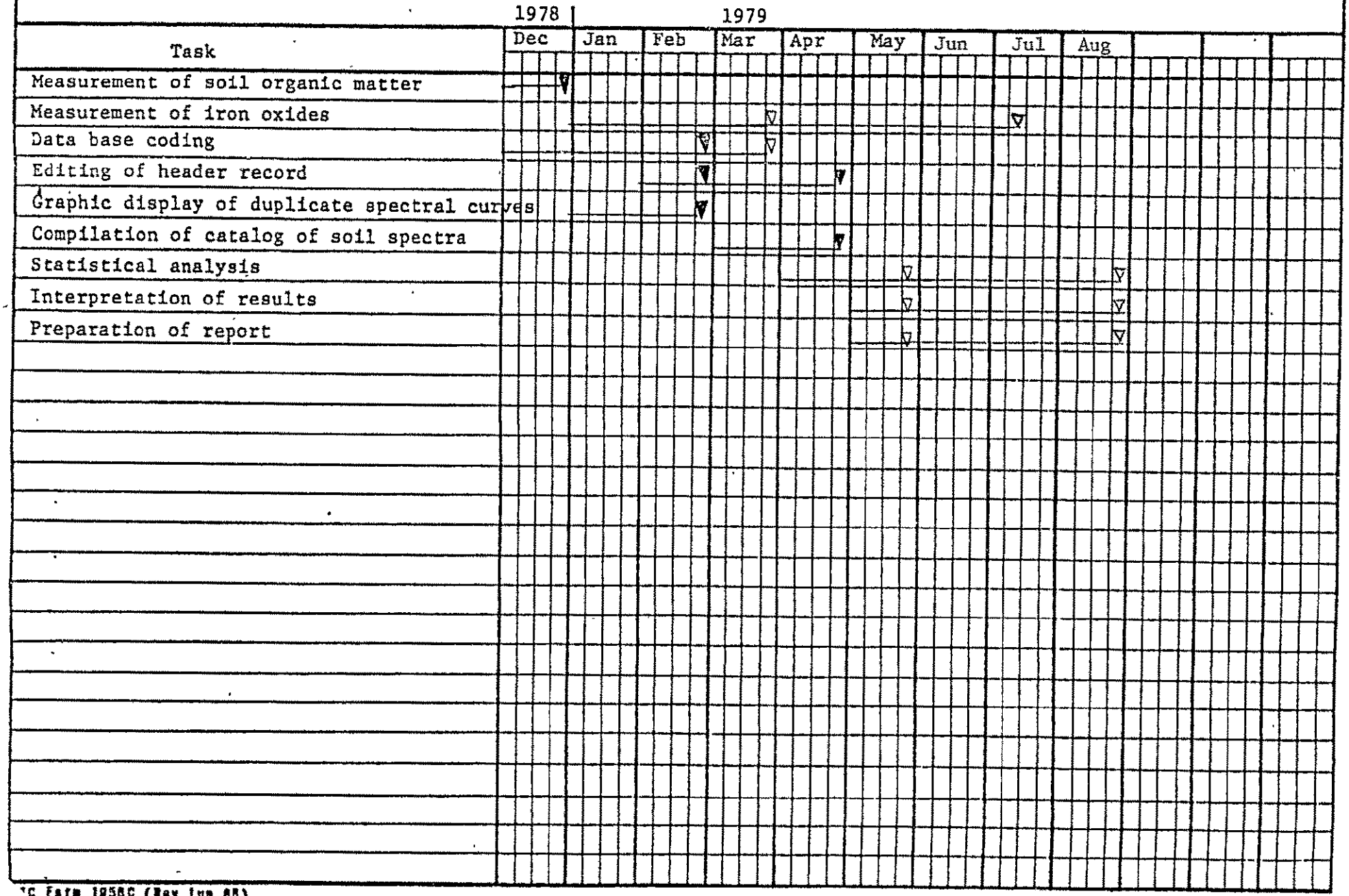
Table 2-D. Best Simple Correlation Coefficients for Four Soil Parameters Versus Spectral Bands by General Climatic Zones. (Band numbers of best band are in parentheses.)

General Climatic Zone	Soil Parameter				
	Organic Matter	Natural Log of Organic Matter	Moisture Weight Percent	Clay Content	Cation Exchange Capacity
All Climates					
481 Soils	-.36(1)	-.68(2)	-.53(10)	-.41(10)	-.48(10)
Moisture Zone					
185 Humid Soils	-.46(2)	-.68(1)	-.47(10)	-.25(10)	-.50(1)
128 Subhumid Soils	-.71(7)	-.78(6)	-.78(10)	-.61(10)	-.71(10)
94 Semiarid Soils	-.46(2)	-.53(3)	-.39(10)	-.37(10)	-.22(10)
62 Arid Soils	-.67(2)	-.73(2)	-.71(2)	-.58(2)	-.37(10)
Temperature Regime					
102 Frigid Soils	-.34(1)	-.43(1)	-.41(10)	-.40(10)	-.47(10)
211 Mesic Soils	-.53(1)	-.68(1)	-.48(10)	-.27(10)	-.52(10)
140 Thermic Soils	-.53(8)	-.64(6)	-.68(10)	-.57(10)	-.48(10)
28 Hyperthermic Soils	-.71(8)	-.75(3)	-.75(8)	-.42(1)	-.65(8)

Table 3-D. Best Simple Correlation Coefficients for Four Soil Parameters Versus Spectral Bands by Specific Climatic Zones. (Band numbers of best band are in parentheses.)

Specific Climatic Zone	Soil Parameter				
	Organic Matter	Natural Log of Organic Matter	Moisture Weight Percent	Clay Content	Cation Exchange Capacity
38 Humid Frigid Soils	-.52(1)	-.66(10)	-.39(10)	-.32(10)	-.45(1)
75 Humid Mesic Soils	-.59(10)	-.66(10)	-.29(10)	-.43(10)	-.73(10)
60 Humid Thermic Soils	-.71(9)	-.71(8)	-.65(10)	-.53(10)	-.73(9)
42 Subhumid Frigid Soils	-.72(9)	-.77(4)	-.75(10)	-.67(9)	-.86(9)
46 Subhumid Mesic Soils	-.80(8)	-.81(6)	-.64(10)	-.63(10)	-.71(10)
36 Subhumid Thermic Soils	-.49(2)	-.60(6)	-.82(10)	-.66(5)	-.63(10)
18 Semiarid Frigid Soils	-.38(1)	-.28(1)	-.32(6)	-.67(10)	-.60(10)
46 Semiarid Mesic Soils	-.31(2)	-.32(2)	-.34(10)	-.31(10)	-.44(1)
20 Semiarid Thermic Soils	-.58(3)	-.58(3)	-.55(10)	-.54(3)	-.40(3)
32 Arid Mesic Soils	-.83(5)	-.79(3)	-.79(3)	-.62(3)	-.73(4)
24 Arid Thermic Soils	-.62(2)	-.67(2)	-.75(10)	-.62(10)	-.47(10)

Figure 1D-A. Detailed implementation schedule for Task 1D.



Task 2. Processing Techniques Development

2A. Application and Evaluation of Landsat Training, Classification, and Area Estimation Procedures for Crop Inventory

The activities of this task during the past quarter have been in the areas of data receipt, data preparation and processing, programming support, and data analysis.

Data requested for the 80 high density sample segments have been arriving. The status of Landsat MSS data, PFC products, and reference data is detailed in the following material. Retro-order data, additional reference data products, and full-frame data are expected.

The first shipment of Landsat MSS data (355 runs) has been reformatted to LARSYS format. As acquisition dates are selected for analysis, the runs are being merged.

Several programs to make various aspects of EOD-LARSYS and LARSYS compatible have been completed. We are currently investigating the feasibility of programming the capability for LARSYS to read Universal format tapes.

Three data analysis tasks are described. A technical memorandum detailing the study of ISOCLS parameters is being prepared. A study assessing the effects of sampling wavelength bands and pixels in clustering and classification is described. Results of a study comparing five classifiers and two training methods are presented.

Analysis plans for next quarter include a study of the relationship of Landsat data acquisition history and classification performance and further evaluation of classification approaches.

PROGRESS THIS QUARTER

- DATA RECEIPT
- DATA PREPARATION AND PROCESSING
- PROGRAMMING SUPPORT
- DATA ANALYSIS

Data Status

DATA REQUESTED FOR 80 HIGH DENSITY AND 1 LOW DENSITY SAMPLE SEGMENTS IN INDIANA, ILLINOIS, AND IOWA.

DATA RECEIVED

- LANDSAT MSS DATA FOR SEGMENTS
  - COMPLETE DATA FOR 41 SEGMENTS
  - LATER SEASON DATA FOR 38 SEGMENTS
  - NO DATA FOR 2 SEGMENTS
- PFC PRODUCT 1
  - COMPLETE DATA FOR 41 SEGMENTS
  - LATER SEASON DATA FOR 38 SEGMENTS
  - NO DATA FOR 2 SEGMENTS
- REFERENCE DATA

  BASIC
  - AERIAL PHOTOGRAPHS AND FIELD OVERLAYS FOR 44 SEGMENTS

  EXTENDED (22 SEGMENTS)
  - DOT GRIDS FOR 22 SEGMENTS
  - 418 DOT FILES FOR 17 SEGMENTS
  - DIGITAL WALL-TO-WALL "GROUND TRUTH" FOR 6 SEGMENTS

DATA EXPECTED

- RETRO ORDER OF LANDSAT MSS AND PFC DATA
- ADDITIONAL DIGITAL "GROUND TRUTH" TAPES AND DOT PRODUCTS
- FULL-FRAME DATA

DATA PREPARATION AND PROCESSING

LANDSAT MSS DATA

- REFORMATTING
  - 355 RUNS REFORMATTED FROM UNIVERSAL TO LARSYS FORMAT
  - TIME-CONSUMING AND EXPENSIVE PROCESS
  - CURRENTLY INVESTIGATING FEASIBILITY OF PROGRAMMING CAPABILITY FOR LARSYS TO READ UNIVERSAL FORMAT TAPES
- COMBINING RUNS
  - DATAMERGE FUNCTION IN EOD-LARSYS CAN BE USED FOR UNIVERSAL FORMAT
  - LARSYS FORMATTED RUNS MUST BE MERGED BY THE LARS REFORMATTING GROUP
  - ALSO AN EXPENSIVE AND TIME-CONSUMING PROCESS

PFC PRODUCT 1

- FILED BY SEGMENT
- SCREENED FOR CLOUD AND HAZE
- BASIS FOR SELECTION OF RUNS TO BE MERGED

PROGRAMMING SUPPORT

PROGRAMS TO MADE EOD-LARSYS AND LARSYS COMPATIBLE

- STATISTICS CONVERSION (EOD-LARSYS ⟶ LARSYS)
- STATISTICS CONVERSION (LARSYS ⟶ EOD-LARSYS)
- RESULTS CONVERSION (LARSYS ⟶ EOD-LARSYS)
- RESULTS CONVERSION (EOD-LARSYS ⟶ LARSYS)

FIRST THREE PROGRAMS ARE COMPLETED, DEBUGGED, AND DOCUMENTED.

PERMIT USE OF ASPECTS OF EACH ANALYSIS SYSTEM INTERCHANGED.

ISOCLS Parameter Study

Several aspects of Procedure 1 were investigated and their effects on estimates were assessed.

- Use of different training and test sets
- Distribution of training and test sets
- Distance measure used in LABEL
- Number of pixels required per cluster class
- Number of iterations (passes) in ISOCLS

These results are being compiled into a technical memorandum, comparing and contrasting results found in previous studies.

SAMPLING STUDY

OBJECTIVES: DETERMINE EFFECT OF SAMPLING IN CLUSTERING AND CLASSIFICATION ON PROPORTION ESTIMATES AND ACCURACY.

- SAMPLE OF DATA
- SAMPLE OF WAVELENGTH BANDS

STUDY BASED ON TWO PRINCIPLES

- PAST STUDIES HAVE NOTED TENDENCY FOR PERFORMANCE TO DECREASE AS NUMBER OF WAVELENGTH BANDS USED IN CLASSIFICATION INCREASES.
- VERY EXPENSIVE TO CLUSTER AND CLASSIFY ALL PIXELS IN A SEGMENT

RESULTS INDICATE SAMPLING IS FEASIBLE AND DOES NOT NECESSARILY ADVERSELY AFFECT ACCURACY

RESULTS ARE BEING COMPILED INTO A MEMORANDUM.

Comparison of Several Classification Approaches
Experimental Approach

Five Classifiers Were Used:

- CLASSIFYPOINTS (Gaussian maximum likelihood per point classifier in LARSYS)
- ECHO (uses local spatial information to identify homogeneous objects which are classified using a Gaussian maximum likelihood sample classification rule)
- CLASSIFY (sum of normal densities maximum likelihood classifier in EOD-LARSYS)
- MINIMUM DISTANCE (linear classifier which assigns each pixel to the class whose mean is closest in euclidean distance)
- LAYERED (multistage decision tree classifier which uses an optimum subset of features at each tree node to classify each pixel)

All classifiers were trained using a modified supervised approach where all training fields of the same cover type were clustered together.

A second training method, using dots to seed the ISOCLS algorithm, was used with the CLASSIFY algorithm.

This test was carried out on three data sets and is currently being conducted on 4 additional sites.

Classifier Performance (Percent Correct Classification) for the Three Study Sites.

COUNTY	CLASS	CLASSIFIER: MINIMUM DISTANCE	CLASSIFY POINTS	LAYERED	ECHO	CLASSIFY Using ISOCLS Stats[1]	CLASSIFY Using LARSYS Stats[2]
Fayette, IL							
	Corn	81.9	81.2	63.9	77.3	77.3	78.9
	Soybeans	82.0	77.0	76.8	70.7	49.7	79.0
	Other	85.5	88.6	91.3	87.8	58.8	85.6
	Overall	83.5	83.0	80.5	79.5	61.9	81.6
Pottawattamie, IA							
	Corn	98.7	97.2	95.7	98.2	93.0	98.4
	Soybeans	92.0	89.8	92.3	90.2	86.5	89.3
	Other	85.3	98.0	97.5	97.1	92.1	98.4
	Overall	94.9	94.7	94.7	95.4	90.6	95.3
Shelby, IA							
	Corn	97.1	95.1	94.5	96.1	82.8	95.9
	Soybeans	89.3	92.9	98.2	95.4	98.0	98.0
	Other	75.5	83.7	88.2	79.4	78.7	79.7
	Overall	90.0	91.7	93.3	91.5	83.9	92.1

[1]Training method generally used with CLASSIFY. Uses a random selection of individual pixels to define initial cluster seeds for clustering the entire area.

[2]Training method used with all other classifiers. Training fields were clustered to develop means and covariances to define spectral subclasses for each of the classes of interest.

Comparison of Several Classification Approaches
Summary of Results

Segment-to-segment variability was significant

No significant difference among classifiers using the same training method

CLASSIFY using different training method did not yield as high accuracies

ECHO achieved the single highest overall accuracy

MINIMUM DISTANCE and CLASSIFYPOINTS were the easiest to use

MINIMUM DISTANCE was the least expensive classifier, CLASSIFY was the most expensive

PLANS FOR NEXT QUARTER

DATA RECEIPT AND PREPARATION CONTINUES

BEGIN PROGRAMMING CAPABILITY FOR LARSYS TO READ UNIVERSALLY FORMATTED TAPES.

STUDY IMPORTANCE OF ACQUISITION HISTORY ON IDENTIFICATION AND ESTIMATION OF CROPS

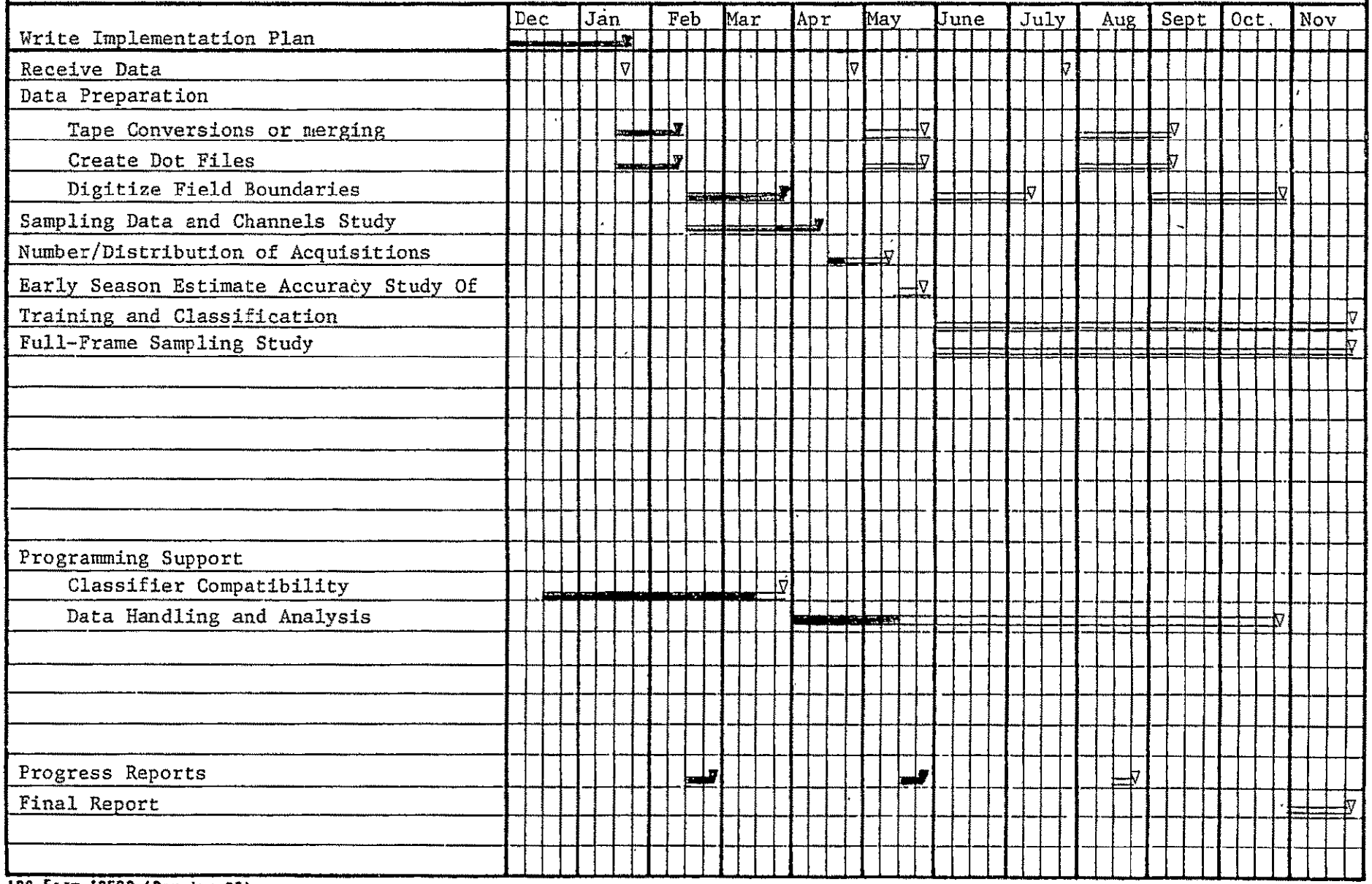
- USING DIFFERENT SETS OF ACQUISITIONS, EVALUATE CLASS SEPARABILITY AND CLASSIFICATION PERFORMANCE
- INVESTIGATE CROP SEPARABILITY BY EXAMINING CHANGE IN SPECTRAL PROPERTIES THROUGHOUT THE GROWING SEASON.

STUDY THE INTERRELATIONSHIPS OF TRAINING, CLASSIFICATION, AND AREA ESTIMATION PROCEDURES

- BASED UPON RESULTS TO DATE, TRAINING WILL BE MOST EMPHASIS
- SEVERAL GEOGRAPHIC AREAS WILL BE EXAMINED

Figure 1. Detailed implementation schedule.

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



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Task 2B. Initial Development of a Spectromet Crop Response Information System for Corn.

I. Introduction

Considerable evidence indicates that remote sensing technology can provide information about crop condition and yields. If this spectral information about crops can be combined effectively with meteorological and ancillary data, then potentially much better information about crop production could be gained.

The overall objective of this task represents a multiyear research effort to integrate the best mix of spectral, meteorological, and ancillary data into a crop information system for estimating crop condition and expected yield during the growing season. Specifically this task will:

(First Year)

- identify important factors in determining and predicting corn yields.
- determine how these factors can be observed or estimated from alternate sources of data.
- define long-term data requirements for continued model development.
- select and further develop several candidate approaches for corn yield modeling.
- identify and obtain data required for these yield models.
- conduct initial calibrations and tests of models using spectroradiometer data from controlled experiments and using Landsat MSS data from selected 5 x 6 nm Multicrop segments.

(Second Year)

- test, evaluate and refine performance of these models on independent data sets.
- select the most promising approach for continued development and testing.

These goals represent multiyear, interdisciplinary research efforts to combine the latest techniques and technologies of crop yield forecasting.

II. Activities During This Quarter

1. A literature review to assess previous work in this area is essentially completed. As a result of this review, the physiologically-based crop simulation approach which does not require a long period of record for development was selected as having the most potential to use spectral information directly. The multiple regression (e.g. Thompson 1969) and regression integrall (e.g. Leeper et al 1974, Benci and Runge, 1974) approaches which generally require long periods of record (i.e. 30 years or more) for estimating their parameters may benefit from indirect, iterative methods of incorporating spectral information. These statistical approaches will be pursued but will receive less attention than the physiological approach.

2. Computer compatable tapes of 1978 weather data for the test sites will not be available from the National Climatic Center until midsummer. Daily temperature and precipitation data for the cooperative stations surrounding the five test sites in Indiana and Iowa have been entered in LARS' computer from the monthly Climatological Data for these states. Data from the Purdue Agronomy Farm have also been assembled.

3. Requests for soil surveys and soil productivity indices were sent to each state with a test site. Only limited information is available from most states. The feasibility of using SIMBAL (Staff and Dale 1978) to provide a productivity index is being investigated. SIMBAL Version 3 has been implemented at LARS and initial tests are being conducted.

4. Examination and analyses of 1978 Landsat MSS data from the test sites and spectrometer data from the Purdue Agronomy Farm is in progress. Correlations, regressions and trajectory plots of these spectral data and various transformations (e.g. Kauth's greenness and brightness and Cate's normalization) with crop maturity stage and harvested grain yields are incomplete and inconclusive at this time.

5. Conceptually a corn yield model based on physiological-logic has been formulated. Further examination and critique of this model will be necessary before it will be ready for initial calibrations.

III. Plans For Next Quarter

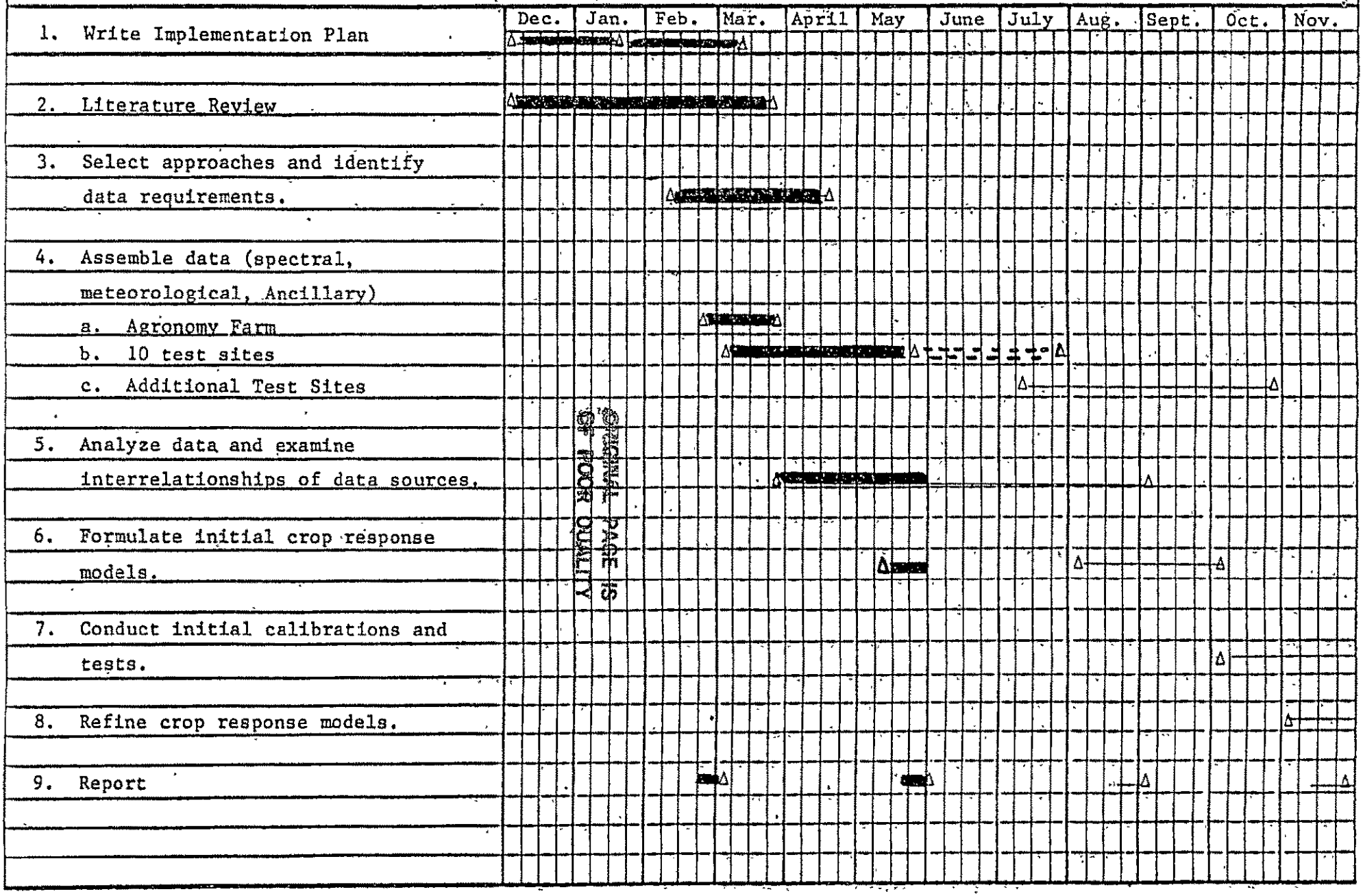
1. Continue to assemble the required spectral, meteorological, soil and ancillary data sets from the Multicrop Test Sites as the data becomes available.

2. Write computer programs for the crop models and begin initial calibrations of these models with whatever data is available.

3. Continue to support Task IA for analysis of spectral data collected in 1978 at the Purdue Agronomy Farm. These analyses will examine:

- basic spectral characteristics of corn as functions of biomass and maturity,
- effects of agronomic treatments on spectral characteristics of corn, and
- interrelationships among possible information sources.

Figure 1. Detailed Task Schedule.-Task 2B. Initial Development of Spectral-Meteorological Crop Response Information System For Corn.



2C. Multispectral Data Analysis Research

The following pages summarize the status of this task at the end of the second quarter. Work is directed toward development and application of multistage classifiers and a context classifier which incorporates spatial information in the decision process. A special aspect of the latter involves implementation on a special-purpose multiprocessor system in order to explore the potential benefits of such systems for remote sensing data processing.

Despite a number of annoying problems, primarily associated with availability of computer systems on which the classifiers are to be implemented, the research is proceeding only slightly behind the pace anticipated. Developments during the third quarter, especially with respect to availability of the Cyber-Ikon System at Control Data Corp., could have a considerable impact on some aspects of the schedule since we had expected to begin the real-system implementation during the period. Solution of this problem is being pursued.

TASK 2C. MULTISPECTRAL DATA ANALYSIS RESEARCH

OBJECTIVES

2C1. MULTISTAGE CLASSIFICATION

1. TEST KNOWN MULTISTAGE PROCEDURES ON APPLICATIONS INVOLVING MULTITEMPORAL AND MULTITYPE DATA.
2. INITIATE DEVELOPMENT OF OPTIMAL DESIGN PROCEDURES FOR MULTISTAGE CLASSIFIERS.

2C2. CONTEXTUAL CLASSIFICATION

1. DEVELOP PROCEDURES FOR DETERMINING AND REPRESENTING THE CONTEXTUAL CHARACTERISTICS OF A SCENE.
2. DEVELOP AN EFFECTIVE MULTIPROCESSOR IMPLEMENTATION OF THE CONTEXT CLASSIFIER ALGORITHM
   - ALGORITHM ANALYSIS
   - MULTIPROCESSOR SIMULATION
   - CDC CYBER-IKON IMPLEMENTATION.

2C1. Multistage Classification

STATUS

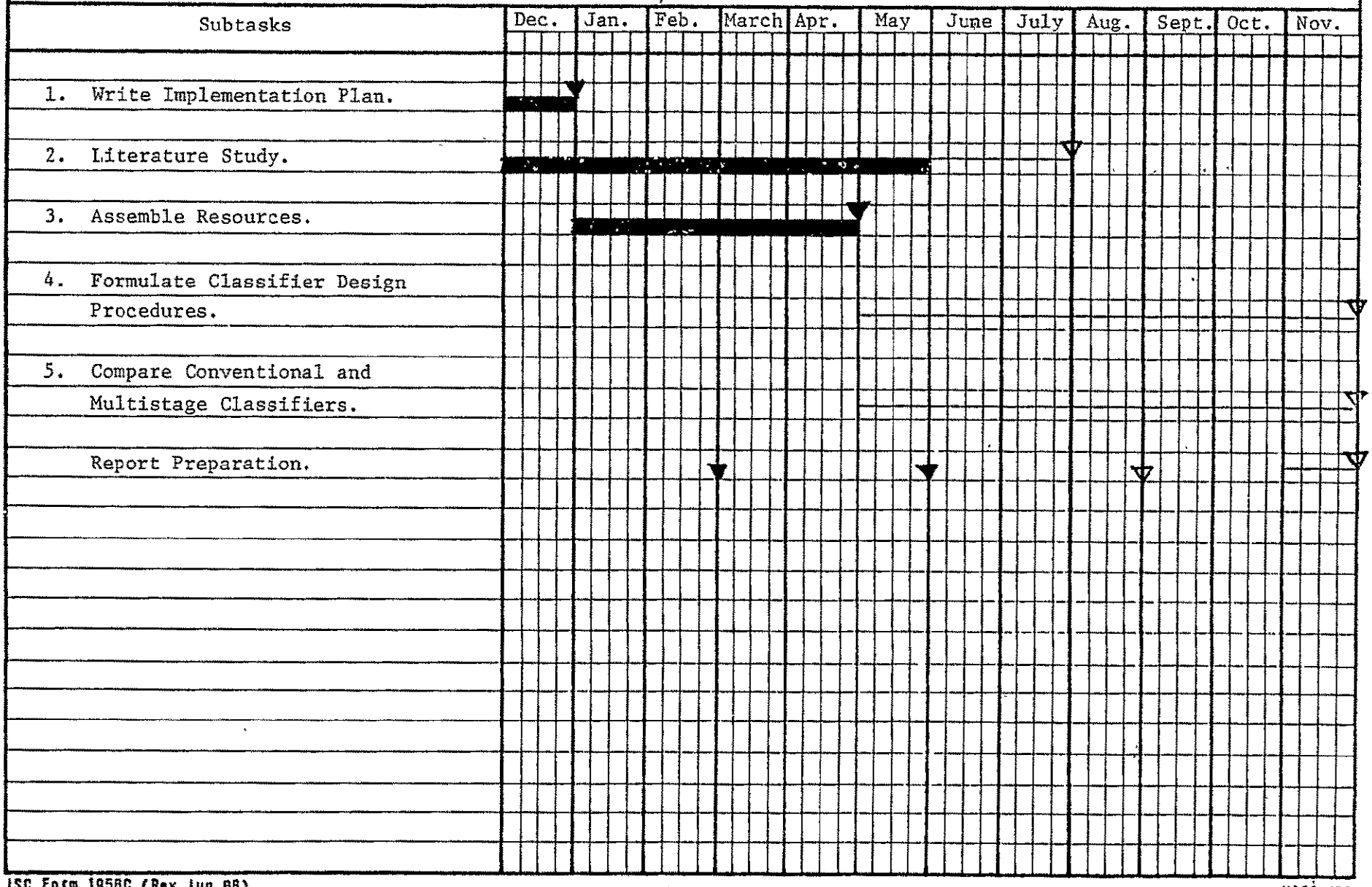
1. PRESENT EMPHASIS ON LAYERED CLASSIFIER.
2. LITERATURE SURVEY IN PROGRESS.
3. SOFTWARE FOR LAYERED CLASSIFIER OBTAINED AND TESTED.
4. DATA SET ASSEMBLY IN PROGRESS.
5. FORMULATION OF LAYERED CLASSIFIER DESIGN PROCEDURES INITIATED.

2C1. MULTISTAGE CLASSIFICATION

PLANS FOR THIRD QUARTER

1. COMPLETE LITERATURE SURVEY AND PREPARE SUMMARY, BIBLIOGRAPHY.
2. COMPLETE SELECTION AND ASSEMBLY OF TEST DATA SET.
3. PURSUE FORMULATION OF APPROACHES FOR CLASSIFIER DESIGN.
4. BEGIN COMPARATIVE TESTS OF CONVENTIONAL AND MULTISTAGE CLASSIFIERS.

Figure 2C-1. Detailed Implementation Schedule for Task 2C1.



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2C2. Context Classification

POTENTIAL BENEFITS

1. DEVELOP A METHOD FOR INCORPORATING SPATIAL CONTEXT IN THE CLASSIFICATION OF REMOTE SENSING IMAGERY.
2. DEMONSTRATE ABILITY TO DEVELOP ANALYSIS TECHNIQUES WHICH MAY BE COMPUTATIONALLY INFEASIBLE ON CONVENTIONAL SERIAL COMPUTERS.
3. DEVELOP METHODS FOR IMPLEMENTING AND EVALUATING IMAGE ANALYSIS ALGORITHMS ON PARALLEL PROCESSING SYSTEMS.
4. EVALUATE THE COST-EFFECTIVENESS OF THE CYBER-IKON SYSTEM FOR CONTEXTUAL CLASSIFICATION.
5. ANALYSIS OF WHICH ARCHITECTURAL FEATURES OF COMPUTER SYSTEMS ARE MOST IMPORTANT FOR EFFICIENT CONTEXTUAL (AND OTHER FORMS OF) CLASSIFICATION.

2C2. Context Classification

STATUS

1. BASELINE (NO-CONTEXT) ANALYSIS OF BLOOMINGTON, INDIANA AREA DATA SET COMPLETED (INCLUDING ASSEMBLY OF REFERENCE DATA FROM PHOTOGRAPHY). LACIE SEGMENT SELECTED.
2. INITIAL CONTEXTUAL CLASSIFICATIONS OF BLOOMINGTON DATA COMPLETED.
3. ANALYSIS OF CONTEXT ALGORITHM FOR MULTI-PROCESSOR IMPLEMENTATION INITIATED.
4. CYBER-IKON SIMULATOR DEVELOPMENTS:
   DEBUGGING, USER INTERFACE IMPROVEMENT, UPGRADE FLOATING POINT ARITHMETIC SOFTWARE, EXPAND TO HANDLE UP TO SIX FLEXIBLE PROCESSORS.
5. IMPLEMENTATION BEGUN OF MAXIMUM LIKELIHOOD CLASSIFIER ON THE CYBER-IKON SIMULATOR TO GAIN EXPERIENCE, DEVELOP STRATEGY FOR INTER-FACING THE HOST COMPUTER AND FLEXIBLE PROCESSOR ARRAY.

2C2. Context Classification

PROBLEMS ENCOUNTERED

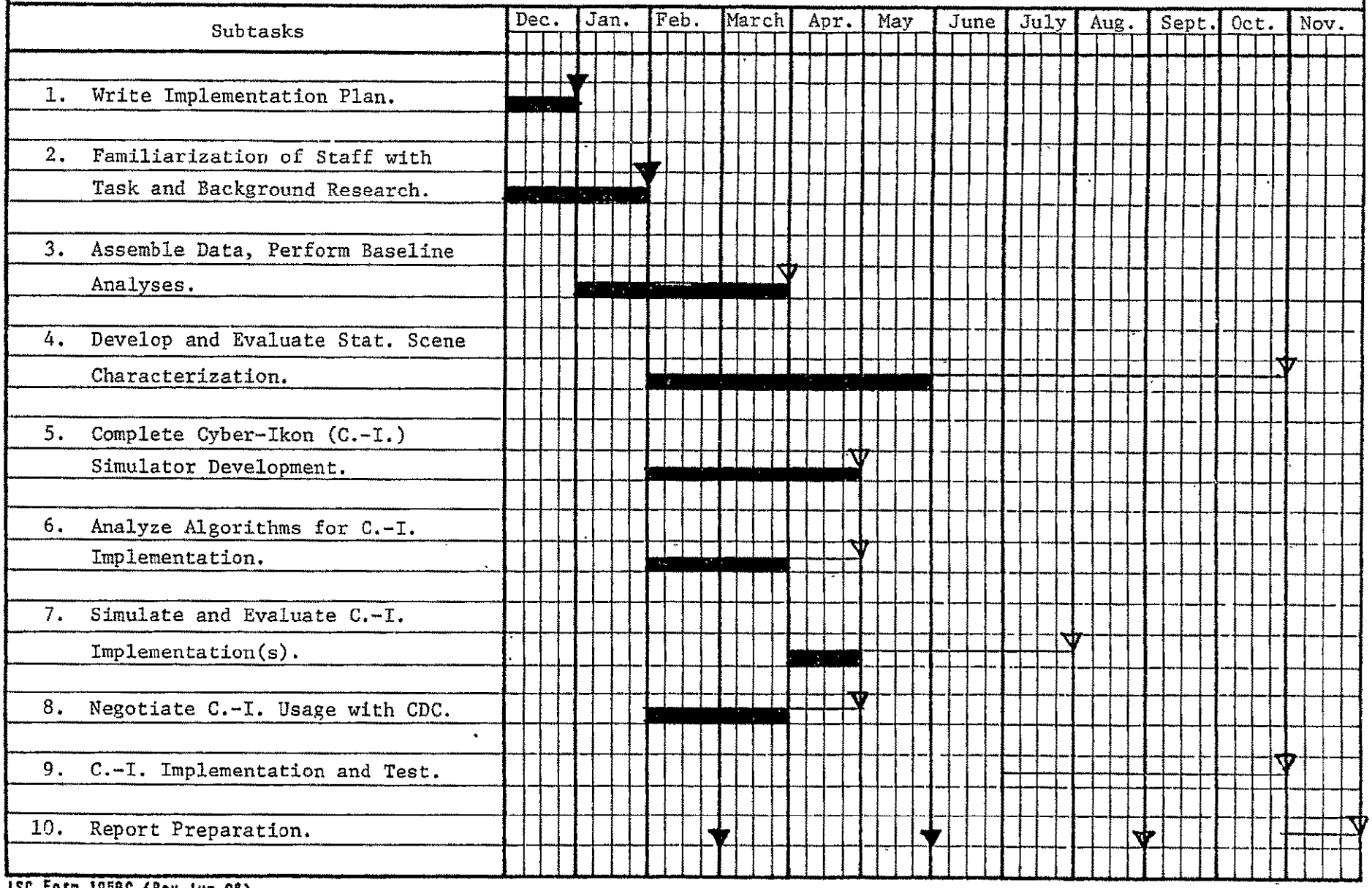
1. INITIAL CONTEXT CLASSIFICATIONS OF BLOOMINGTON AREA DATA ARE DISAPPOINTING. CURRENT HYPOTHESIS IS THAT TOO MANY SUB-CLASSES WERE INVOLVED TO ALLOW ADEQUATE ESTIMATION OF THE CONTEXTUAL DISTRIBUTION BY THE "ITERATIVE APPROACH."
2. FLAWS IN SIMULATOR SOFTWARE BECOME APPARENT AS MORE COMPLEX USE OF IT IS MADE. ALL PROBLEMS DISCOVERED SO FAR HAVE BEEN RESOLVED.
3. UNIX OPERATING SYSTEM NOT YET AVAILABLE ON LARS PDP-11, DELAYING TRANSFER OF SOFTWARE TO LARS.
4. NEGOTIATIONS WITH CONTROL DATA CORP. FOR ACCESS TO CYBER-IKON COMPLICATED BY CURRENT USE OF THE SYSTEM.

2C2. Context Classification

PLANS FOR THIRD QUARTER

1. EXTEND EXPERIMENTAL EVALUATION OF THE "ITERATIVE APPROACH" FOR CONTEXT DISTRIBUTION ESTIMATION AND FORMULATE THEORETICAL LIMITATIONS OF THIS APPROACH; FORMULATE ALTERNATIVE APPROACHES.
2. COMPLETE IMPLEMENTATION OF THE MAXIMUM LIKELIHOOD CLASSIFIER ON THE CYBER-IKON SIMULATOR.
3. COMPLETE EVALUATION OF ALTERNATIVE PARALLEL/PIPELINED IMPLEMENTATIONS OF THE CONTEXT CLASSIFIER FOR THE CYBER-IKON SYSTEM AND IMPLEMENT THE CONTEXT CLASSIFIER ON THE CYBER-IKON SIMULATOR.
4. COMPLETE TRANSFER OF SIMULATOR TO LARS PDP-11.
5. OBTAIN FROM CDC DETAILED INFORMATION ABOUT HOST/ARRAY INTERFACES IN THE CYBER-IKON.
6. BEGIN TESTING AND EVALUATION OF THE CYBER-IKON ALGORITHMS ON THE REAL MACHINE (PENDING SUCCESSFUL ARRANGEMENTS WITH CDC).

Figure 2C-2. Detailed Implementation Schedule for Task 2C2.



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2D. Multisensor, Multidate Spatial Feature Matching, Correlation, Registration and Information Extraction

I. Introduction

An oral presentation will not be given for this task for this quarter; thus, the format of the written report will be paragraphical rather than a sequence of overheads. The activities during the quarter focused on three tasks: 1) Crop Classification Using SAR and Landsat Data, 2) Digitization of Ancillary Data; 3) Multidate Spatial-Spectral Modeling.

II. Crop Classification Using SAR and Landsat (Subtask 4)

Further analysis was performed on the registered SAR/Landsat data set in the Phoenix area. In the first quarter a first cut classification was performed and the results were somewhat favorable. In the current quarter more detailed classification analysis was performed and results were not encouraging. The procedure followed was as follows:

1. Boundaries for fields in the data set for which ground truth was available were selected. Ground truthed classes in the data set are:

Class	No. Fields
Alfalfa	14
Cotton	17
Barley	3
Pasture	4
Oranges	4
Residential	2
Wheat	2

Class	No. Fields
Bare Soil	3
Sugar Beets	1
Woods	1
Onions	1

2. A subset of the fields was clustered to obtain training samples in each class with and without the SAR channel. Training sets were selected from the cluster maps to form training classes with the following number of samples:

Alfalfa	323
Cotton	357
Barley	200
Oranges	90
Urban (Residential)	103
Wheat	32
Bare Soil	20
Sugar Beets	64

3. A block of data containing the fields was classified using the LARSYS point classifier with and without the SAR channel. Due to data processing system problems at GSFC and EDC band 4 was not available on the CCT. The Landsat only case was thus run with bands 5, 6, 7 and the case with the SAR was done with these plus the SAR channel. The training field performance was:

	Percent Correct Landsat	Percent Correct Landsat and SAR
Alfalfa	99.4	100.0
Cotton	100.0	98.6

	Percent Correct Landsat	Percent Correct Landsat and SAR
Barley	100.0	100.0
Oranges	98.9	100.0
Urban	100.0	88.5
Wheat	100.0	97.6
Bare Soil	95.0	100.0
Sugar Beets	100.0	88.0

No test fields were evaluated since many of the classes were so small the training took all of the available pixels. The conclusion taken from this work is that the SAR does not greatly influence the classification performance and may degrade accuracy. Evidence of improvement in classification accuracy was obtained in the first quarter using a crude training procedure thus the results thus far must be considered as further evidence and not as conclusive.

III. Ancillary Data Merging (Subtask 6)

An alternate method of ancillary map data digitization using color scanning continued to be studied. The conventional method is manual digitization on a table graphics digitizer. The method consists of color coding and color separation scanning of the document and classification to extract the polygons. Previous SR&T results by Chu and Anuta [1] indicated potential benefits from this approach.

Tests were run in the quarter on two forest resource map blocks using high saturation artists colors. The maps were color coded for 17 "operating areas" OA's on each map and photographed. The 35mm color slides were red, green, blue separation scanned on a microdensitometer and converted to a three channel multispectral tape file. Training fields were taken from each color area and the maps were classified.

The results were visually evaluated since no precise count of the error pixels could be obtained. A general indication of performance was obtained by counting error pixels in the interior of the color polygons. The results are presented below:

	No. of Errors		
Color	AU268	Color	AU271
White	53	White	96
Bright Red	3	Red	0
Red	48	Lt. Green	0
Dark Red	17	Med. Green	0
Orange	9	Dk. Green	0
Lt. Green	4	Yellow	0
Green	2	Gold	0
Dk. Green	318	Orange	355
Pink	0	Dk. Orange	2
Lavender	1	Lt. Blue	9
Lt. Yellow	0	Med. Blue	1
Yellow	7	Dk. Blue	1
Lt. Brown	0	Brown	0
Brown	0	Tan	0
Lt. Blue	1	Lt. Brown	0
Blue	11	Gray	0
Dk. Blue	4	Purple	2
	478		457
Total Area (Pixels)	279,006		243,714

A final test was made on a color block test slide in which all 24 available artists colors were painted in blocks, scanned and fields picked in the digital data. Statistics were computed and the transformed divergence computed for

each of the 276 combinations of 24 classes taken two at a time. The divergence was the maximum of 2000 for all cases indicating essentially perfect separability for the colors. The extremely low error rates and ease of classification indicates that this method is a viable approach to ancillary data digitization.

IV. Multidate Spatial-Spectral Modeling (Subtask 3)

The question of the correctability of Landsat and SAR imagery was pursued further by employing a correlation coefficient shifting image correlation algorithm. Work in the previous quarter used only the Larsys correlation algorithm which does not shift images and it produced discouragingly low correlation values.

The tests performed in this quarter examined twenty 16 by 16 point blocks in the previously registered SAR-Landsat data for the Phoenix site. Both data and magnitude of gradient images were correlated for the two data types. The results of the tests are shown in Table 2D-1. The assumption is that the SAR and Landsat data are perfectly registered. The misregistration is small if it does exist such that total failure of the correlation will be clearly detectable, i.e., shift peaks many pixels away from zero are assumed to be bad correlation and not misregistration.

Out of the twenty correlations carried out only ten were judged successful (no. 4, 5, 7, 10, 12, 13, 14, 15, 18, 19). The results using the magnitude of the gradient (judged the best enhancement for low correlation cases by Svedlow [2]) were not significantly different than for the unaltered data. Correlation peaks in all cases were very low but in many instances a correct peak was assumed found. The sites chosen were road intersections and similar linear intersections.

Table 2D-1. Correlation Results for Landsat vs. SAR LARS Run 72069111.

	Correlation Block Center		Landsat Data (Band 5) vs. SAR			Gradient Magnitude of Landsat vs. G.M. of SAR		
No.	Line	Col.	Line Shift	Col. Shift	Corr.	Line Shift	Col. Shift	Corr.
1	390	460	-1	-12	.273	-1	-9	.276
2	90	460	-7	11	.206	6	9	.214
3	260	332	15	16	.237	16	16	.265
4	290	202	-1	2	.218	-3	-1	.205
5	120	200	0	0	.372	0	0	.405
6	475	42	-9	7	.406	-9	8	.369
7	107	300	0	-2	.329	0	-2	.274
8	80	60	15	-8	.215	14	-12	.247
9	390	88	-6	5	.480	-6	5	.440
10	240	60	-2	3	.370	-1	4	.368
11	321	332	13	3	.312	-2	16	.249
12	322	268	-4	1	.359	-4	1	.370
13	314	116	-3	4	.274	-3	6	.305
14	221	119	0	3	.147	-5	13	.204
15	107	113	1	4	.210	1	5	.321
16	44	204	-6	3	.269	-6	4	.272
17	129	332	15	0	.305	2	-1	.309
18	192	460	0	-3	.259	-1	-1	.317
19	118	227	0	0	.176	0	1	.216
20	180	160	-5	8	.200	0	-12	.247

Other enhancements and site selections could be tested; however, it was concluded that sufficient evidence exists from these tests to indicate that the correlations of SAR and Landsat imagery would likely work about half the time. The value of this performance level depends on the efficiency of the processor and the volume of imagery to be registered. In a production situation it will be very attractive to generate an automatic correlator but in a small volume individual research task visual control point location will be preferable.

Plans for Third Quarter

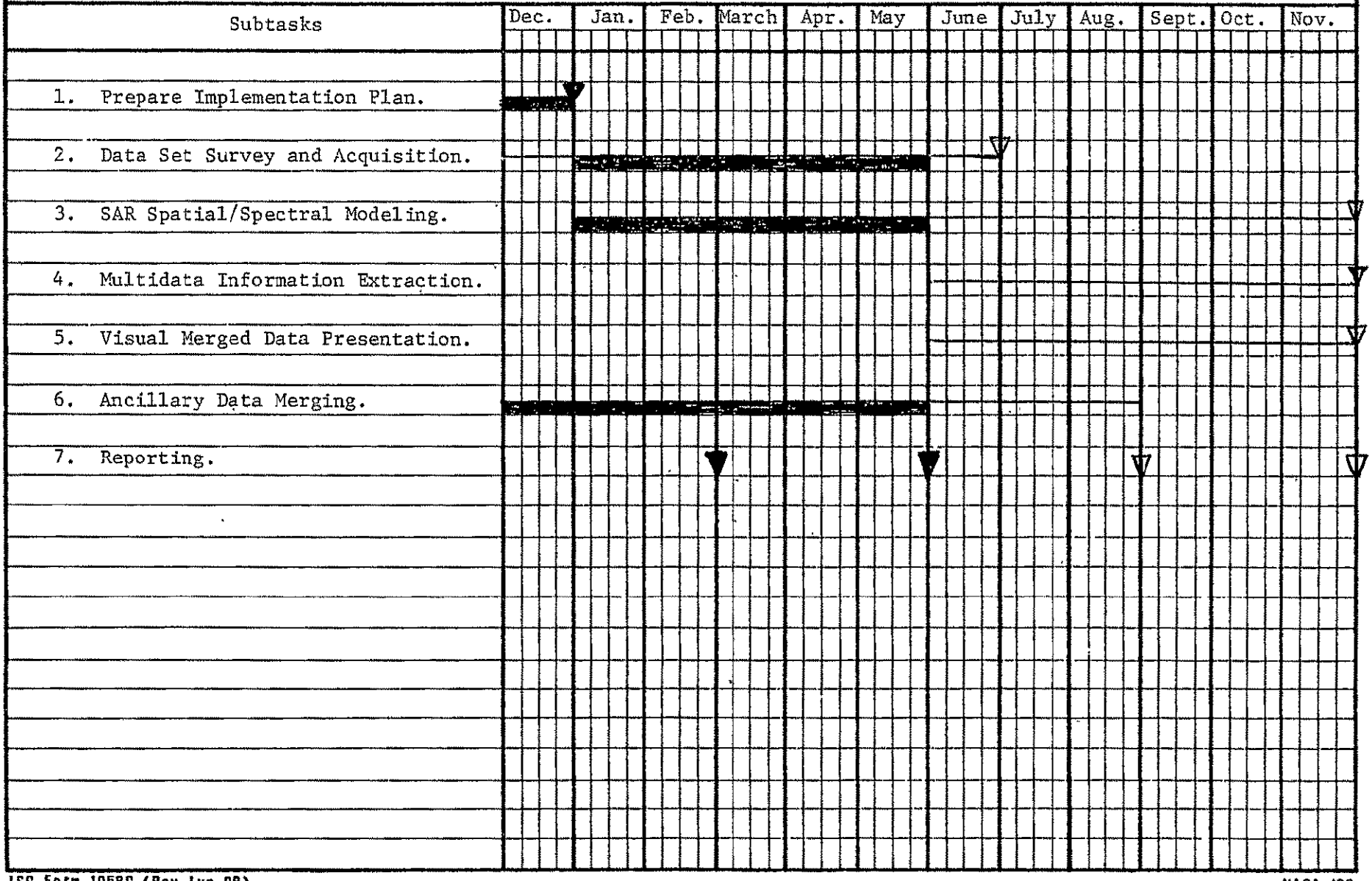
The concept of information extraction using a high resolution panchromatic image and lower resolution multispectral images has evolved from the study of merged SAR/Landsat data sets. This concept will be developed and evaluated in the remainder of the contract. All tasks are on schedule and sufficient data is being acquired to complete the desired investigations.

REFERENCES

1. Nim-Yau Chu, P. E. Anuta, "Automatic Color Map Digitization by Spectral Classifications," Photogrammetric Engineering and Remote Sensing Journal, Vol. 45, No. 4, April 1979, pp. 507-515.

2. M. Svedlow, C. D. McGillem, P. E. Anuta, "Image Registration: Similarity Measure and Preprocessing Method Comparisons," IEEE Transactions on Aerospace and Electronic Systems, Vol. AES-14, Jan. 1978, No. 1, pp. 141-149.

2D. Multisensor Multidate Spatial Feature Matching, Correlation, Registering, Resampling and Information Extraction



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Task 3. Computer Processing and Data Base Services

3A. Computer Processing Support

The following pages contain quarterly report material for the Computer Processing Support Task as presented in an oral briefing. The overleads summarize the task, its accomplishments for the second quarter and plans for the third quarter.

Key achievements for the second quarter include improvements in the accessibility of the shared system for ERIM and for JSC, installation of Release 8 of SPSS, Edition 7 of IMSL, design and implementation of a backup system for user mini-disks, expansion of batch machine capabilities, acquisition of additional direct access disk space, initiation of an investigation on means of interchanging technology using the shared data processing system, design of a data base for NOAA weather data, a study on the communications problems encountered by remote users of the system, a reduction in the rate charged for basic CPU time and an increase in batch usage.

TASK 3A: COMPUTER PROCESSING SUPPORT

JUNE QUARTERLY REVIEW

BY

JIM KAST

JLK: 5/21/79

COMPUTER PROCESSING SUPPORT

OBJECTIVE: PROVIDE JSC AND ITS ASSOCIATED RESEARCH COMMUNITY WITH THE ENVIRONMENT NECESSARY FOR THE IMPLEMENTATION OF A SHARED DATA PROCESSING SYSTEM FOR RESEARCH OF REMOTE SENSING.

PURDUE'S SUPPORT INCLUDES A COMPUTER AND SUPPORTING HARDWARE, SOFTWARE, DATA, PERSONNEL, PROCEDURES AND TRAINING.

JLK: 5/21/79

POTENTIAL BENEFITS

* THE OPPORTUNITY TO BETTER MOLD KEY, GEOGRAPHICALLY-DISPERSED RESEARCH GROUPS INTO A MORE INFORMED AND COORDINATED RESEARCH TEAM.

* A MECHANISM FOR EFFICIENT TRANSFER OF INFORMATION BETWEEN RESEARCH CENTERS, NASA, AND OTHER PARTICIPATING GOVERNMENT AGENCIES.

* FASTER, LESS REDUNDANT SOFTWARE DEVELOPMENT.

* FASTER TRANSFER OF NEWLY-DEVELOPED ANALYSIS TECHNIQUES AND RESEARCH RESULTS TO AND FROM PARTICIPATING RESEARCH GROUPS.

* CONCENTRATION OF SYSTEMS PROGRAMMING SUPPORT, DATA ACQUISITION, DATA LIBRARY AND CERTAIN COMPUTER SERVICES AT THE SYSTEM'S CENTRAL SITE.

JLK: 5/21/79

IN ORDER FOR A PROMISING NEW ANALYSIS TECHNIQUE TO BE SHARED WITHIN THE RESEARCH COMMUNITY, RECIPIENTS OF THE NEW TECHNIQUE MUST HAVE:

* ACCESS TO SOFTWARE SUPPORTING THE NEW TECHNIQUE,
* ACCESS TO HARDWARE WHICH SUPPORTS THE SOFTWARE,
* ACCESS TO THE DATA REQUIRED BY THE TECHNIQUE,
* A TECHNICAL UNDERSTANDING OF THE TECHNIQUE,
* KNOWLEDGE OF HOW TO OPERATIONALLY USE THE SUPPORTING SOFTWARE,

JLK
5/22/79

Second Quarter Improvements in System Accessibility

Status 2/28/79

Good Access:	Purdue/LARS	11 Terminals 7 Dial-Ups	3 Printers 3 Readers 1 Punch	(2 Data 100's)
	NASA/JSC LEC IBM	4 Terminals 4 Dial-Ups	2 Printers 2 Readers 1 Tape Drive 2 Punches	(1 Data 100) (1 IBM 2780)
Marginal Access:	ERIM	Dial LARS	Dial-Up Keyboard	
	TAMU	Dial Through JSC	"	
	UCB	Dial LARS?	"	

Accessibility Improvements:

* Dial-up RJE capability for ERIM (Cope 1200 emulating a HASP Work Station)
* Replacement of JSC's IBM 2780 by a Data 100 which supports tape transfer capability.

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Second Quarter Software Upgrades

* Release 8 of SPSS was installed.
* Edition 7 of IMSL was installed.
* PLC 11 and PLC 12 of CMS Release 5 were installed.
* VS1 was installed on the system to support CSMP.
* CSMP has been installed under VS1.
* A Backup Procedure for 3A mini disks has been written and implemented.
* A new batch machine with a six megabyte memory, BATHOUST, has been implemented and is available on a prior-arrangement basis.
* EXOSYS has been converted to a CMS370 compatible software system.

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5/22/79

Second Quarter Hardware Upgrades

* Acquired two CDC disk drives compatible with an IBM 3330 disk system.
* Ordered a third IBM compatible 3330 drive.
* Installed an Optronics System C-4300 Color film writing device for a two month trial period.
* Ordered a 1200 baud clock to provide an upgraded data transfer rate when the statistical multiplexor and 9600 baud modem are installed at LARS and JSC this fall.

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Second Quarter Data Base Work

* The foreign transition year Landsat data was acquired, and is being placed in the data library and entered into the segment catalogue.

* The segment catalogue and data search (SUBSET) software were re-designed to allow segments from different geographic areas to have identical segment numbers.

* The segment catalogue was placed on disk upon installation of the 3330 disk system and its use documented in SCANLINES.

* Ground truth data collected over the LACIE Phase III blind sites were entered into the data base and software to search the ground truth table were written.

* A data base for NOAA weather data has been designed and submitted to NOAA for review.

JLK: 5/21/79

SECOND QUARTER COMMUNICATIONS WORK

* A VISITING CONSULTANT TRIP OCCURRED DURING EARLY MAY.
* ONE-ON-ONE INSTRUCTION ON THE USE OF THE FIELD ANALYSIS SYSTEM (EXOSYS) WAS PROVIDED TO AN ERIM REPRESENTATIVE.
* A COMMUNICATIONS STUDY WAS UNDERTAKEN TO IDENTIFY PROBLEMS USERS HAVE COMMUNICATING WITH INTERFACE PEOPLE AT LARS.
* AN INVESTIGATION OF PROCEDURES TO INTERCHANGE TECHNOLOGY USING THE LARS COMPUTER SYSTEM WAS BEGUN.

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COMMUNICATIONS STUDY

1. Assess overall performance.

2. Identify which means of communication are important and effective, and which are not.

3. Identify what the major communications problems are.

JLK: 5/21/79

OVERALL PERFORMANCE

	Respondents	NASA	Support Contractors	Very Good	Good	Adequate	Needs Work	Totally Inadequate
3A Users	16	10	6	7	6	2	0	1
LARS Users	15			4	7	2	2	0
System Services Staff	16			4	7	4	1	0
TOTALS	47			15	20	8	3	1

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EFFECTIVE AND IMPORTANT MEANS OF COMMUNICATION

1. Personal Contact
2. Phone
3. Terminals
4. SCANLINES
5. Memo
6. Correspondence
7. Staff Meetings, Documentation, SRTNEWS

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PROBLEM AREAS

	Very	Some	Little	None	Weighted Avg.
Weight	3	2	1	0	
1. Inability to contact person due to absence from desk.	2	0	7	6	.87
2. Information given is not adequate.	0	4	2	8	.71
3. Promises for services are made; then not kept.	1	1	4	8	.64
4. Misinformation is given.	1	1	2	9	.54

Also:
- Don't know whom to contact should something go wrong.
- Long delays in placing long-distance calls.
- Too few people to interface with at JSC on a technical level.
- Inadequate IBM and LARS documentation available.
- System is slow and sluggish.
- Hard to get hold of part-time LARS personnel.

JLK: 5/21/79

ADMINISTRATIVE MATTERS

* THE RATE FOR BASIC COMPUTER SERVICE WAS REDUCED FROM $200/CPU HOUR TO $150/CPU HOUR EFFECTIVE 4/1/79.
* EMPHASIS WAS PLACED ON MORE ECONOMICAL AND COMPLETE USE OF THE LARS COMPUTER THROUGH THE BASIC RATE BATCH MACHINES. THIS EFFORT HAS MET WITH SUCCESS AS 44% OF COMPUTER PROCESSING SUPPORT USAGE WAS CONDUCTED IN BATCH MODE DURING THE FIRST TWO MONTHS OF THE SECOND QUARTER AS COMPARED TO 11% DURING THE FIRST QUARTER.
* RESPONSIBILITY FOR EOD LARSYS PROMPTING EXEC WAS TRANSFERRED TO THE EOD LARSYS LIBRARIAN AT JSC.
* A DECISION WAS REACHED NOT TO PURSUE THE SALE OF THE THIRD SHIFT AT THIS TIME.
* PRODUCTION AND DISTRIBUTION OF A LARS COMPUTER USER'S GUIDE TOOK PLACE IN MAY.

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PLANNED IMPROVEMENTS IN SYSTEM ACCESSIBILITY

* WORK WITH ERIM TO IMPROVE ACCESSIBILITY OF THE PURDUE/LARS SYSTEM FOR ERIM'S TAPE CASSETTE TERMINAL.

* WORK WITH UCB ON POSSIBLE MEANS OF ACCESS.

JLK: 5/21/79

THIRD QUARTER SOFTWARE UPGRADES

* AN AUTOMATED RESOURCE REQUEST PROCEDURE WILL BE IMPLEMENTED.
* UPGRADES TO THE CMS370 BATCH FACILITIES WILL BE PURSUED:
  - CONFIGURE THE BATCH MACHINE TO MATCH THE MACHINE OF THE USERID;
  - SET DEFAULT GLOBAL'S AND FILEDEF'S;
  - APPEND AN OPERATOR'S MESSAGE TO A BATCH PRINT OUT IF A JOB MUST BE CANCELLED;
  - IMPROVE BATCH ERROR REPORTING FACILITIES.
* ORDER A CMS370 COMPATIBLE VERSION OF SAS.
* IMPLEMENTATION OF AN ANALYSIS PROCEDURE USING ECHO AND GRPSAM AS A P1-ALTERNATIVE (IN A P1 COMPATIBLE FORM) WILL BE PURSUED.
* FUNCTIONAL SPECIFICATIONS WILL BE PRODUCED FOR A FIELD DATA ANALYSIS SYSTEM BASED ON EXOSYS EXPERIENCE. THIS SYSTEM SHOULD BE SUITABLE FOR USE WITH THE MULTIBAND RADIOMETER UNDER DEVELOPMENT AS WELL AS THE FIELD MEASUREMENTS DATA BASE CURRENTLY IN PLACE AT PURDUE/LARS.

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5/22/79

PLANNED HARDWARE UPGRADES

* INSTALLATION OF AN IBM 3031 AND ASSOCIATED EQUIPMENT.
* INSTALLATION OF A STATISTICAL MULTIPLEXOR, 1200 BAUD CLOCK AND 9600 BAUD MODEM FOR USE BY JSC.
* INSTALLATION OF A SECOND DIAL-UP MODEM FOR RJE INPUT FROM ERIM.

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5/22/79

PLANNED DATA BASE WORK

* WORK WITH NOAA ON A WEATHER DATA BASE WILL CONTINUE.
* RECEIPT OF U.S. TY LANDSAT DATA AND ITS ENTRY INTO THE DATA BASE AND THE SEGMENT CATALOG IS ANTICIPATED.
* VERIFICATION OF DATA IN THE RTE DATA BASE WILL BE PERFORMED.

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5/22/79

PLANNED COMMUNICATION AND INFORMATION EXCHANGE ACTIVITIES

* PLANS AND PROCEDURES WILL BE DEVELOPED TO ALLEVIATE PROBLEMS UNEARTHED BY THE COMMUNICATIONS STUDY.
* WORK WILL BEGIN ON A STANDARD TRAINING COURSE FOR USERS OF THE SHARED SYSTEM.
* THE INVESTIGATION OF PROCEDURES TO EXCHANGE TECHNOLOGY USING THE PURDUE/LARS SYSTEM WILL CONTINUE.
* A VISITING CONSULTANT TRIP WILL OCCUR DURING JULY.

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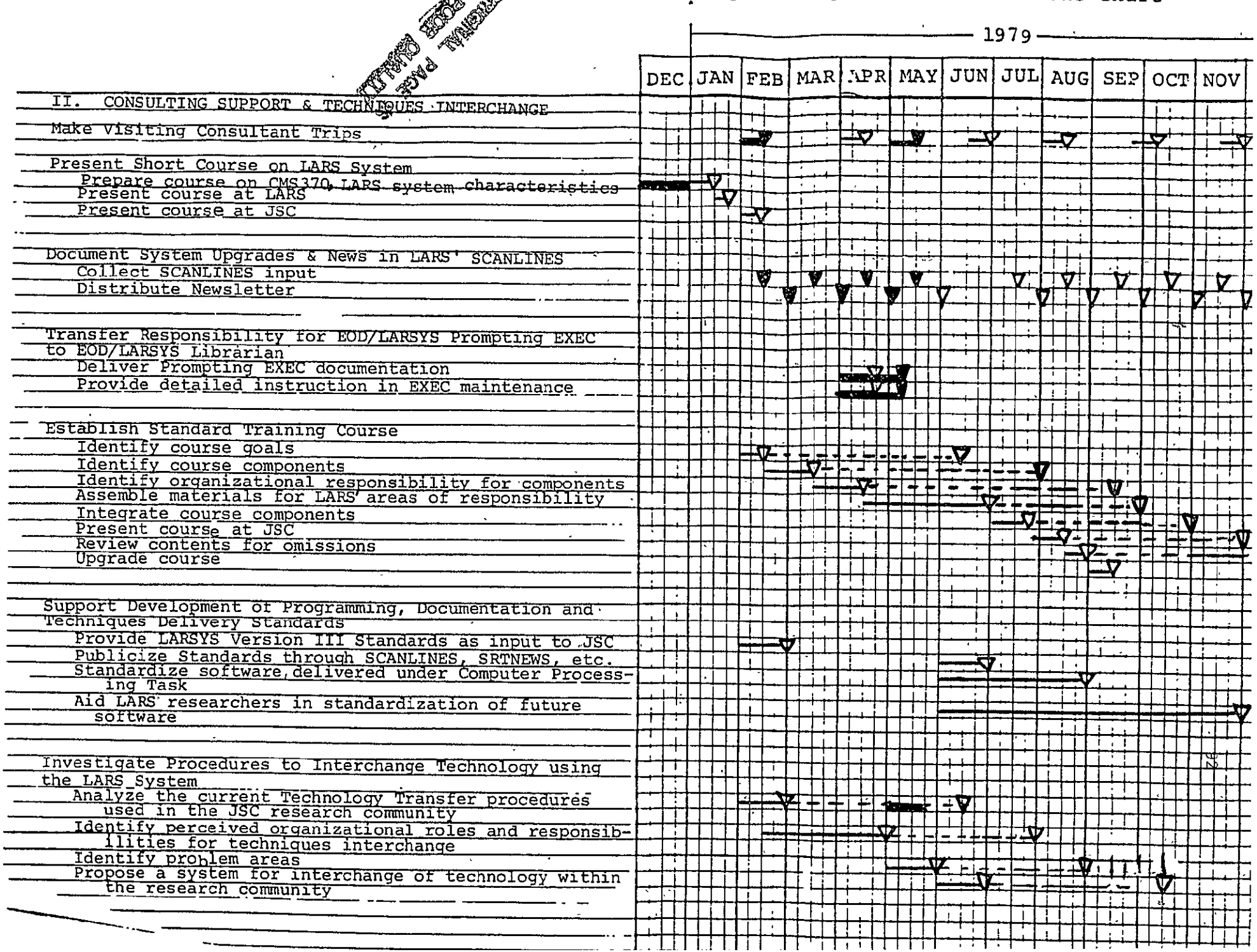
ADMINISTRATIVE MATTERS

ANNOUNCE RATES FOR THE 3031 (8/1/79).

JLK: 5/21/79

TASK 3A: COMPUTER PROCESSING SUPPORT DETAILED SCHEDULE

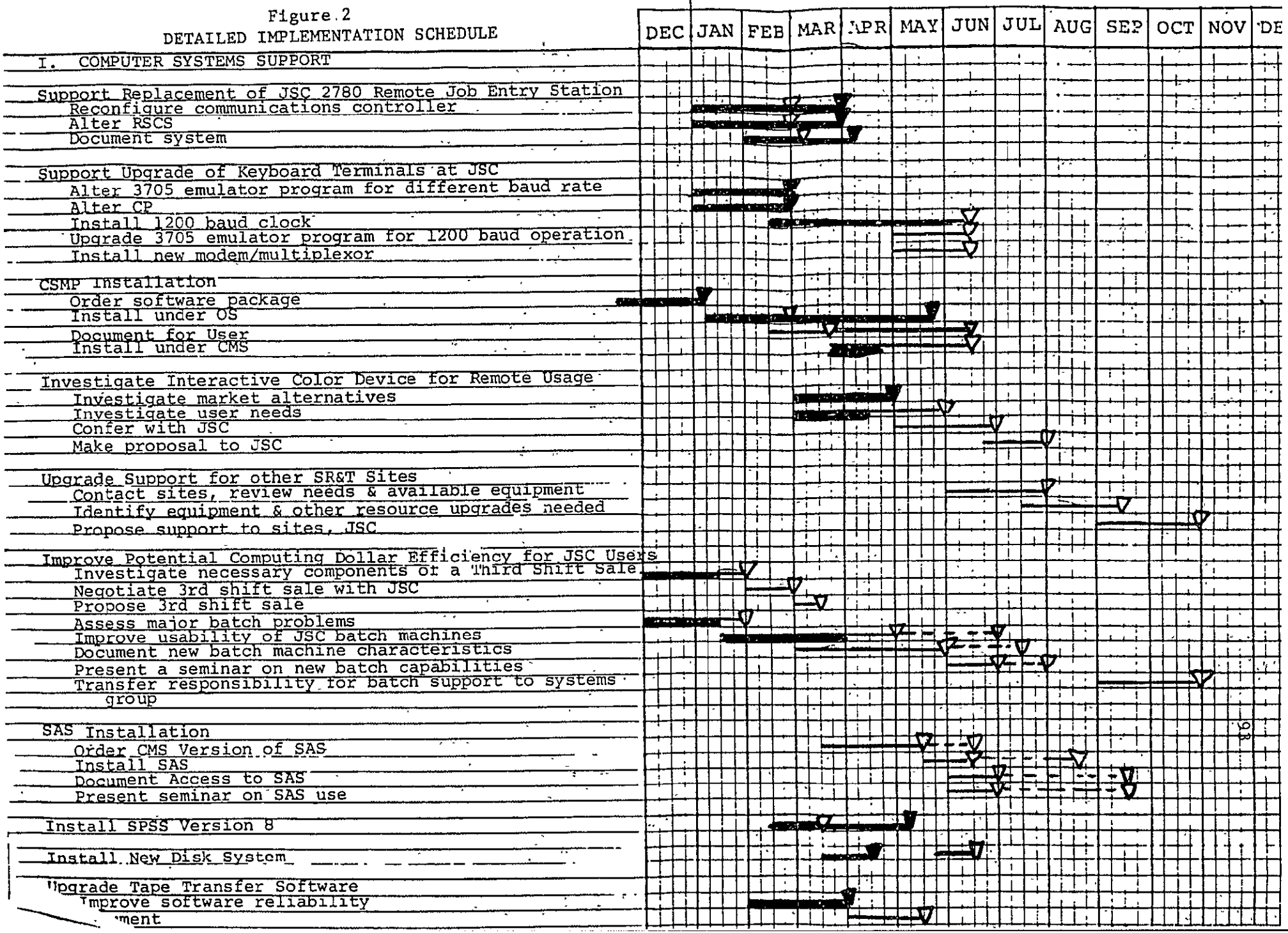
Computer Capabilities Milestone Chart



TASK 3A: COMPUTER PROCESSING SUPPORT DETAILED SCHEDULE

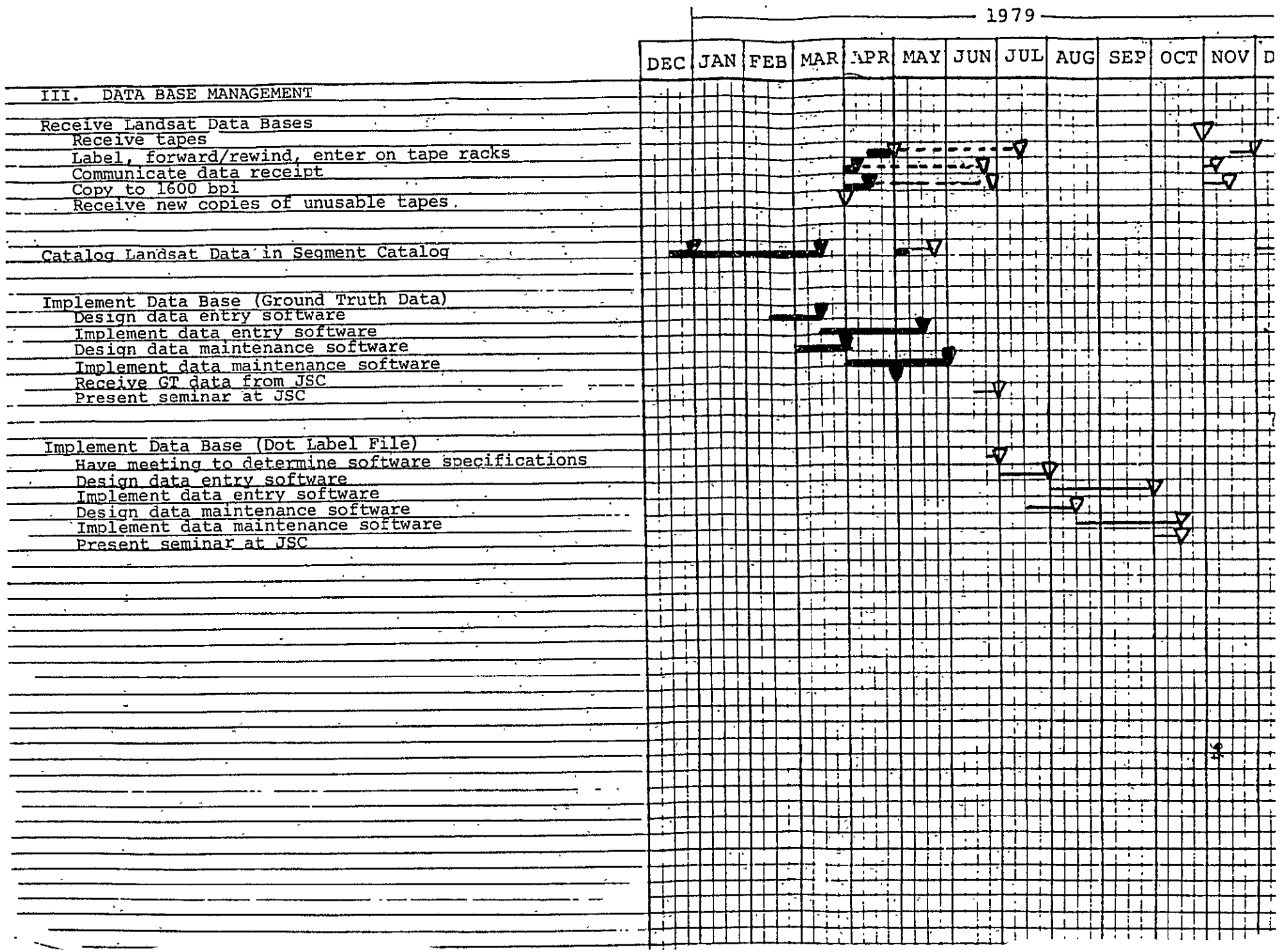
Computer Capabilities Milestone Chart

Figure 2
DETAILED IMPLEMENTATION SCHEDULE



TASK 3A: COMPUTER PROCESSING SUPPORT DETAILED SCHEDULE

Computer Capabilities Milestone Chart



3B. Field Research Data Base Management and Distribution

The overall objective of this task is to assure the timely availability to researchers of the Johnson Space Center field research data stored at Purdue/LARS. The following pages contain the material presented in the oral briefing for this quarterly report.

The first two charts summarize the objectives for this task. The third chart lists the specific accomplishments in this quarter. The Exotech 20C data and agronomic measurements collected during 1978 at the Purdue Agronomy Farm are available for researchers to use. The .7 μm anomaly in the FSS data was studied and a report prepared for the technical monitor. The data library catalogs have been reorganized and combined into one document. The catalog will include more information specifically for spectrometer/radiometer data, to help users and potential users of the data. The fourth chart summarizes the status of the data processing.

Charts 5 through 10 are a summary of the NASA/Johnson Space Center Field Research data base, including major spectral instruments, test sites, data available, and users.

The last chart includes the plans for the next quarter.

Task 3B Field Research Data Base Management and Distribution

Objective:

Assure the timely availability to researchers of the Johnson Space Center Field Research Data stored at Purdue/LARS

C-2

Field Research Data Base Management and Distribution

Specific Objectives:

1. Distribute field research data for all approved requests
2. Maintain and update present field research data base
3. Include 1978 Purdue Agronomy Farm data into data base
4. Include 1978 Hand County, South Dakota data into data base
5. Revise and update field research catalogs
6. Document calibration and correlation of the spectral data in the data base
7. Determine feasibility of using computer data base management system
8. Include available 1979 Field Research Data into data base
9. Include soil data of task 1D into data base

ACCOMPLISHMENTS FOR THE QUARTER

1978 EXOTECH 20C SPECTROMETER DATA COLLECTED AT PURDUE AGRONOMY FARM MADE AVAILABLE FOR RESEARCHERS.

6 DATES OF 1978 EXOTECH 100 RADIOMETER DATA COLLECTED AT PURDUE AGRONOMY FARM MADE AVAILABLE FOR RESEARCHERS.

FIELD RESEARCH DATA DISTRIBUTED TO GODDARD INSTITUTE FOR SPACE STUDIES.

CAUSE FOR .7 μM ANAMOLY IN FSS DATA STUDIED.

FIELD RESEARCH DATA LIBRARY CATALOGS HAVE BEEN REORGANIZED. DRAFT COPIES WILL BE AVAILABLE DURING FIRST PART OF NEXT QUARTER FOR REVIEW.

Processing Status for Field Research Data Base

Instrument/Data Type	Crop Year(s) 1975-1977	1978 Complete	In Process
Landsat MSS			
Whole Frame CCT (Frames)	116	8	---
Aircraft Scanner			
(Dates/Flightlines)	42/281	4/20	---
Helicopter Mounted Field Spectrometer (Dates/Observations)			
Field Averages	67/6409	2/128	6/
Individual Scans	67/102,115	2/4062	6/
Truck Mounted Field Spectrometer/Multiband Radiometer (Dates/Observations)			
FSAS	45/813	---	---
Exotech 20C	63/5216	24/1155	---
Exotech 20D	45/645	---	---
Exotech 10C	11/3000	6/1500	20/

Summary of Major Spectral Instruments Used for NASA/Johnson Space Center Field Research

Spacecraft Multispectral Scanners

Aircraft Multispectral Scanners

Helicopter Mounted Spectrometer

Truck Mounted Spectrometers

Truck Mounted Multiband radiometer

Tripod Mounted Multiband Radiometers

Summary of NASA/Johnson Space Center Field Research Test Sites

Controlled Experimental Plot Test Sites

Garden City, Kansas, Agriculture Experiment Station: 1974-1977

Williston, North Dakota, Agriculture Experiment Station: 1975-1977

West Lafayette, Indiana, Purdue University Agronomy Farm: 1978-1979

Sandhills, Nebraska, Agriculture Experiment Station: 1979

Summary of NASA/Johnson Space Center Field Research Test Sites (cont.)

Commercial Field Test Sites

Finney County, Kansas, 1974-1977

Williams County, North Dakota, 1975-1977

Hand County, South Dakota, 1975-1979

Webster County, Iowa, 1979

Summary of Data in NASA/Johnson Space Center Field Research Data Base

Landsat frames	124
Aircraft Scanner dates/flightlines	46/301
Helicopter Mounted Spectrometer dates/observations	69/115,000
Truck Mounted Spectrometer dates/observations	177/8,000
Truck Mounted Multiband Radiometer dates/observations	17/4,500

SR&T Users of NASA/Johnson Space Center

Field Research Data

Environmental Research Institute of Michigan

NASA, Johnson Space Center

Purdue University, Laboratory for Applications of Remote Sensing

Texas A&M University, Remote Sensing Center

Non-SR&T Recipients of NASA/Johnson Space Center Field Research Data

Institution/Company	Number of Requests
NASA/Goddard Space Flight Center 45,000 spectrometer observations Aircraft photography 8 Landsat segments and photography Helicopter and ground photography	5
General Electric Corporation 15,000 spectrometer observations 7 Landsat frames and color composites	2
University of South Florida 2,600 spectrometer observations	1
USDA, Agriculture Research Service, Weslaco, Texas 3,500 spectrometer observations 2 dates helicopter photography	1
Goddard Institute for Space Studies 20,000 spectrometer observations 4 dates/12 flightlines aircraft scanner data	2

Field Research Data Base Management and Distribution

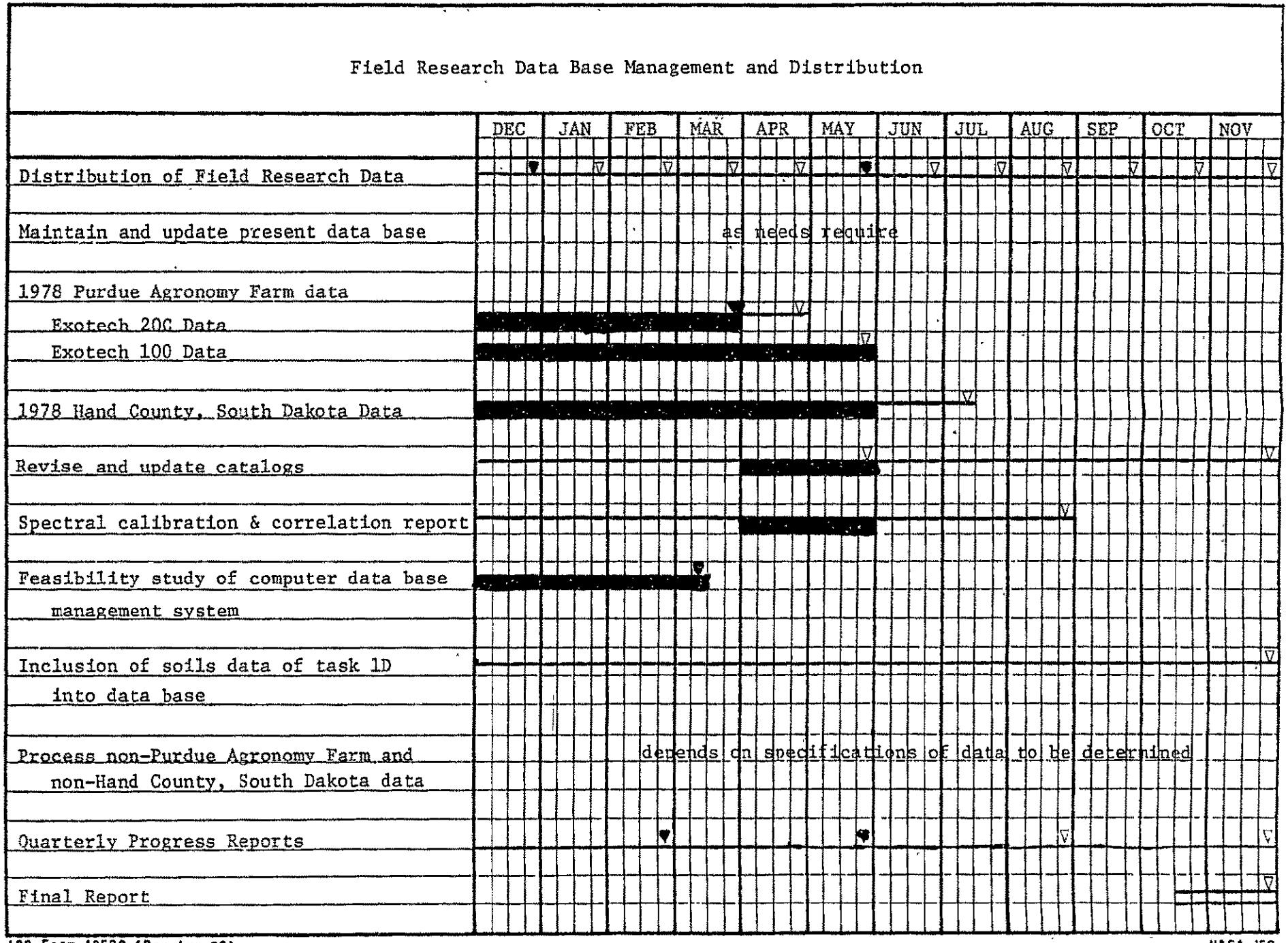
Plans for Next Quarter

Make last 15 dates of 1978 Exotech 100 radiometer data collected at Purdue University Agronomy Farm available for researchers.

Make 1978 FSS data collected over Hand County, South Dakota Intensive Test Site available for researchers.

Provide draft copies of revised catalogs for technical monitor for review.

Figure 3B-1 Detailed Implementation Schedule for Task 3B



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