LARS Contract Report 053180

Quarterly Progress Report and Presentation (March 1, 1980 to May 31, 1980)

on

Remote Sensing of Agriculture and Earth Resources

Contract NAS9-15466

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West Lafayette, Indiana

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May 20, 1980

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QUARTERLY REVIEW PRESENTATION AGENDA

1. SUPPORTING FIELD RESEARCH AND AGRICULTURAL SCENE UNDERSTANDING

TASK 1A: EXPERIMENT DESIGN AND DATA ANALYSIS

MARVIN BAUER AND VERN VANDERBILT

SUPPORTING FIELD RESEARCH

- FIELD RESEARCH PROVIDES BASIS FOR LARGER SCALE SATELLITE EXPERIMENTS, PILOT TESTS AND EVALUATIONS

OBJECTIVES

- ANALYSIS AND PHYSICAL MODELING OF SPECTRAL PROPERTIES OF CROPS AND SOILS IN RELATION TO AGRONOMIC AND OTHER PHYSICAL CHARACTERISTICS
  - DEVELOPMENT OF RELATIONSHIPS AND MODELS WHICH PREDICT AGRONOMICALLY IMPORTANT CROP CANOPY CHARACTERISTICS FROM SPECTRAL, ETC. INPUTS
    - GROWTH AND DEVELOPMENT STAGES
    - LEAF AREA INDEX, BIOMASS, PERCENT CANOPY COVER
    - CANOPY VIGOR OR STRESS
  - DEVELOP RELATIONSHIPS AND MODELS WHICH PREDICT SPECTRAL RESPONSE OF CROPS BASED ON CULTURAL AND ENVIRONMENTAL FACTORS
    - AGRONOMIC FACTORS - ROW WIDTH, VARIETY, ETC.
    - SOIL BACKGROUND CONDITIONS
    - ATMOSPHERIC EFFECTS
- ASSESS CAPABILITY OF CURRENT, PLANNED, AND FUTURE SATELLITE SENSOR SYSTEMS TO CAPTURE AVAILABLE INFORMATION

SUPPORTING FIELD RESEARCH (CON'T)

- LANDSAT MSS AND THEMATIC MAPPER
- MULTISPECTRAL RESOURCE SAMPLE (MRS)
- OPTICAL + RADAR/MICROWAVE MEASUREMENTS

- PROVIDE CANDIDATE MODELS, ANALYST AIDS, ANALYSIS TECHNIQUES AS INPUT TO SUPPORTING RESEARCH AND FCPF EXPLORATORY EXPERIMENTS AND PILOT TESTS
  - GROWTH STAGE MODELS
  - SPECTRAL AIDS (E.G. TRANSFORMATIONS OF TM)
  - STRESS MODELS
  - IMAGE PRODUCTS

Supporting Field Research--Experiment Design and Data Analysis

Objectives

- DESIGN MULTIYEAR TECHNICAL PROGRAM OF SUPPORTING FIELD RESEARCH FOR CORN, SOYBEANS, AND SMALL GRAINS
- DESIGN EXPERIMENTS REQUIRING DATA COLLECTION IN 1980-81
- PERFORM ANALYSIS OF FIELD RESEARCH DATA IN SUPPORT OF CORN-SOYBEAN GROWTH STAGE AND YIELD TASKS
- ANALYZE FIELD RESEARCH DATA ON CORN, SOYBEANS, AND SMALL GRAINS IN TERMS OF DEVELOPING MODELS OF REFLECTANCE OF CROP CANOPIES AS FUNCTION OF IMPORTANT AGRONOMIC AND MEASUREMENT VARIABLES

General Approach

- EXPERIMENT DESIGN AND DATA ANALYSIS BASED ON TECHNICAL ISSUES AND NEEDS
- DATA ACQUISITION ON CONTROLLED EXPERIMENTS AND COMMERCIAL FIELDS; COOPERATIVE WITH USDA AND LAND GRANT UNIVERSITIES
- SPECTRAL MEASUREMENTS WITH LANDSAT MSS, AIRCRAFT MSS, HELICOPTER SPECTROMETER AND TRUCK-MOUNTED SPECTROMETER AND RADIOMETER
- DATA ANALYSIS INCLUDES PHYSICAL OR EXPLANATORY AS WELL AS CORRELATIVE MODELS OF SPECTRAL-AGRONOMIC PROPERTIES OF CROP CANOPIES

SPECIFIC TASKS

1. DESIGN OF MULTIYEAR SUPPORTING FIELD RESEARCH

IN CONCERT WITH JSC, UPDATE CURRENT PLANS DESCRIBING TECHNICAL OBJECTIVES, DATA REQUIREMENTS, DESCRIPTIONS OF TEST SITES AND CONTROLLED EXPERIMENTS, PREPROCESSING, AND DATA ANALYSIS AND MODELING.

2. DEFINITION OF 1980-81 EXPERIMENTS/DATA REQUIREMENTS

UPDATE SFR PROJECT PLAN INCORPORATING NEW SPRING WHEAT-BARLYE AND RICE TEST SITES AND PROVIDING MORE INFORMATION ON DATA ANALYSIS TASKS, OBJECTIVES AND APPROACHES, INCLUDING DATA REQUIREMENTS.

<u>RECOMMENDED DESIGN OBJECTIVES</u>

- TO DETERMINE THE REFLECTANCE AND RADIANT TEMPERATURE CHARACTERISTICS OF CORN AND SOYBEANS AS A FUNCTION OF MATURITY STAGE AND AMOUNT OF VEGETATION PRESENT.
- TO DETERMINE THE EFFECTS OF STRESSES INCLUDING MOISTURE DEFICITS, NUTRIENT DEFICIENCIES AND DISEASE ON THE REFLECTANCE AND RADIANT TEMPERATURE PROPERTIES OF CORN, SOYBEANS, AND WINTER WHEAT.
- TO DETERMINE THE EFFECT OF IMPORTANT AGRONOMIC PRACTICES (E.G. PLANTING DATE, PLANT POPULATION, FERTILIZATION) AND ENVIRONMENT FACTORS ON THE SPECTRAL CHARACTERISTICS OF CORN AND SOYBEANS.
- TO SUPPORT THE DEVELOPMENT OF CORN, SOYBEANS AND SMALL GRAIN DEVELOPMENT STAGE AND YIELD MODELS WHICH USE AS AN INPUT SPECTRAL RESPONSE AS A FUNCTION OF CROP DEVELOPMENT STAGE.

- TO DETERMINE USING PRESENT AND FUTURE LANDSAT SPECTRAL BANDS THE SPECTRAL SEPARABILITY OF CORN, SOYBEANS, AND OTHER TYPICAL CORN BELT CROPS AND SPRING WHEAT AND BARLEY AS A FUNCTION OF DATE, MATURITY STAGE, SOIL BACKGROUND CONDITIONS, AND OTHER AGRONOMIC AND MEASUREMENT VARIABLES.

3. Data Analysis and Modeling

1. Spectral crop development stage determination
2. Estimation of canopy variables from spectral measurements
3. Assessment of effects of agronomic factors on corn and soybean reflectance
4. Analysis of effects of nitrogen nutrition on spectral reflectance of corn and winter wheat
5. Analysis of effects of moisture stress on spectral response of corn
6. Analysis and model of relationship of percent soil cover, row direction and sun angle to reflectance of soybeans
7. Comparison of MSS and TM spectral bands for discrimination of corn and soybeans
8. Theoretical model of potential of polarization measurements to estimate crop development stage, leaf area and vigor; comparison of model and empirical results
9. Analysis and model of effects of sun angle and view angle on reflectance of spring wheat as a function of development stage

ACCOMPLISHMENTS THIS QUARTER

1. DATA ANALYSIS PLANS, INCLUDING LITERATURE REVIEW, OBJECTIVES, DATA ANALYSIS APPROACH, DATA REQUIREMENTS AND PRODUCTS COMPLETED FOR

   - CROP GROWTH AND DEVELOPMENT STAGE DETERMINATION
   - ESTIMATION OF CANOPY VARIABLES FROM SPECTRAL MEASUREMENTS
   - EFFECTS OF CULTURAL, SOIL AND ENVIRONMENTAL FACTORS ON SPECTRAL PROPERTIES OF CORN AND SOYBEANS

2. PLANS ARE CURRENTLY BEING COMPLETED FOR

   - EFFECTS OF STRESS ON REFLECTANCE AND RADIANT TEMPERATURE OF CORN AND WINTER WHEAT CANOPIES
   - COMPARISON AND EVALUATION OF SPECTRAL BANDS FOR CROP IDENTIFICATION AND CONDITION ASSESSMENT
   - ANALYSIS AND MODEL OF RELATIONSHIP OF PERCENT SOIL COVER, ROW DIRECTION AND SUN ANGLE TO REFLECTANCE OF SOYBEANS

3. TECHNICAL REPORT COMPLETED ON THREE TOPICS

   - EFFECTS OF MANAGEMENT PRACTICES ON REFLECTANCE OF SPRING WHEAT CANOPIES
   - A MODEL OF PLANT CANOPY POLARIZATION RESPONSE
   - SIMULATED RESPONSE OF A MULTISPECTRAL SCANNER OVER WHEAT AS A FUNCTION OF WAVELENGTH AND VIEW/ILLUMINATION DIRECTIONS

ACCOMPLISHMENTS, CONT

4. DATA ANALYSES IN PROGRESS

- CORN AND SOYBEAN DEVELOPMENT STAGE DETERMINATION
- EFFECTS OF SOIL BACKGROUND (DARK VS. LIGHT COLOR), PLANTING PATTERN (ROW WIDTH/PLANT POPULATION) AND PLANTING DATA ON SPECTRAL RESPONSE OF CORN AND SOYBEANS
- ESTIMATION OF LEAF AREA INDEX, BIOMASS AND PERCENT SOIL COVER OF CORN AND SOYBEANS FROM SPECTRAL MEASUREMENTS
- EFFECTS OF NITROGEN FERTILIZATION ON REFLECTANCE PROPERTIES OF CORN AND WINTER WHEAT CANOPIES
- ANALYSIS AND MODEL OF RELATIONSHIP OF PERCENT SOIL COVER, ROW DIRECTION AND SUN ANGLE TO REFLECTANCE OF SOYBEANS

Plans For Next Quarter

Completion and documentation of the following analyses

1.	Initial model of corn and soybean growth and development stage determiniation from reflectance measurements	July 1
2.	Analysis of effects of nitrogen nutrition on reflectance of corn (results of 2 years)	August 1
3.	Analysis of effects of nitrogen nutrition on reflectance of winter wheat (preliminary report, 1 year of data)	August 1
4.	Initial analyses (1 year data) of effects of soil type, cultivar, planting date and row spacing on reflectance of soybeans	September 1
5.	Initial analyses (1 year data) of effects of soil type, planting date, plant population on reflectance of corn	September 1
6.	Analysis and model of relationships of percent soil cover, row direction and sun angle to reflectance of soybeans	July 1
7.	Analysis of effect of moisture stress on spectral response of corn (Nebraska scanner data)	September 1

SIMULATED RESPONSE OF A MULTISPECTRAL SCANNER OVER WHEAT AS A FUNCTION OF WAVELENGTH AND VIEW/ILLUMINATION DIRECTIONS

VERN VANDERBILT

OBJECTIVE

MEASURE AND EMPIRICALLY MODEL SUN ANGLE-VIEW ANGLE EFFECTS FOR WAVELENGTH AND DEVELOPMENT STAGE IN CANOPY SPECTRA.

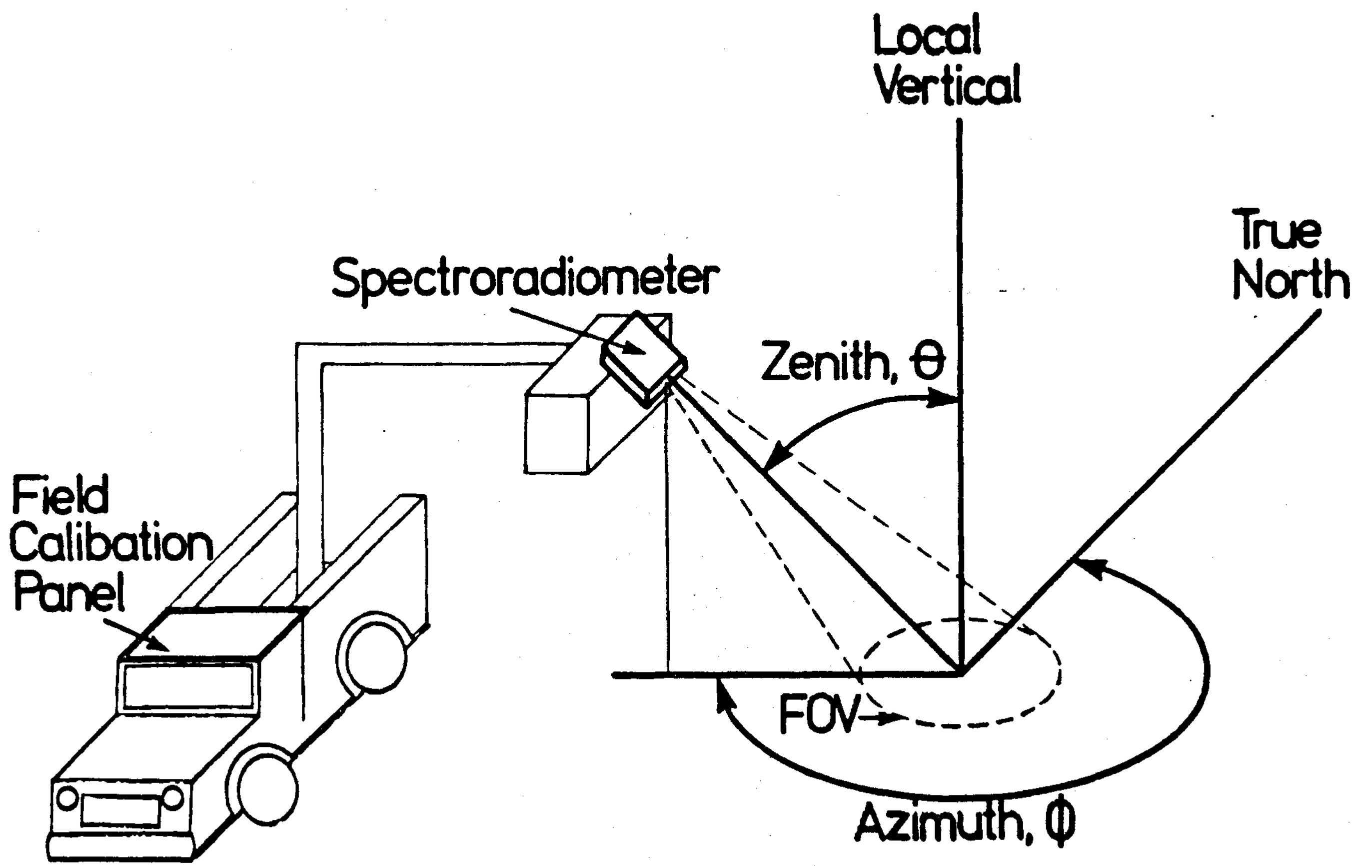
BACKGROUND

THIS KNOWLEDGE WILL INCREASE UNDERSTANDING OF THE SCENE DEPENDENT VARIATIONS ASSOCIATED WITH SCAN ANGLE IN LANDSAT DATA. THIS KNOWLEDGE WILL SUPPORT EFFORTS TO ANTICIPATE THE OFF-NADIR RESPONSE OF TWO FUTURE SATELLITE SENSORS, MULTISPECTRAL RESOURCE SAMPLER (MRS) AND SYSTEME PROBATOIRE D'OBSERVATION DE LA TERRE (SPOT).

Acquisition of Sun Angle-View Angle Data

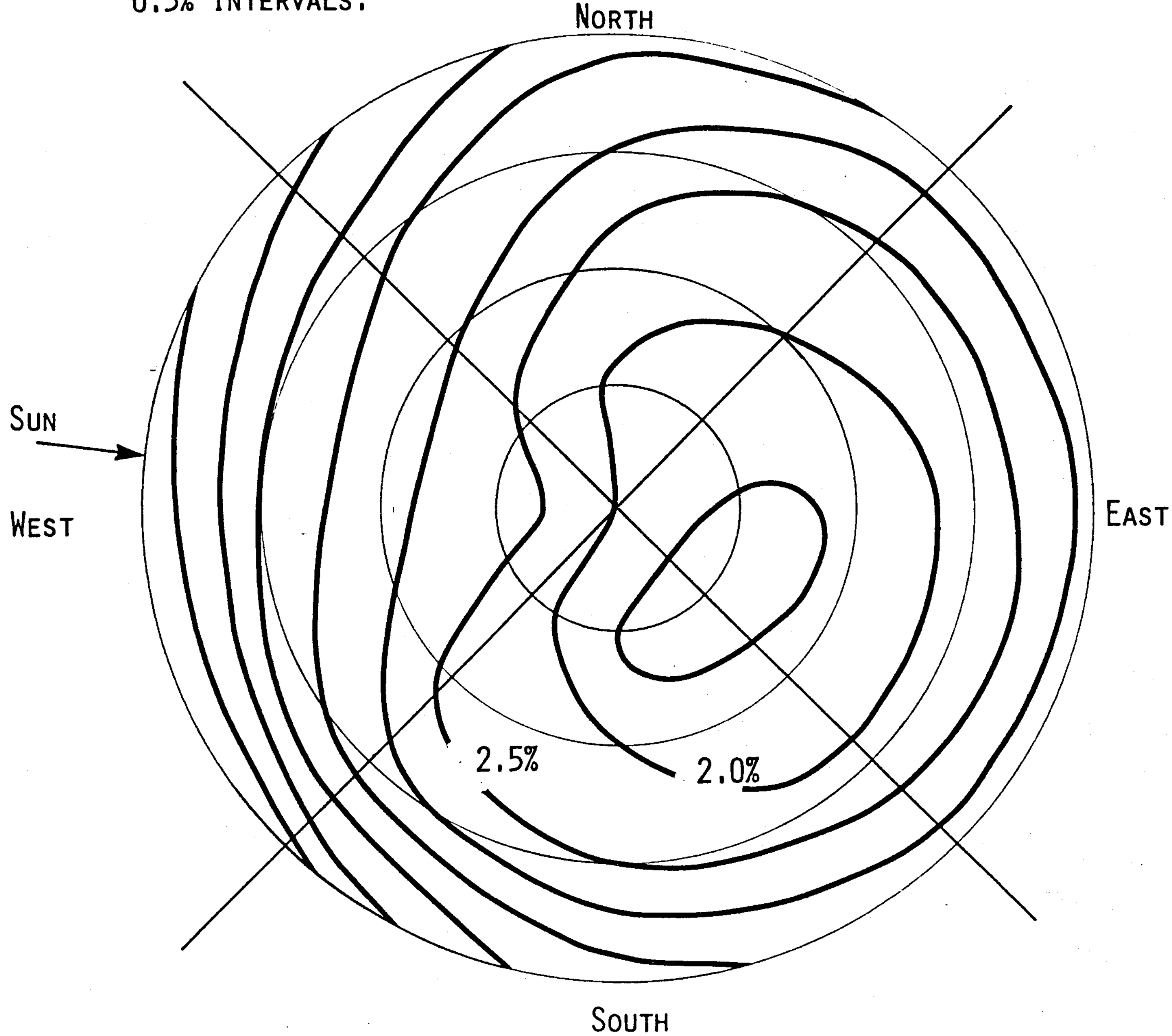
- More than 1200 spectra
- Four canopies - Four development stages
- Five zenith view angles
- Eight azimuth view angles
- Illumination angles from
  - 3 hours before solar noon to
  - 4 hours after solar noon
- Wavelength continuous from .45 to 2.4 μm

Coordinate System Used to Acquire Data

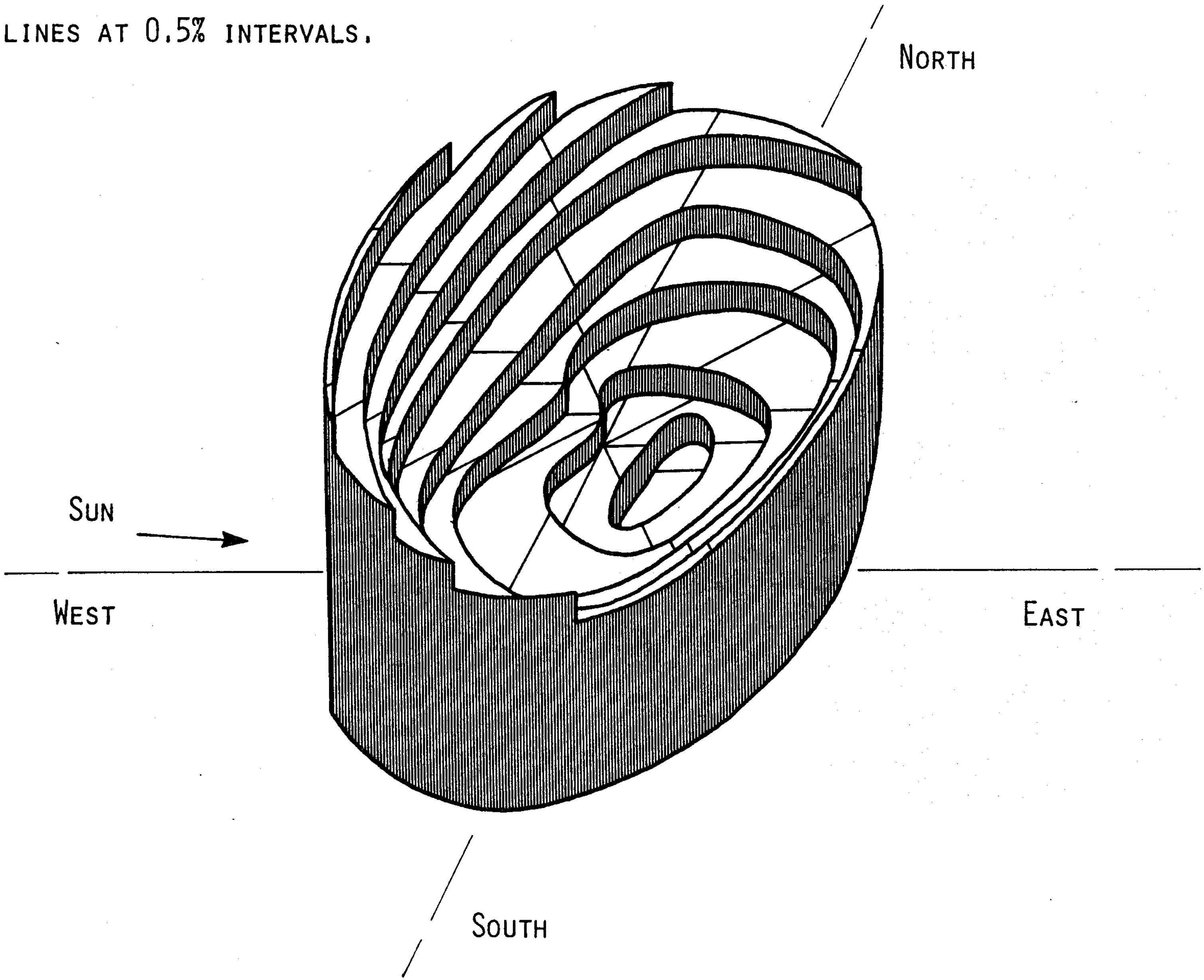


Bidirectional Reflectance Distribution Function of Wheat

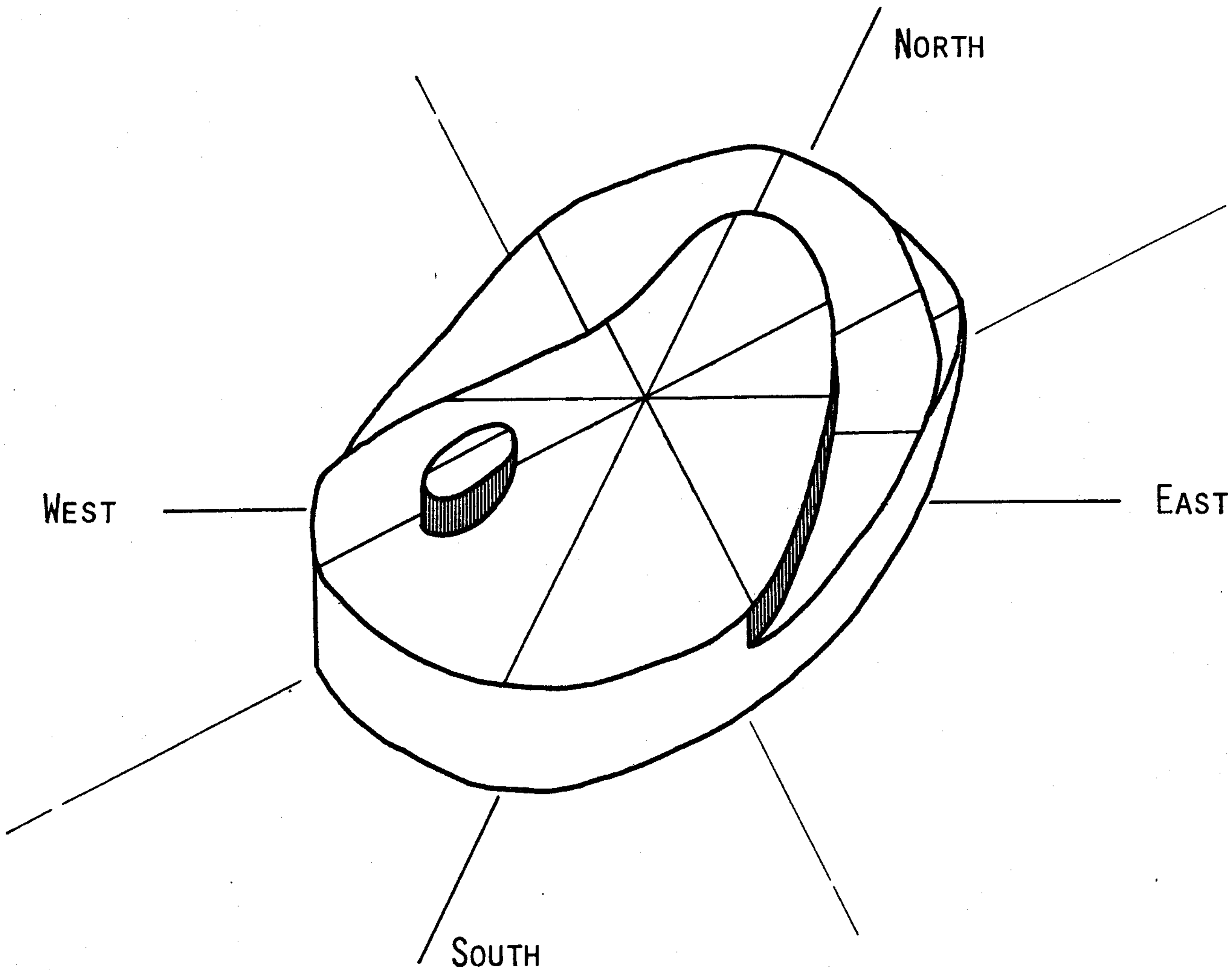
Data taken 21 July 1975, 00:05 GMT, Green Wavelengths. Data plotted using topographic notation with contour lines at 0.5% intervals.

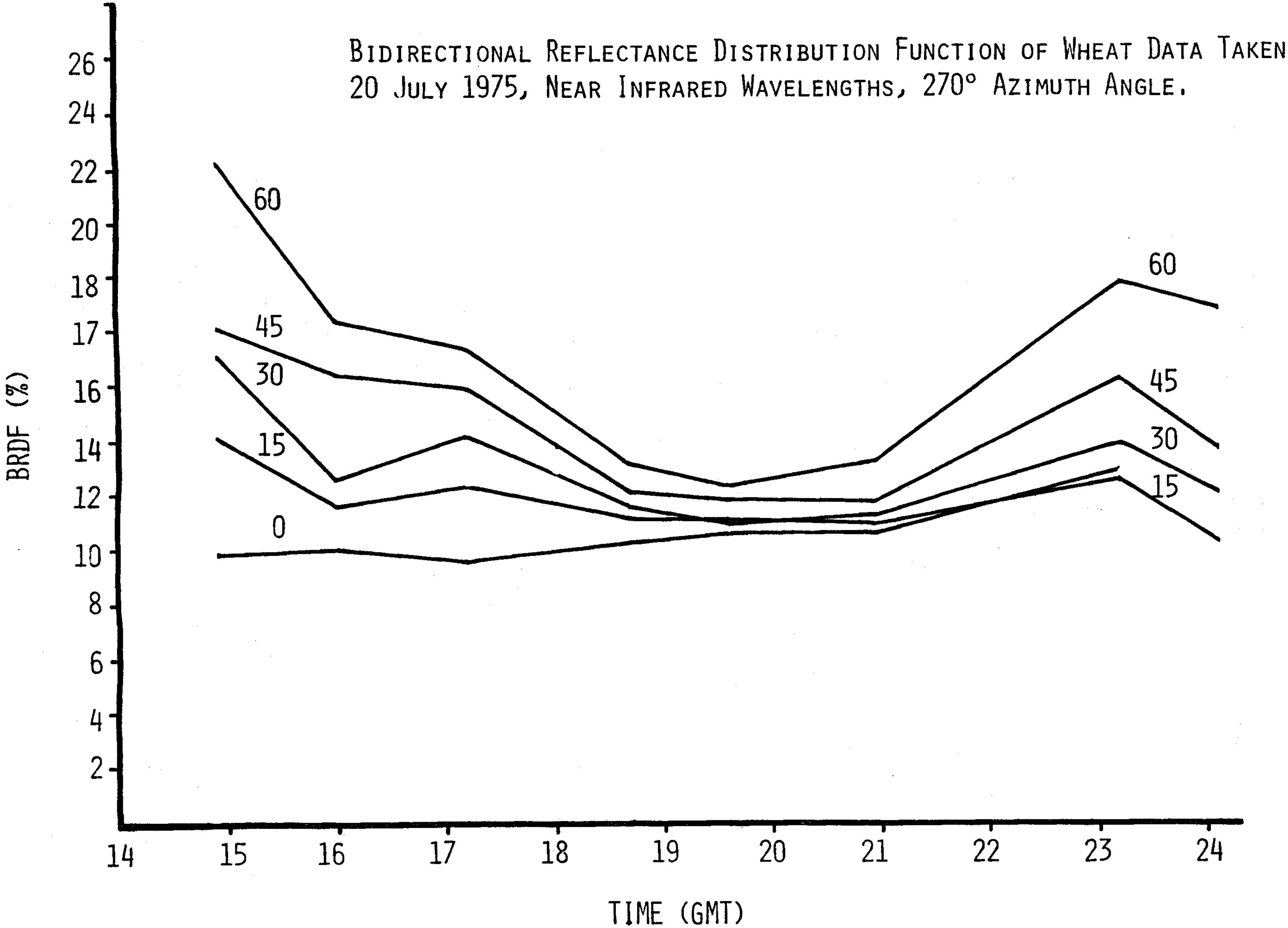


Bidirectional Reflectance Distribution Function of Wheat Data Taken 21 July 1975, 00:05 GMT, Green Wavelengths. Data plotted using topographic notation with contour lines at 0.5% intervals.

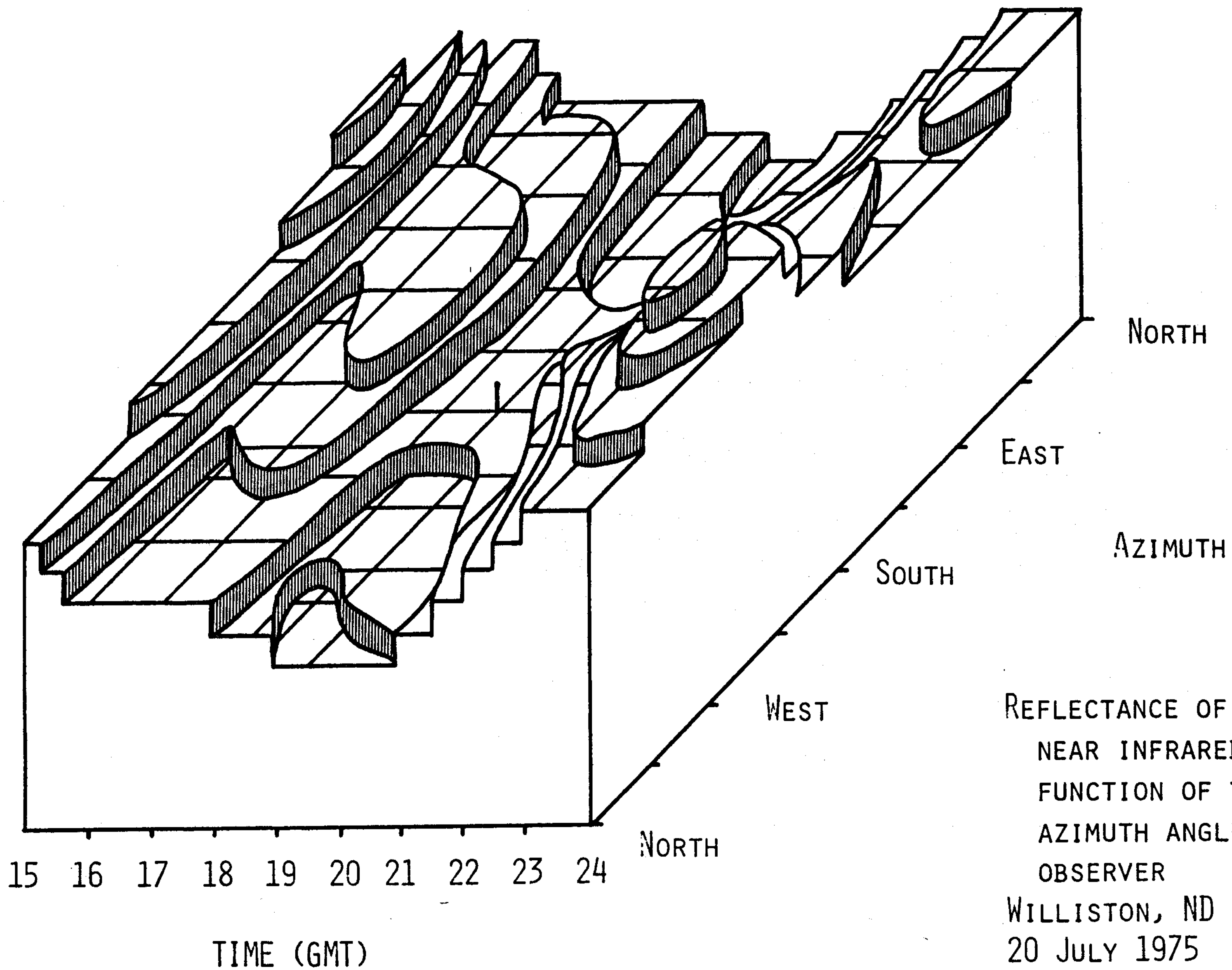


Bidirectional Reflectance Distribution Function of Wheat Data Taken 20 July 1975, 19:38 GMT, Red Wavelengths. Data plotted using topographic notation with contour intervals of 0.5%.




BIDIRECTIONAL REFLECTANCE DISTRIBUTION FUNCTION OF WHEAT DATA TAKEN
20 JULY 1975, NEAR INFRARED WAVELENGTHS, 270° AZIMUTH ANGLE.
BRDF (%)
TIME (GMT)
60
45
30
15
0
26
24
22
20
18
17
16
14
12
10
8
6
4
2
14
15
16
17
18
19
20
21
22
23
24

BIDIRECTION REFLECTANCE DISTRIBUTION FUNCTION OF WHEAT. DATA PLOTTED IN TOPOGRAPHIC NOTATION WITH CONTOUR INTERVALS OF 2.0 PERCENT. DATA TAKEN 20 JULY 1975, NEAR INFRARED WAVELENGTHS, 60° ZENITH ANGLE.



REFLECTANCE OF WHEAT IN NEAR INFRARED AS A FUNCTION OF TIME AND AZIMUTH ANGLE OF OBSERVER
WILLISTON, ND
20 JULY 1975
ZENITH ANGLE = 60°

Ancillary meteorologic and agronomic data.

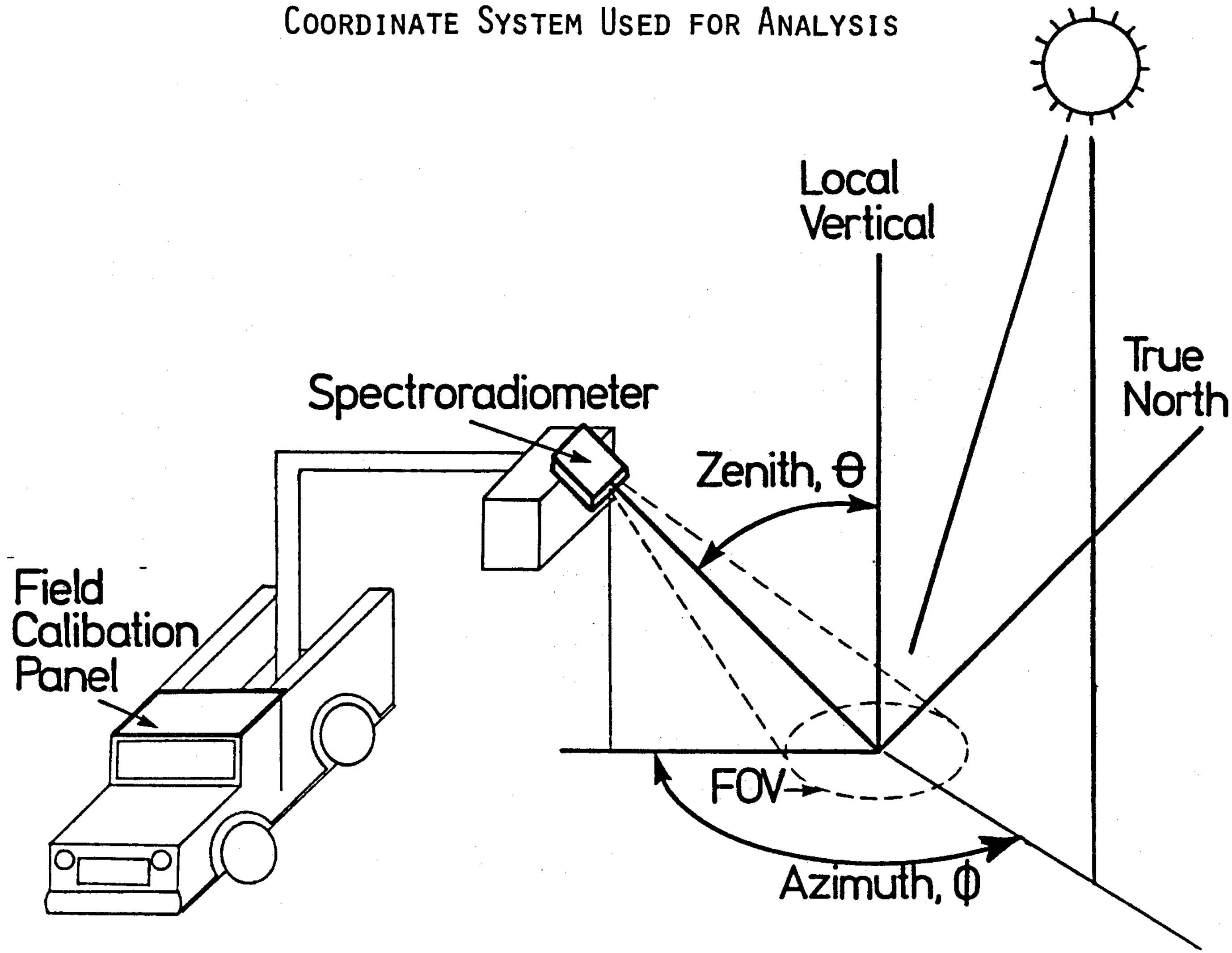
Variable	Date			
	21 Jun 76	20 Jul 75	17 Jul 76	31 Jul 76
relative humidity (%)	51	54	36	57
air temperature (C^{o})	19	27	28	23
barometric pressure (mm Hg)	770.9	759.4	771.4	777.2
cloud cover (%)	1		1	5
wind direction	northeast	southwest	southeast	southeast
wind speed (km/hr)	14	16	10	13
cultivar	Waldron	Wells	Ellar	Ellar
maturity stage	3.5/boot	4.5/fully headed	5.1/milk	5.4/ripe
row direction	east-west	east-west	north-south	north-south
row width (m)	0.18	0.21	0.18	0.18
fruit count (per m^2)	0.0		444.4	394.4
plant count (per m^2)	477.8	310.0	455.6	405.6
plant heigh (m)	0.48	0.72	0.85	0.86
leaves per plant	5.0		4.0	4.0
leaf condition (%)				
green	93		27	0
yellow	3		7	0
brown	4		66	100
dry biomass-total (gr/m^2)	216.9	345.1	689.8	625.9
fruit	0.0		268.1	330.2
green leaves	84.7		51	0.0
yellow leaves				
brown leaves			25.4	56.8
stems	132.3		345.3	238.9
fresh biomass-total (gr/m^2)	1131.1		1466.1	840.0
plant moisture (%)	81		53	25
leaf area index*	1.85	1.48	0.81	0.0

*leaf area index is the green one-sided leaf area per unit ground area

ANALYSIS APPROACH

- REGRESSION MODEL DEVELOPED
- EQUATION DEVELOPED AT EACH OF 48 WAVELENGTHS AND FOR EACH OF FOUR GROWTH STAGES, 194 EQUATIONS
- TRUNCATED SPHERICAL HARMONIC SERIES HANDLES VIEW ANGLE DEPENDENCE
- TRUNCATED POWER SERIES IN TIME (I.E., HOURS FROM SOLAR NOON) HANDLES SUN ANGLE DEPENDENCE

COORDINATE SYSTEM USED FOR ANALYSIS



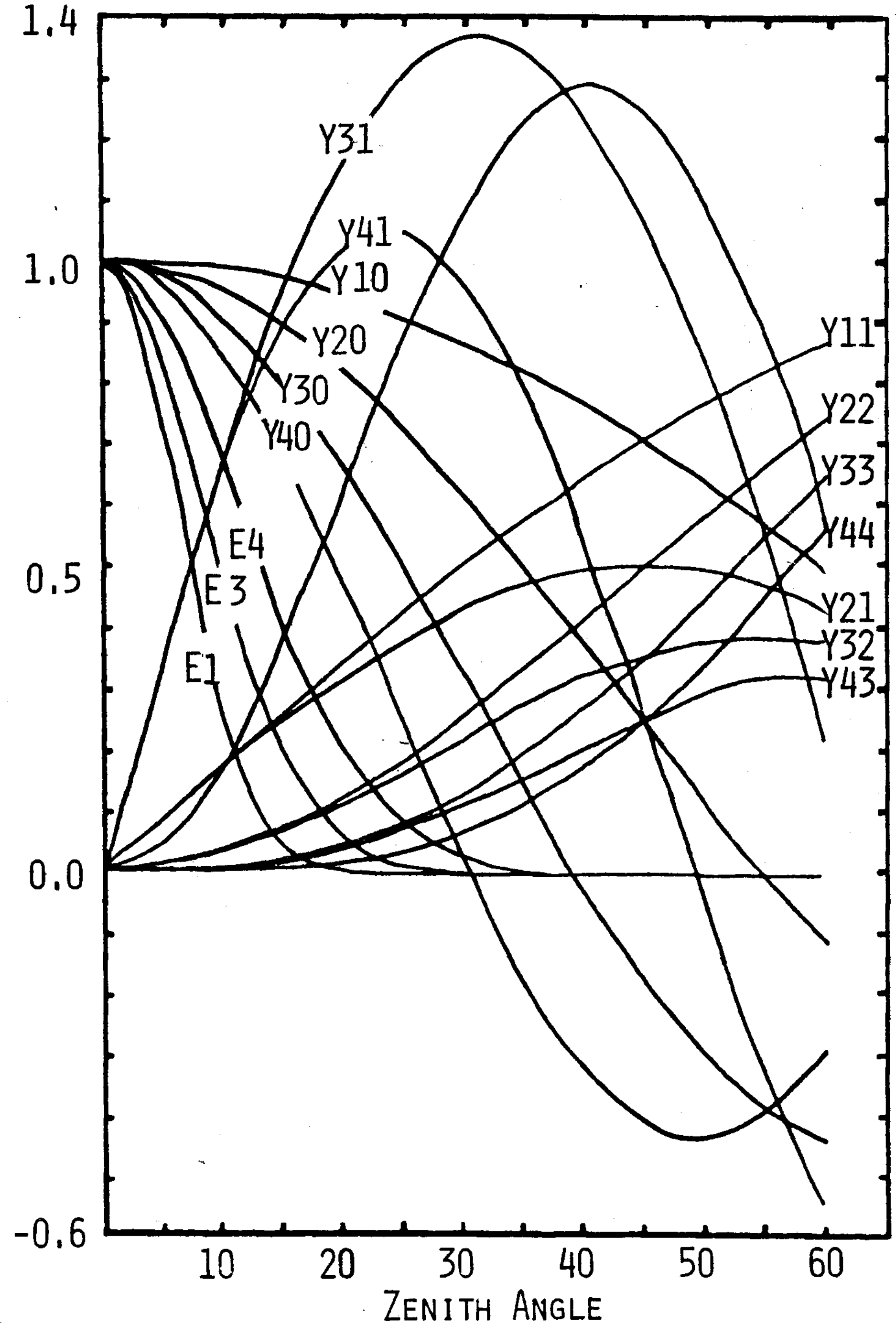
FUNCTIONS USED IN ANALYSIS

- Y10 TO Y44 TERMS OF SPHERICAL HARMONIC SERIES (ϕ = 0)
- E1, E3, AND E4 ARE DEFINED:

E1 = EXP(-0.0133*0**2)

E3 = EXP(-0.0071*0**2)

E4 = EXP(-0.0040*0**2)



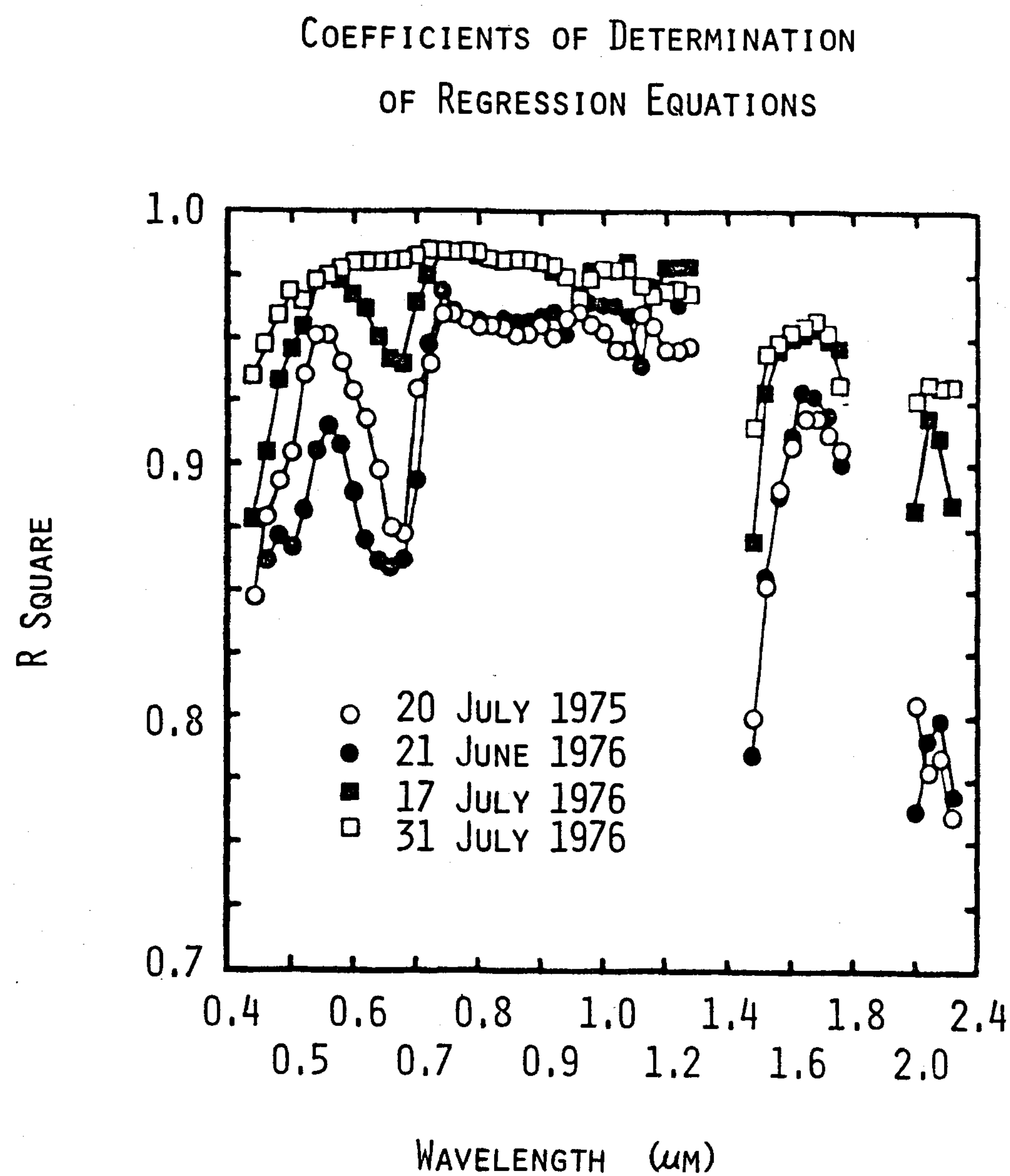
EXAMPLE OF REGRESSION EQUATION

21 JUNE 1976

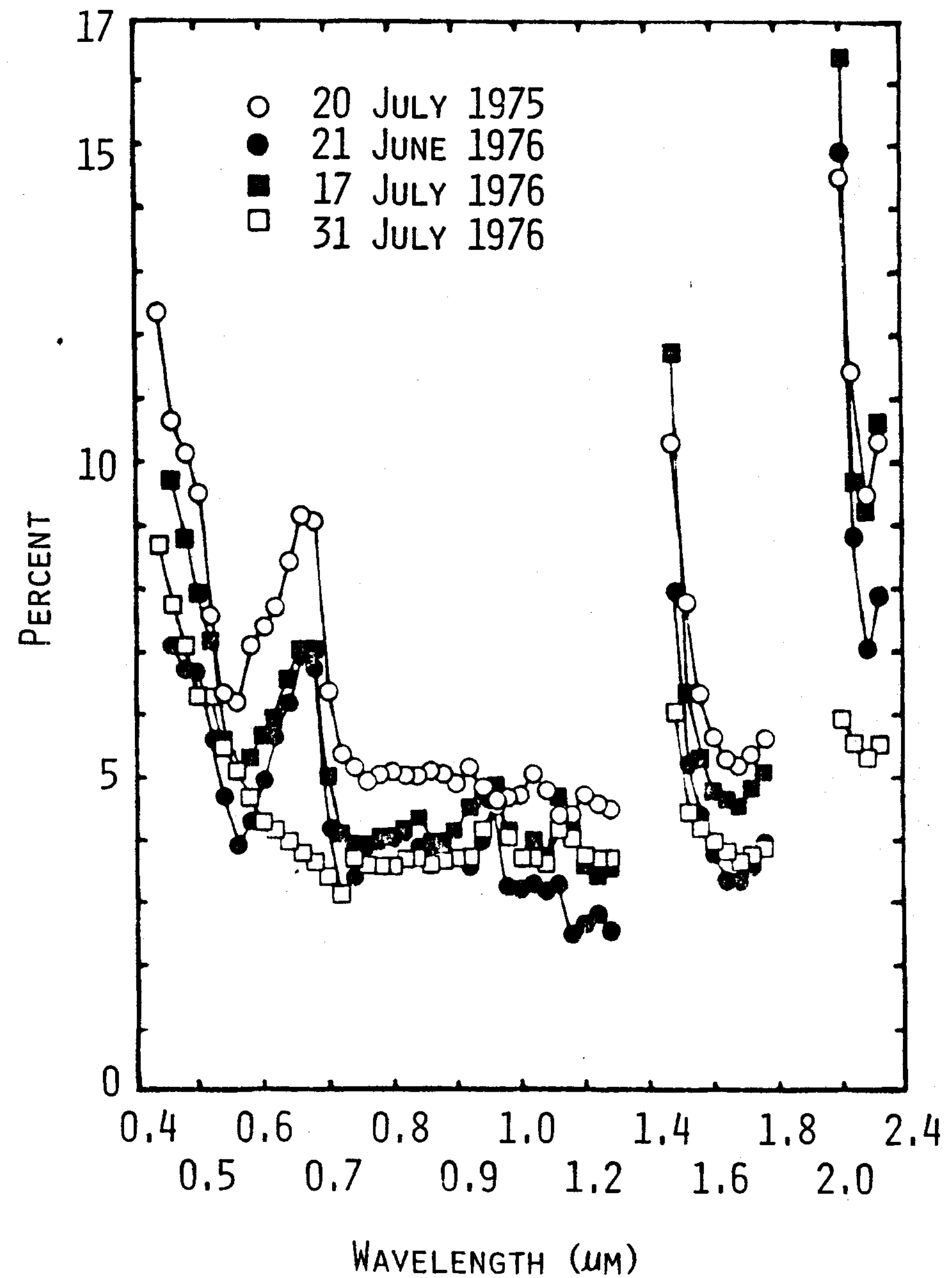
0.78 μM WAVELENGTH

LAMBDA = 0.78 UM	
Y10	-0.14244D 02
T2	0.10488D 01
Y21C	0.85274D 01
T2Y20	-0.87974D 00
Y22C	0.22996D 01
T1Y11S	-0.48615D 00
T5Y11C	0.16076D-02
T1Y22C	-0.90389D 00
T3Y22C	0.27100D-01
T6Y30	0.31372D-03
T1Y44S	-0.43185D 00
T5	0.23330D-02
T1Y10	0.28204D 00
T3	-0.83816D-01
E4	-0.10018D 01
T5Y43C	0.20359D-02
T1	0.38758D 00
T6Y22C	0.89107D-03
T2Y32C	-0.41139D 00
Y42C	0.55671D 00
CONSTA	0.44751D 02

$$
\begin{aligned}
\text{REFLECTANCE }(\theta,\phi,T) &= Y10*(-.14244*10^{2}) \\
&+ T^{2}*(0.10488*10^{1}) + Y21c*(0.85274*10^{1}) \\
&+ T^{2}*(Y20(-0.87974) + Y22c*(0.22996*10^{1}) \\
&+ T*Y11s*(-0.48615) + T^{5}*Y11c*(0.16076*10^{-2}) \\
&+ T*Y22c*(-0.90389) + T^{3}*Y22c*(0.27100*10^{-1}) \\
&+ T^{6}*Y30*(0.31372*10^{-3}) + T*Y44s*(-0.43185) \\
&+ T^{5}*(0.23330*10^{-2}) + T^{1}*Y10*(0.28204) \\
&+ T^{3}*(-0.83816*10^{-1}) + E4*(-0.10018*10^{1}) \\
&+ T^{5}*Y43c*(0.20359*10^{-2}) + T^{1}*(0.38758) \\
&+ T^{6}*Y22c*(0.89107*10^{-3}) + T^{2}*Y32c*(-0.41139) \\
&+ Y42c*(0.55671) + 0.44751*10^{2}
\end{aligned}
$$


COEFFICIENTS OF DETERMINATION
OF REGRESSION EQUATIONS
R SQUARE
1.0
0.9
0.8
0.7
20 JULY 1975
21 JUNE 1976
17 JULY 1976
31 JULY 1976
0.4
0.6
0.8
1.0
1.4
1.8
2.4
0.5
0.7
0.9
1.2
1.6
2.0
WAVELENGTH (μM)

Prediction Ability of Regression Equations: Standard Deviation of [100% (predicted - observed)/(observed)]



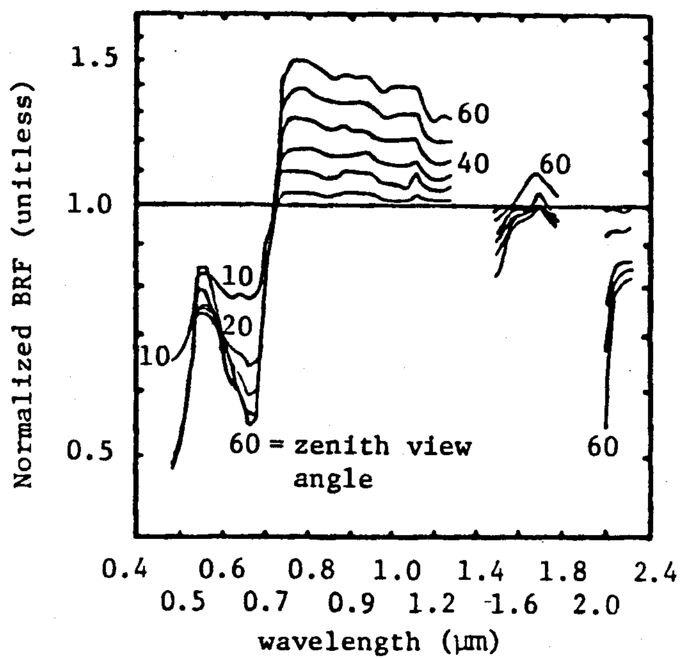
Results

- REGRESSION EQUATIONS AVAILABLE AS COMPUTER ALGORITHMS
- PLOTS OF CANOPY SPECTRAL RESPONSE COMPLETED AS FUNCTION OF ZENITH AND AZIMUTH VIEW ANGLES, TIME FROM SOLAR NOON, WAVELENGTH, AND GROWTH STAGE
- SCANNER RESPONSE SIMULATED AS FUNCTION OF SCAN ANGLE

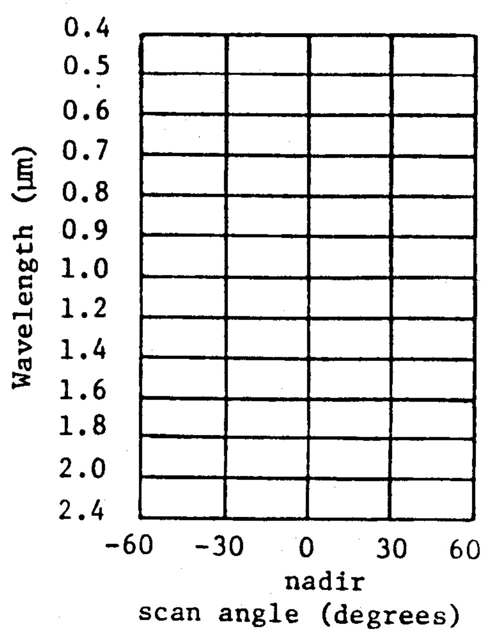
```
FILE: REQ731    FORTRAN  A
C**************************************************************REQ00
C                                                              REQ00
C     SUBROUTINE REQ731 CALCULATES THE REFLECTANCE FOR A GIVEN VALUE  REQ00
C     OF ZENITH, AZIMUTH, TIME, WAVELENGTH FOR 760731 FOR WHEAT AT    REQ00
C     WILLISTON, ND.                                           REQ00
C                                                              REQ00
C                                                              REQ00
C                      WRITTEN BY VERN VANDERBILT              REQ00
C                        6 APRIL 1979                          REQ00
C                                                              REQ00
C**************************************************************REQ00
      SUBROUTINE REQ731(Z,A,NUMLAM,R)                          REQ00
      COMMON ZZ,T1,T2,T3,T4,T5,T6,C,S,C1A,S1A,C2A,S2A,C3A,S3A,C4A,S4A
                                                               REQ00
      IF(NUMLAM.LT. 1)GOTO 49                                  REQ00
      IF(NUMLAM.GT.48)GOTO 50                                  REQ00
      GOTO ( 1, 2, 3, 4, 5, 6, 7, 8, 9,10,                     REQ00
     1      11,12,13,14,15,16,17,18,19,20,                     REQ00
     1      21,22,23,24,25,26,27,28,29,30,                     REQ00
     1      31,32,33,34,35,36,37,38,39,40,                     REQ00
     1      41,42,43,44,45,46,47,48),     NUMLAM               REQ00
    1 R=                                                       REQ00
     1 +( 0.2856789E-01)*Y11C   (Z,A) +( 0.1964688E-01)*T2*Y30   REQ00
     1 +( 0.3962099E-01)*T2*E4  (Z,A) +( 0.1863655E 01)*Y32C     REQ00
     1 +(-0.2511816E 01)*E1     (Z,A) +( 0.1384672E 00)*T2       REQ00
     1 +(-0.1003595E 01)*Y10    (Z,A) +( 0.4452762E 00)*Y21S     REQ00
     1 +(-0.1443572E 00)*T1           +(-0.7989221E-01)          REQ00
     1 +( 0.2134176E 00)*T2*Y20 (Z,A) +(-0.2044132E-01)          REQ00
     1 +( 0.1826282E 00)*T2*Y31C (Z,A) +( 0.1814257E-02)*T2*Y.   REQ00
     1 +( 0.5299904E-03)*T6*Y41C (Z,A) +( 0.1096805              REQ00
     1 +( 0.4017395E-01)*T2*Y33C (Z,A) +(-0.13                    REQ00
     1 +( 0.1997554E-01)*T2*Y33S (Z,A)                 (Z,A)     REQ00
     1 +( 0.5456339E 01)                               (Z,A)     REQ00
      GOTO 999                                                 REQ00
    2 R=                                                       REQ00
     1 +( 0.3789440E 01)*Y11C                                  REQ00
     1 +( 0.2030171E 01)*E1                                    REQ00
     1 +( 0.4998003E 00)
     1 +(-0.3306665E
     1 +(-0.6608
     1 +(-0.
```

Normalized BRF for Wheat

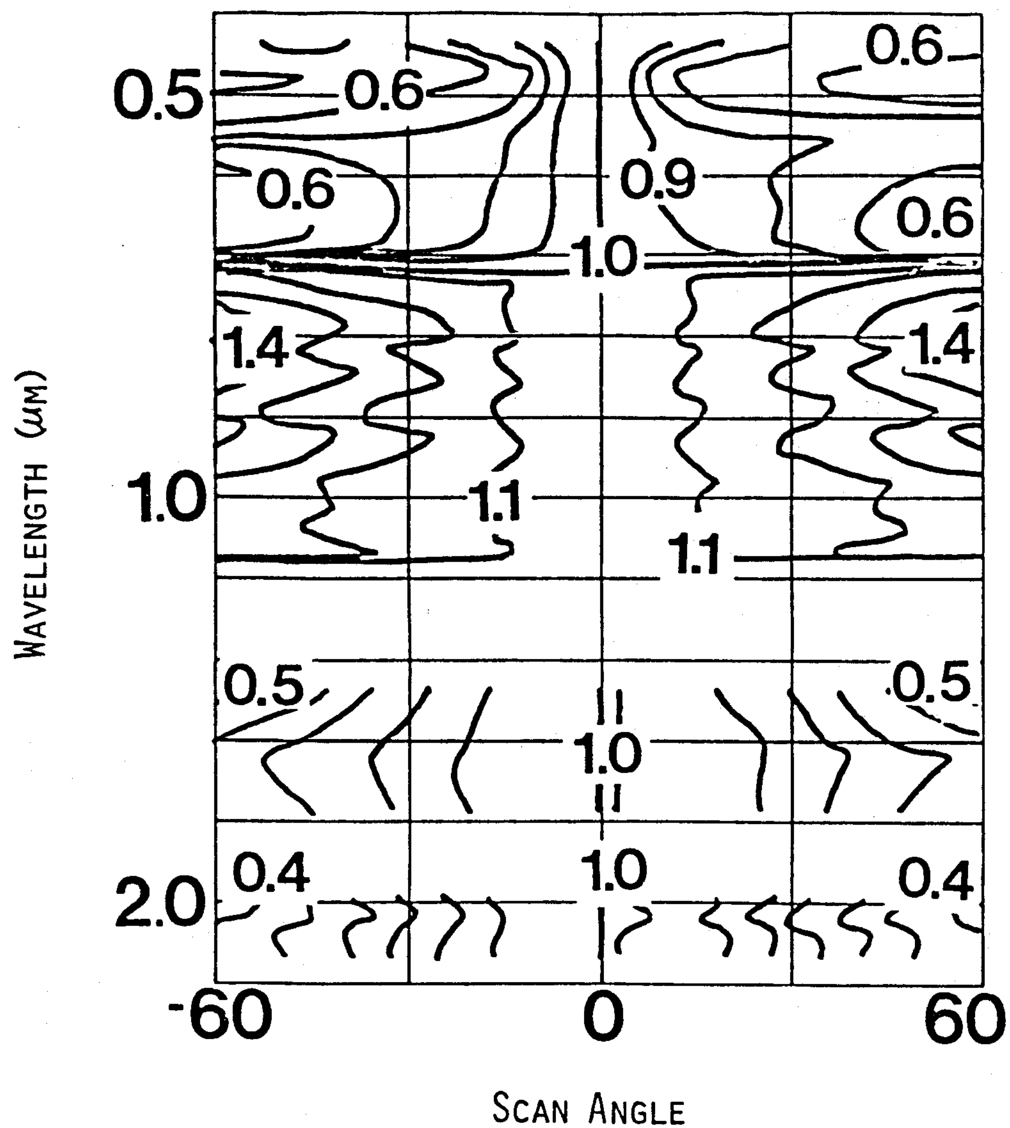
21 June 1976 three hours before noon with view azimuth 90° to sun azimuth. Sun (zenith, azimuth) = 43°,109°)



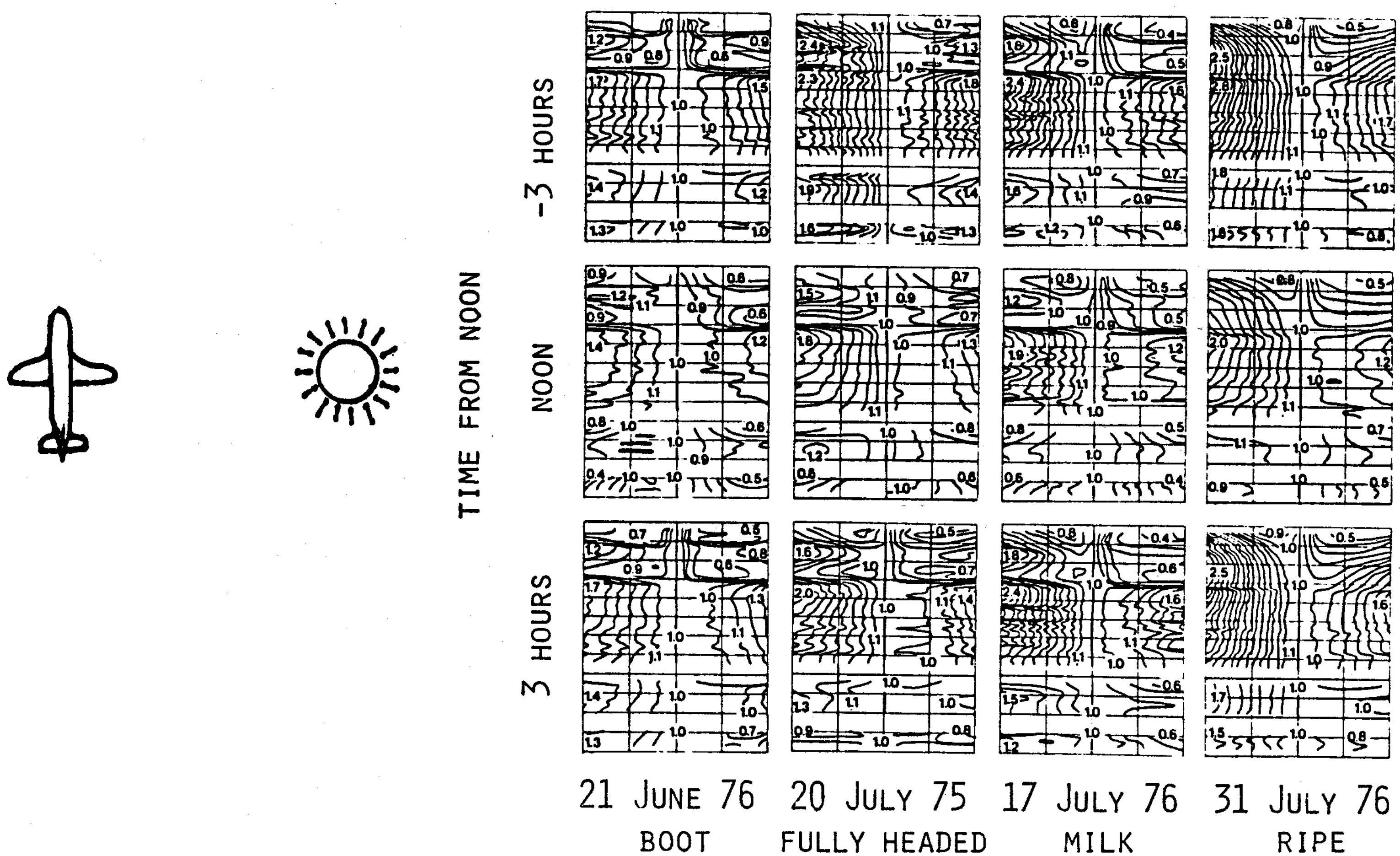
COORDINATE SYSTEM OF EACH PLOT IN ARRAY OF PLOTS.



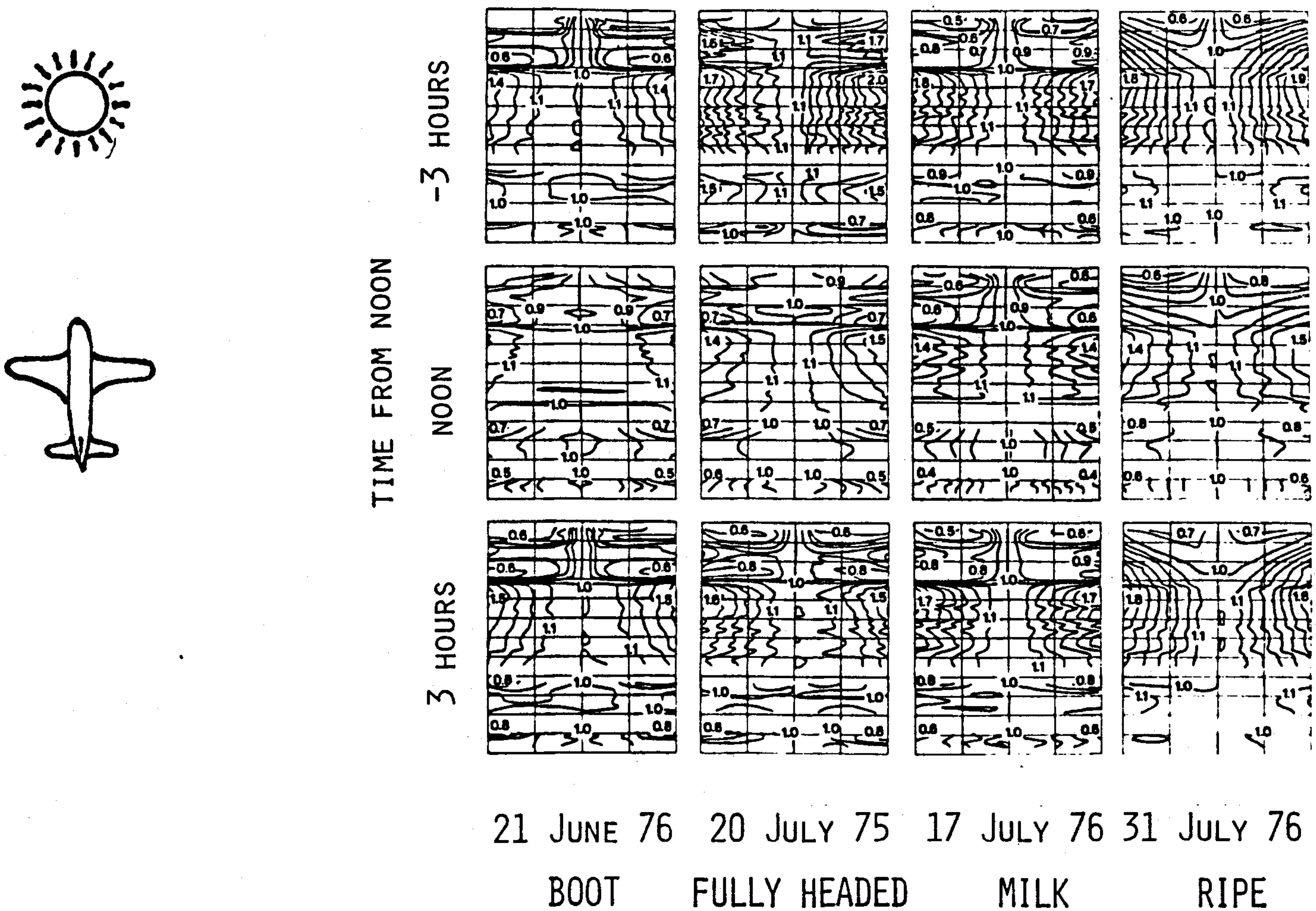
SIMULATED, NORMALIZED BRF FOR A MULTISPECTRAL LINE SCANNER PLOTTED IN TOPOGRAPHIC NOTATION WITH CONTOUR LINES AT 0.1 INTERVALS. NOON, 17 JULY 1976, AIRCRAFT FLYING TOWARD SUN.



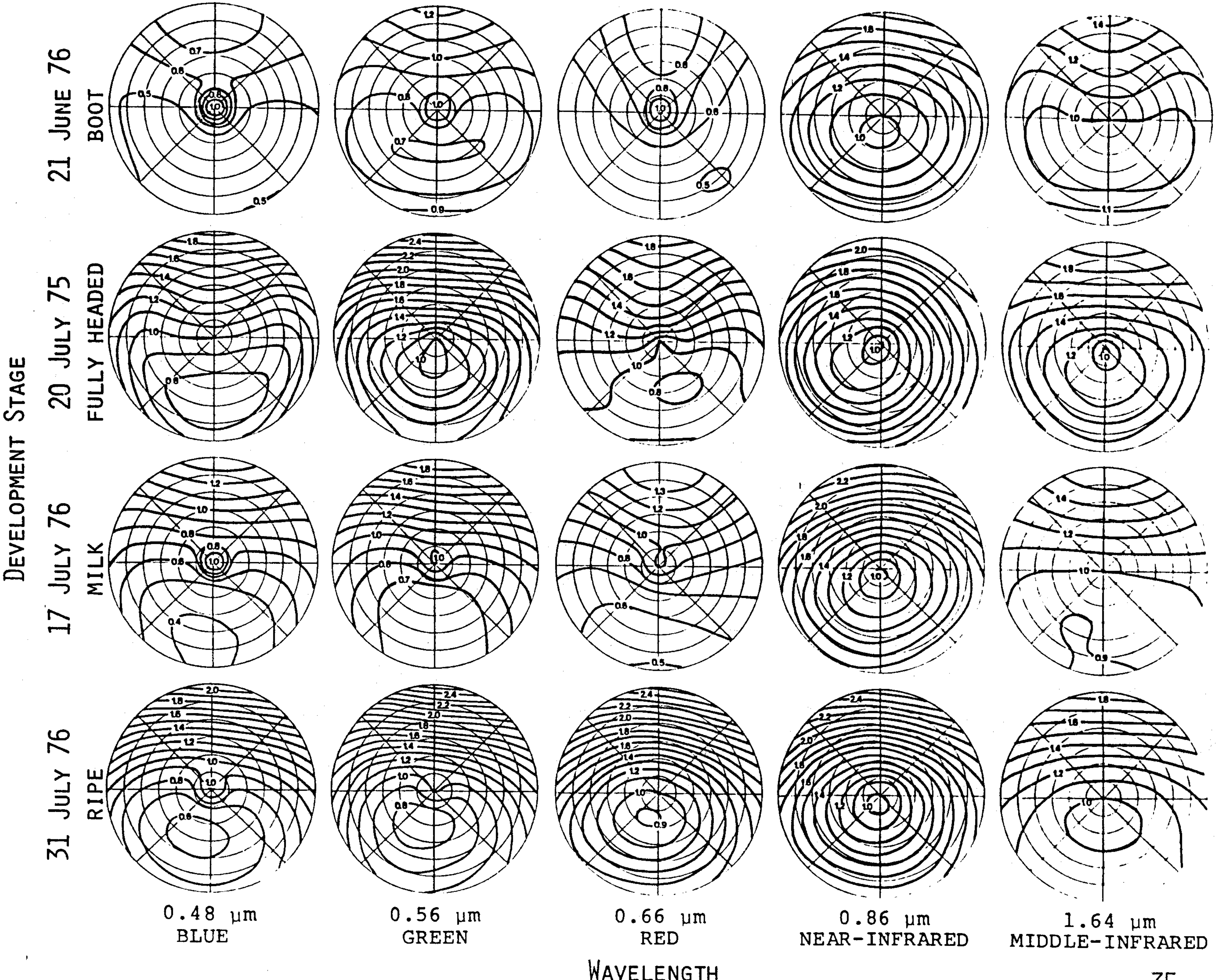
Normalized BRF for a Multispectral Line Scanner Plotted in Topographic Notation with Contour Lines at 0.1 Intervals.

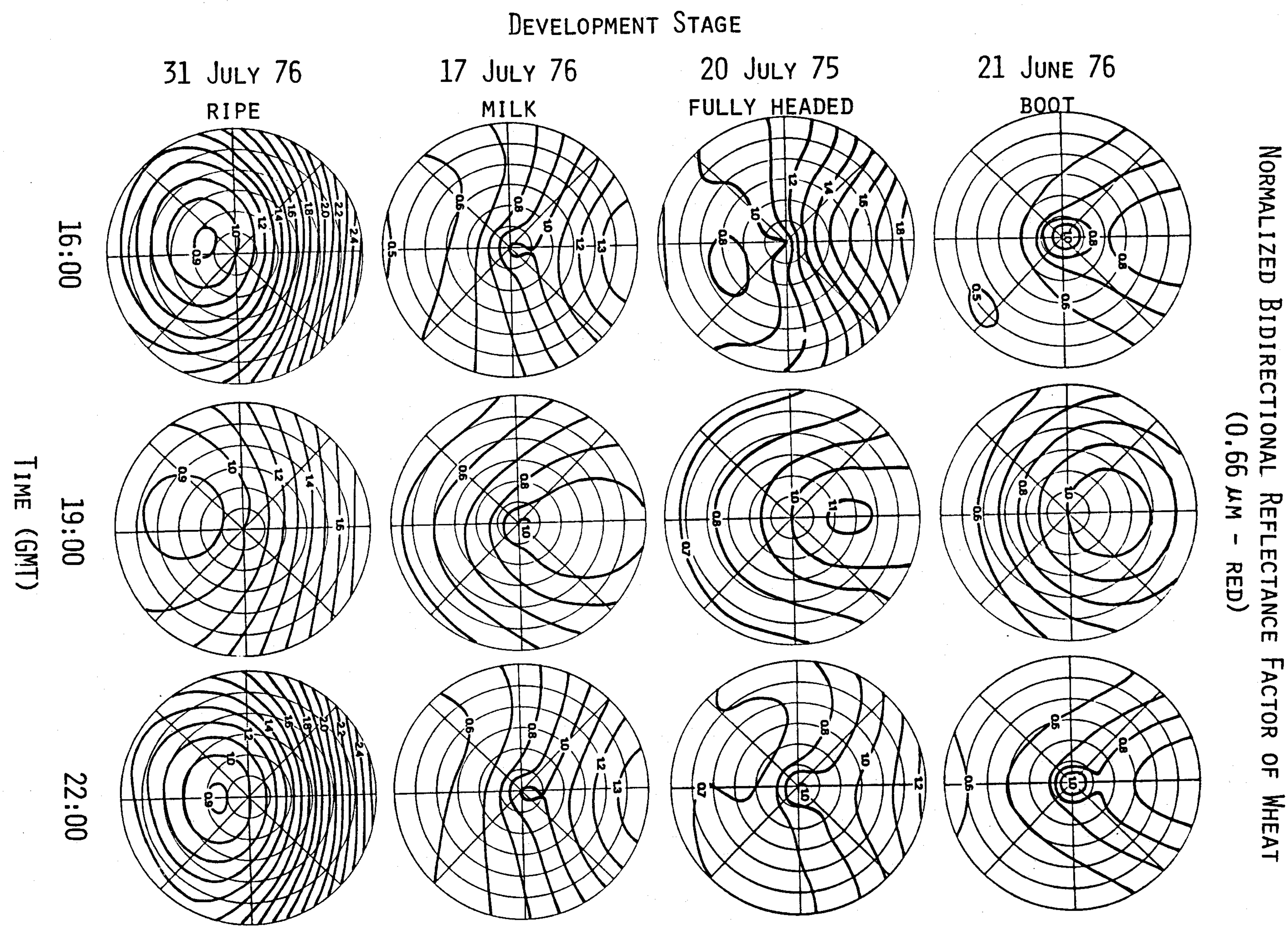


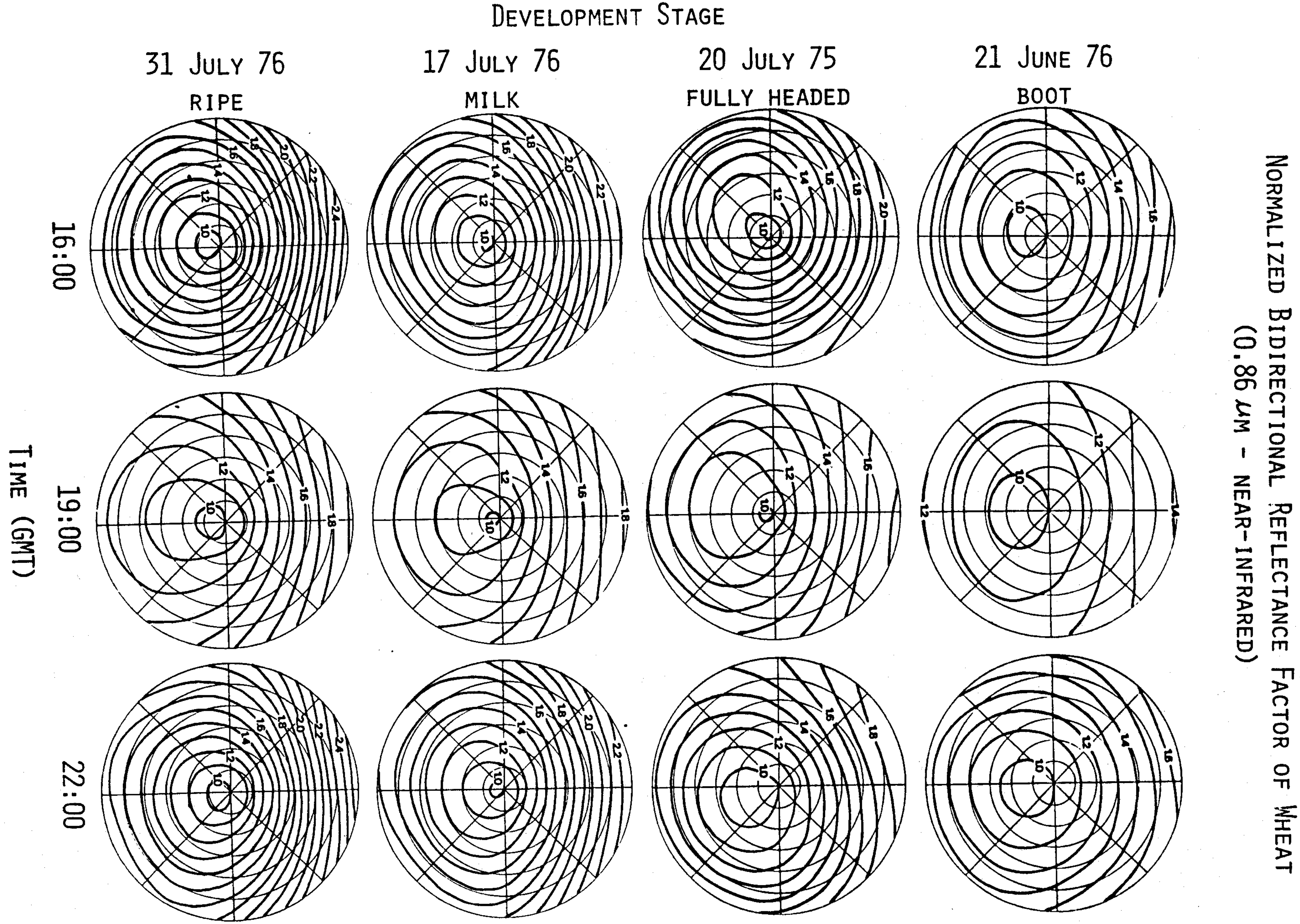
NORMALIZED BRF FOR A MULTISPECTRAL LINE SCANNER PLOTTED IN TOPOGRAPHIC NOTATION WITH CONTOUR LINES AT 0.1 INTERVALS.



Normalized Bidirectional Reflectance Factor of Wheat
(16:00 GMT)




DEVELOPMENT STAGE
31 JULY 76
RIPE
17 JULY 76
MILK
20 JULY 75
FULLY HEADED
21 JUNE 76
BOOT
16:00
19:00
22:00
TIME (GMT)
NORMALIZED BIDIRECTIONAL REFLECTANCE FACTOR OF WHEAT
(0.66 μM - RED)



DEVELOPMENT STAGE
31 JULY 76
RIPE
17 JULY 76
MILK
20 JULY 75
FULLY HEADED
21 JUNE 76
BOOT
TIME (GMT)
16:00
19:00
22:00
NORMALIZED BIDIRECTIONAL REFLECTANCE FACTOR OF WHEAT
(0.86 μm - NEAR-INFRARED)

LIMITATIONS

- THE STUDY RESULTS ARE LIMITED IN ACCURACY IN THE DIRECTION OF THE HOT SPOT (WHICH REQUIRES SPECIAL TECHNIQUES TO MEASURE) AND FOR ZENITH VIEW ANGLES $0 < \theta < 15^\circ$. (TO IMPROVE THE MODEL FOR $0 < \theta < 15^\circ$ MORE DATA MUST BE MEASURED IN THIS REGION.)

CONCLUSIONS

- THERE IS A SUN ANGLE-VIEW ANGLE SIGNATURE
- SIGNATURE IS MODULATED BY WAVELENGTH AND GROWTH STAGE
- THE SHADOWING EFFECT OF FOLIAGE IS THE MOST IMPORTANT FACTOR EXPLAINING REFLECTANCE VARIATIONS WITH VIEW ANGLE IN THE VISIBLE REGION OF THE SPECTRUM
- THE INTERACTION OF SHADOWING AND MULTIPLY SCATTERED LIGHT APPEARS TO BE THE PREDOMINANT FACTOR EXPLAINING REFLECTANCE VARIATIONS WITH VIEW ANGLE IN THE NEAR INFRARED SPECTRAL REGION
- THE CANOPY REFLECTANCE AS A FUNCTION OF ANGLE VARIED BY A FACTOR OF AS MUCH AS 1.0 TO 2.5 FROM VIEW ZENITH = 0 TO VIEW ZENITH = 60 IN THE NEAR INFRARED THREE HOURS AFTER SOLAR NOON
- THE WHEAT CANOPY THAT WAS MEASURED WAS NEVER A PERFECTLY DIFFUSE REFLECTOR AT ANY WAVELENGTH AT ANY TIME. THE CANOPY REFLECTIVE RESPONSE WITH ANGLE WAS CLOSEST TO THAT OF A LAMBERTIAN REFLECTOR NEAR SOLAR NOON IN THE VISIBLE AND MIDDLE INFRARED REGIONS.
- CANOPY REFLECTANCE CHANGES VERY RAPIDLY BETWEEN ZENITH VIEW ANGLES OF 0° AND 15°. THESE RAPID CHANGES ARE ATTRIBUTABLE IN PART TO ROW AND SOIL EFFECTS.

TASK 1B

FIELD RESEARCH DATA ACQUISITION AND PREPROCESSING

LARRY BIEHL

1B. FIELD RESEARCH DATA ACQUISITION AND PREPROCESSING

OVERALL OBJECTIVE.

COORDINATE AND/OR ACQUIRE AND PREPROCESS THE REQUIRED MULTICROP FIELD RESEARCH DATA TO SUPPORT THE AGRISTARS PROGRAM.

1B. FIELD RESEARCH DATA ACQUISITION AND PREPROCESSING

SPECIFIC OBJECTIVES FOR 1980 (AND COMPLETION DATE OR TARGET COMPLETION DATE)

1. DATA ACQUISIITION

- PLAN AND COORDINATE 1980 ACQUISITION OF REQUIRED FIELD RESEARCH DATA IDENTIFIED IN EXPERIMENT DESIGN PLANS DEVELOPED UNDER TASK 1A (COMPLETED 5/1/80)

- ACQUIRE 1980 PURDUE AGRONOMY FARM DATA (10/15/80)

- ACQUIRE DETAILED AGRONOMIC MEASUREMENTS FOR WEBSTER CO., & CASS CO. SITES (10/15/80)

- PREPARE AND CALIBRATE FIELD REFLECTANCE STANDARDS (5/30/80)

- PREPARE PLAN FOR 1981-82 FIELD RESEARCH DATA ACQUISITION (11/1/80)

SPECIFIC OBJECTIVES FOR 1980 (AND COMPLETION DATE OR TARGET COMPLETION DATE) CON'T.

2. DATA PREPROCESSING

- COMPLETE PROCESSING OF 1979 DATA
  - PURDUE AGRONOMY FARM (COMPLETED 4/1/80)
  - WEBSTER CO., & HAND CO. FSS (MAJORITY COMPLETED 4/1/80)
  - WEBSTER CO., HAND CO., & MCPHERSON CO. AIRCRAFT SCANNER (5/30/80)
- PREPROCESS FIELD RESEARCH DATA ACQUIRED IN 1980
  - PURDUE AGRONOMY FARM (1/1/81)
  - WEBSTER CO., & CASS CO. FSS (2/1/81)
  - WEBSTER CO., CASS CO., MCPHERSON CO. & WHARTON CO. AIRCRAFT SCANNER 1/1/81

ACCOMPLISHMENTS THIS QUARTER

1. Data Acquisition

- 1980 Purdue Agronomy farm data acquisition begun
- Arrangements made for acquisition of detailed agronomic measurements and support of FSS missions for Cass Co., ND and Webster Co., IA test sites
- Field reflectance standards for 1980 prepared
- Gray panel field reflectance standards calibrated

2. DATA PREPROCESSING

- ADDITIONAL 1979 PURDUE AGRONOMY FARM AGRONOMIC DATA PROCESSED
- 1979 HAND CO., FSS AND AGRONOMIC DATA PROCESSING COMPLETED
- 1979 (MAY THRU AUGUST) WEBSTER CO., FSS AND AGRONOMIC DATA PROCESSING COMPLETED

SUMMARY OF 1980 FIELD RESEARCH EXPERIMENTS

1. WEBSTER CO., IOWA
   - SPECTRAL CHARACTERISTICS AND SEPARABILITY OF CORN, SOYBEANS AND OTHER AS FUNCTION OF GROWTH STAGE AND CULTURAL PRACTICES
   - VERIFICATION OF SPECTRAL-AGRONOMIC RELATIONSHIPS
2. CASS CO., NORTH DAKOTA
   - SPECTRAL CHARACTERISTICS AND SEPARABILITY OF SPRING WHEAT, BARLEY, SUNFLOWERS AND SOYBEANS AS FUNCTION OF GROWTH STAGE AND CULTURAL PRACTICE
3. TIPPECANOE CO., INDIANA PURDUE AGRONOMY FARM
   - EFFECTS OF FERTILIZATION AND DISEASE ON REFLECTANCE AND RADIANT TEMPERATURE CHARACTERISTICS OF WINTER WHEAT (ALSO GROWTH STAGE AND LEAF AREA INDEX RELATIONSHIPS)
   - RELATIONSHIP OF CROP CANOPY VARIABLES TO (GROWTH STAGE, LAI, BIOMASS, SOIL BACKGROUND ETC.) REFLECTANCE AND RADIANT TEMPERATURE OF CORN AND SOYBEANS
   - EFFECTS OF VARYING AGRONOMIC PRACTICES (PLANTING DATE, ROW SPACING, PLANT POPULATION, CULTIVAR, SOIL TYPE) ON SPECTRAL RESPONSE OF CORN AND SOYBEANS
   - EXPERIMENTS ON INSTRUMENT PARAMETERS, CALIBRATION AND MEASUREMENT VARIABLES
4. MCPHERSON CO., NEBRASKA, SANDHILLS EXPERIMENT STATION
   - RELATIONSHIP OF MOISTURE STRESS EFFECTS ON REFLECTANCE AND THERMAL CHARACTERISTICS OF CORN

1980 Field Research Test Sites and Major Crops

Tippecanoe Co. Indiana	Webster Co. Iowa	Cass Co. N. Dakota	McPherson Co. Nebraska	Wharton Co. Texas
Corn	Corn	Spring Wheat	Corn	Rice
Soybeans	Soybeans	Barley		Soybeans
Winter Wheat		Sunflowers		
		Soybeans		

ORGANIZATIONS INVOLVED IN ACQUISITION OF 1980 FIELD RESEARCH DATA

NASA/JOHNSON SPACE CENTER

PURDUE/LABORATORY FOR APPLICATIONS OF REMOTE SENSING

NORTH DAKOTA STATE UNIVERSITY

UNIVERSITY OF NEBRASKA

PLANS FOR NEXT QUARTER

1. Data Acquisition

- Complete preparation of plots at the Purdue Agronomy Farm
- Calibrate painted barium sulfate field reflectance standards
- Continue acquisition of Purdue Agronomy Farm data
- Begin acquisition of detailed agronomic measurements for Webster Co., IA or Cass Co., ND test sites

PLANS FOR NEXT QUARTER (CON'T)

2. DATA PREPROCESSING

- COMPLETE PROCESSING OF 1979 WEBSTER CO. FSS DATA WHEN RECEIVED FROM NASA/JSC
- COMPLETE PROCESSING 1979 WEBSTER CO., HAND CO., & MCPHERSON CO. AIRCRAFT SCANNER DATA
- COMPLETE PROCESSING OF 1979 PURDUE AGRONOMY FARM SPECTRAL LEAF REFLECTANCE MEASUREMENTS - CLEVENGER SPECTROMETER SYSTEM DATA
- BEGIN PROCESSING 1980 PURDUE AGRONOMY FARM DATA

ISSUES/NEEDS TO BE RESOLVED

DATA PREPROCESSING

- NEED 5 DATES OF 1979 FSS DATA FROM NASA/JSC

Task 1C: Development of Multiband Radiometer System

Barrett F. Robinson

OBJECTIVE: TO COMPLETE THE DEVELOPMENT, TESTING, AND DOCUMENTATION OF A MULTIBAND RADIOMETER SYSTEM FOR REMOTE SENSING FIELD RESEARCH.

APPROACH

- PURDUE/LARS WILL COMPLETE THE ACQUISITION OF A PROTOTYPE MULTIBAND RADIOMETER AND DATA LOGGER
- PURDUE/LARS WILL PREPARE A TEST PLAN FOR THE SYSTEMS AND TEST THEM ACCORDINGLY. IN CONCERT WITH THE TECHNICAL MONITOR, PURDUE/LARS WILL ESTABLISH A REVIEW PANEL FOR THE TEST PLAN AND TEST RESULTS
- PURDUE/LARS WILL PREPARE SPECIFICATIONS FOR PRODUCTION UNITS - TO APPEAR IN FINAL REPORT
- PURDUE/LARS WILL PREPARE

  REVISED SYSTEM MANUAL

  AGRICULTURAL USERS MANUAL
- PURDUE/LARS WILL CONTINUE TO DEVELOP SOFTWARE AND HARDWARE TO INTERFACE DATA LOGGER TO THE LARS PDP11/34 COMPUTER AND INPUT TO THE IBM 3031

PLANNED OUTPUT PRODUCTS

- SPECIFICATIONS FOR PRODUCTION MODELS OF THE MULTIBAND RADIOMETER/DATA RECORDING SYSTEMS
- SYSTEM MANUALS
- USERS MANUAL
- DATA ENTRY PROCEDURES. (TO ACCOMPANY REFORMATTING AND ANALYSIS PROCEDURES DEVELOPED IN 1979 FOR MULTIBAND DATA ANALYSIS BY LARSPEC.)

ACCOMPLISHMENTS FOR THE QUARTER (TO DATE)

- DATA LOGGER - IN CONSTRUCTION.
  - MEMORY MODULE DESIGNED AND TESTED
  - CONTROL CIRCUITS DESIGNED AND INDIVIDUALLY TESTED
  - CASE AND CONTROL PANEL - PRELIMINARY DESIGN
- RADIOMETER - IN CONSTRUCTION.
  - OUTER ASSEMBLIES PAINTED
  - JIG BORING COMPLETE
  - FRONT COVER COMPLETE
  - CIRCUIT BOARDS ASSEMBLED - IN TESTING
  - FILTERS BEING CUT
- TEST PLAN - STILL PRELIMINARY
- DATA INTERFACE/DATA HANDLING MODULES TESTED - FURTHER WORK NEEDED

PLANS FOR NEXT QUARTER

- COMPLETION OF DATA LOGGER
- COMPLETION OF RADIOMETER
- LAB AND FIELD TEST SYSTEM
- SYSTEM MANUAL - COMPLETION OF REVISED DRAFT
- USER MANUAL - COMPLETION OF REVISED DRAFT
- TEST PLAN REVISED AND COMPLETE
- DATA INTERFACE - TESTING AND DOCUMENTATION COMPLETED

2. RESEARCH IN THE APPLICATION OF SPECTRAL DATA TO CROP IDENTIFICATION AND ASSESSMENT

TASK 2D

Spectral-Meteorological Crop Development Stage Estimation for Corn and Soybeans

CRAIG DAUGHTRY, HAROLD REETZ, AND VIC POLLARA

SPECTRAL-METEOROLOGICAL CROP DEVELOPMENT STAGE ESTIMATION FOR CORN AND SOYBEANS

OVERALL OBJECTIVE

DEVELOP METHODS TO ESTIMATE CROP DEVELOPMENT STAGES USING SPECTRAL AND METEOROLOGICAL DATA.

SPECIFIC OBJECTIVES FOR 1980

1. DEFINE, TEST AND DELIVER FIRST GENERATION SPECTRAL-METEOROLOGICAL METHODS TO ESTIMATE CROP PHENOLOGY FOR CORN AND SOYBEANS IN THE U.S.
2. IDENTIFY AND BEGIN INITIAL RESEARCH AND DEVELOPMENT OF SECOND GENERATION CROP PHENOLOGY MODELS.
3. DEFINE DATA REQUIREMENTS FOR DEVELOPING AND TESTING CROP PHENOLOGY MODELS IN U.S. AND FOREIGN AREAS.

CURRENT STATUS AND ACCOMPLISHMENTS

- LITERATURE SURVEY IS 90% COMPLETED
- INITIAL ANALYSES OF SPECTRAL DATA ARE IN PROGRESS
  - SPECTROMETER DATA FROM PURDUE AGRONOMY FARM
  - LANDSAT MSS DATA FOR SEGMENTS IN CORN BELT
- SEGMENTS SELECTED AND DATA BASE DEVELOPMENT INITIATED
  - DATA SET TO BE ASSEMBLED
    INDIANA-JUNE 1
    IOWA-JUNE 10
    ILLINOIS-JUNE 30
- METEOROLOGICALLY-BASED MODELS FOR CORN AND SOYBEANS SELECTED
  - CORN - HEAT UNIT MODELS (CROSS AND ZUBER, 1972)
  - SOYBEANS - HEAT UNITS MODELS (LAWN AND BYTH, 1973)
    - PHOTOTHERMAL MODEL (MAJOR ET. AL. 1975)
- FORMULATED INITIAL APPROACH FOR SPECTRAL-METEOROLOGICAL MODELS
  - PROBABILITY DENSITY FUNCTION APPROACH

RESULTS OF LITERATURE SURVEY

THREE MAJOR APPROACHES TO ESTIMATE CROP DEVELOPMENT STAGE

1. NORMAL OR AVERAGE PHENOLOGY

- BASED ON ACCUMULATION OF DAYS BETWEEN PHENOLOGICAL EVENTS
- DO NOT ACCOUNT FOR YEAR TO YEAR VARIATIONS IN CROP DEVELOPMENT DUE TO WEATHER DIFFERENCES
- SPATIAL RESOLUTION IS GENERALLY FOR CROP REPORTING DISTRICT SIZED AREAS

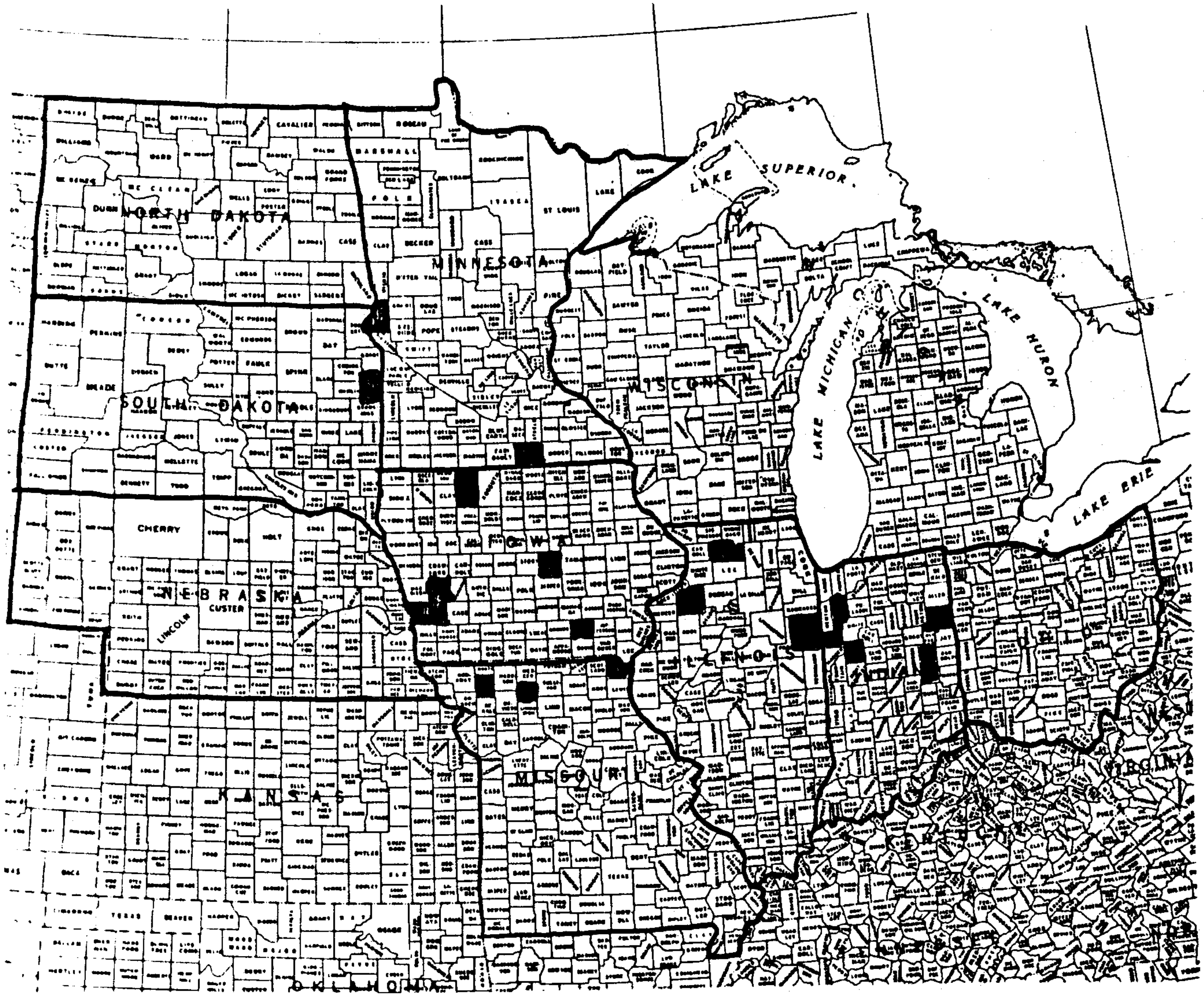
2. METEOROLOGICAL METHODS

- BASED ON ACCUMULATION OF THERMAL OR PHOTO-THERMAL UNITS BETWEEN PHENOLOGICAL EVENTS
- REQUIRE PLANTING DATE AS A STARTING POINT WHICH CAN BE DIFFICULT TO OBTAIN FOR LARGE AREAS
- WIDELY USED BY SEED INDUSTRY TO RANK CULTIVARS
- SPATIAL RESOLUTION LIMITED BY DISTRIBUTION OF WEATHER STATIONS

3. SPECTRAL METHODS

- BASED ON CROP REFLECTANCE (APPEARANCE) CHANGES AS A FUNCTION OF PHENOLOGY
- INTEGRATE WEATHER AND MANAGEMENT EFFECTS ON CROP DEVELOPMENT
- SPATIAL RESOLUTION DEPENDS ON SENSOR (E.G. 0.45 HA FOR LANDSAT MSS)
- SPECIAL PROBLEMS WITH LANDSAT MSS DATA
    - ATMOSPHERIC INTERFERENCE
    - MISSING DATA
    - INFREQUENT TEMPORAL COVERAGE
    - HAVE NOT BEEN TESTED

LOCATION OF SELECTED LANDSAT 5 x 6 MILE SEGMENTS WITH PERIODIC OBSERVATIONS IN 1978.



STATE	SEGMENT	COMMENT
IN	832	NO JULY DATA
	837	
	840	
	843	
	844	
	854	
	860	
IL	807	NO JULY DATA
	809	NO JULY DATA
	824	NO JULY DATA
IA	144	NO JULY DATA
	804	
	867	NO JUNE, JULY DATA
	883	
	886	
	892	
SD	241	
MN	183	
	185	
MO	205	
	209	
	211	

HEAT UNIT MODELS

DESCRIPTION

- LINEAR RESPONSE OF DEVELOPMENT TO TEMPERATURE IS ASSUMED. NONLINEAR RESPONSE VERSIONS ARE GENERALLY BETTER.
- PREDICTS DEVELOPMENT OVER FAIRLY LONG PERIODS (I.E., PLANTING TO TASSELING OR PLANTING TO MATURITY).
- EASY TO APPLY BECAUSE NO RESPONSE OF COEFFICIENTS IS REQUIRED.

DATA REQUIREMENTS

- DAILY MAXIMUM TEMPERATURE
- DAILY MINIMUM TEMPERATURE
- THRESHOLD TEMPERATURE (A CONSTANT)
- HEAT UNITS FOR EACH STAGE (MAY DIFFER AMONG VARIETIES)

EXAMPLE

- CROSS AND ZUBER. 1972 AGRONOMY J. 64:351-355.

HEAT UNIT MODELS

'DAILY ADJUSTED AVERAGE MODEL

$$\sum_{i=1}^{n} (TX_i + TN_i)/2$$

where:

TH_i = high temp on day i

TL_i low temp on day i

$TX_i = TH_i$ if $TH_i < 86$

$= 86$ if $TH_i \geq 86$

$TN_i = TL_i$ if $TL_i > 50$

$= 50$ if $TL_i \leq 50$

'DAILY HEAT STRESS MODEL

$$\sum_{i\ 1}^{n} (TX_i + TN_i)/2$$

where:

$TX = TH_i$ if $TH_i < 86$

$= 86 - (TH_i - 86)$ if $TH_i \geq 86$

'ONTARIO MODEL

$$\sum_{i\ 1}^{n} (TO_i + TN_i)/2$$

where:

$TO_i = 0.256(TH_i)^2 + 4.39(TH_i) - 155.18$

$TN_i = TL_i$ if $TL_i > 40$

$= 40$ if $TL_i \leq 40$

PHOTOTHERMAL MODELS

DESCRIPTION

- SIMILAR TO BIOMETEOROLOGICAL TIME SCALE (BMTS) MODEL OF ROBERTSON (1968)
- INCORPORATES NONLINEAR RESPONSES OF DEVELOPMENT TO TEMPERATURE AND PHOTO PERIOD
- PREDICTS DEVELOPMENT OVER FAIRLY SHORT INTERVALS (I.E., EMERGENCE TO FLOWERING, FLOWERING TO GRAIN FILLING)
- COEFFICIENTS NEED TO BE REDERIVED FOR MATURITY GROUPS OF SOYBEANS.
- NO REPORTED BMTS MODEL FOR CORN

DATA REQUIREMENTS

- DAILY MAXIMUM TEMPERATURE
- DAILY MINIMUM TEMPERATURE
- PHOTO PERIOD
- INITIAL COEFFICIENTS
- PHENOLOGICAL DATA FOR DERIVATION OF COEFFICIENTS FOR MATURITY GROUPS OF CORN AND SOYBEANS

EXAMPLES

- MAJOR ET. AL. 1975 CROP SCI. 15:174-179
- ROBERTSON 1968. INT. J. BIOMETEORO. 12:191-223

PLANNED OUTPUT PRODUCTS

- METEOROLOGICAL DATA FOR SELECTED SEGMENTS IN U.S.
- HISTORICAL CROP PHENOLOGY DATA
- TRAJECTORY PLOTS OF LANDSAT MSS DATA FOR CORN AND SOYBEANS FOR SELECTED SEGMENTS
- EVALUATION OF SELECTED METEOROLOGICAL MODELS FOR PREDICTING CROP PHENOLOGY
- INITIAL EVALUATION OF METEOROLOGICAL MODELS ADJUSTED BY SPECTRAL DATA FOR PREDICTING CROP PHENOLOGY
- FIRST GENERATION SPECTRAL-METEOROLOGICAL MODEL FOR PREDICTING CROP PHENOLOGY
- RECOMMENDATION FOR DEVELOPING ADVANCED MODELS

PLANS FOR NEXT QUARTER

1. Prepare bibiliography
2. Acquire and assemble meteorology data
3. Acquire and assemble crop phenology data
4. Estimate crop development using meteorological models for crop reporting districts
5. Plot temporal trajectories of spectral data
6. Adjust crop development stage using spectral data
7. Conduct initial evaluations of spectrally-adjusted meteorological models
8. Deliver recommended model to U.S. Pilot Experiment.

ISSUES

1. Receipt of meteorological data from NOAA in Ashville, N.C.
2. Receipt of phenological data from USDA-ESCS.

TASK 2B

Determination of the Value of Spectral Information in Estimation of Agronomic Variables Associated with Yield of Corn and Soybeans

Craig Daughtry, Don Holt, Chris Seubert and Nancy Fuhs

DETERMININATION OF THE VALUE OF SPECTRAL INFORMATION IN ESTIMATION OF AGRONOMIC VARIABLES ASSOCIATED WITH YIELD OF CORN AND SOYBEANS

OVERALL OBJECTIVE

EVALUATE SPECTRAL DATA AS A SOURCE OF INFORMATION FOR CROP YIELD MODELS.

SPECIFIC OBJECTIVES FOR 1980

- IDENTIFY IMPORTANT FACTORS DETERMINING YIELD WHICH MAY BE ESTIMATED FROM SPECTRAL DATA.

- DEVELOP REPRESENTATIVE APPROACHES WHICH POTENTIALLY CAN USE SPECTRAL INFORMATION.

- EVALUATE SOIL PRODUCTIVITY INDICES FOR YIELD MODELS. EXPLORE METHODS TO ASSESS SOIL PRODUCTIVITY USING SPECTRAL DATA.

APPROACH

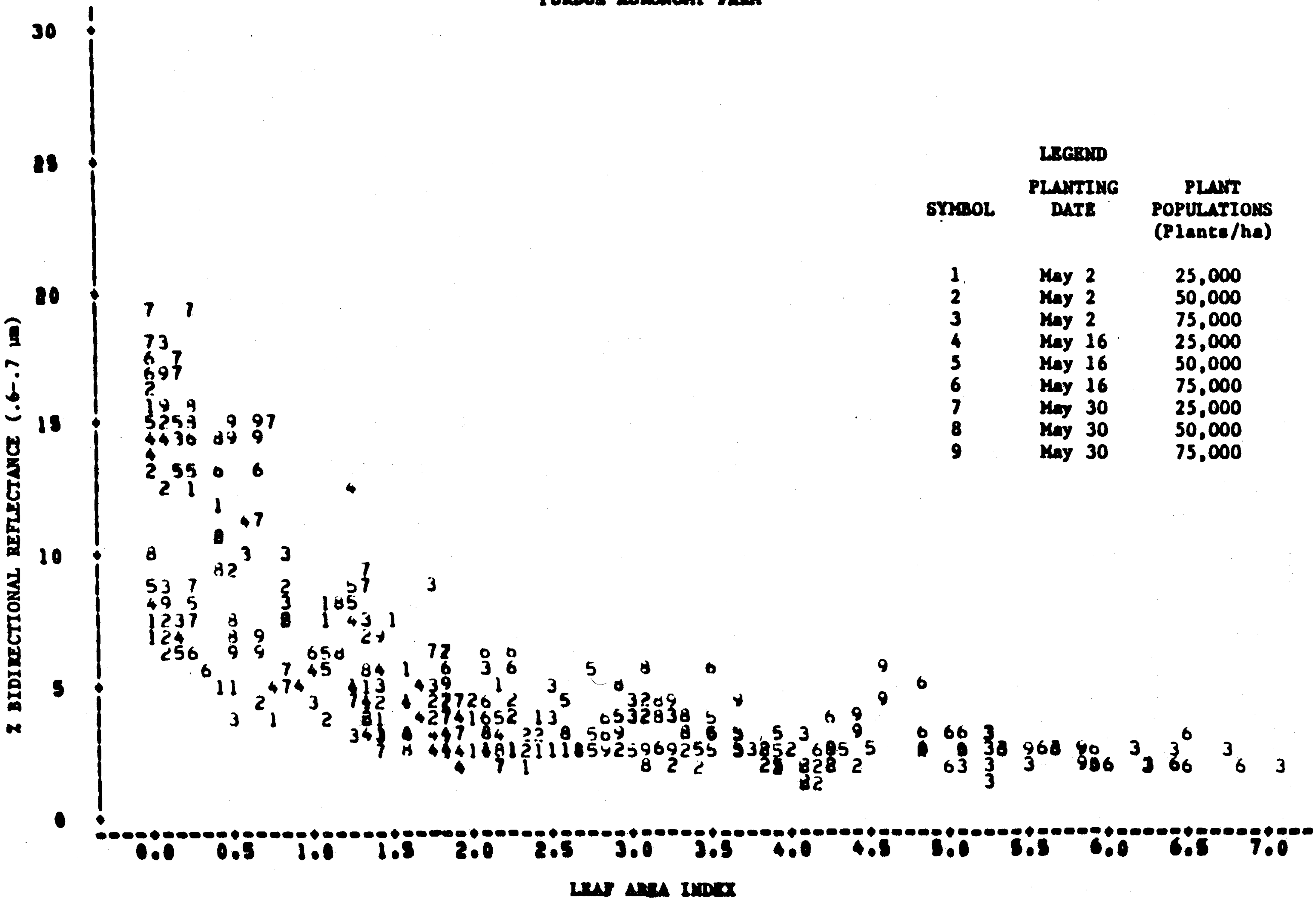
- REVIEW THE LITERATURE.
- ASSEMBLE DATA SETS. ADJUST LANDSAT MSS DATA.
- SELECT IMPORTANT VARIABLES IN DETERMINING YIELD. DEVELOP METHODS TO ESTIMATE THESE VARIABLES FROM SPECTRAL DATA.
- SELECT, ACQUIRE, AND MODIFY YIELD MODELS TO INCLUDE SPECTRAL DATA.
- EVALUATE SOIL PRODUCTIVITY INDICES. EXPLORE METHODS OF DETERMINING SOIL PRODUCTIVITY FROM SPECTRAL DATA.
- IDENTIFY CRITICAL ISSUES FOR EXTENSION OF CONCEPTS TO FOREIGN AREAS.

CURRENT STATUS AND ACCOMPLISHMENTS

- LITERATURE SURVEYS
  - CROP YIELD 90% COMPLETE
  - SOIL PRODUCTIVITY 75% COMPLETE
- SEGMENTS SELECTED AND DATA BASE DEVELOPMENT INITIATED
  - 'SPECTRAL DATA SET ASSEMBLED
  - 'METEOROLOGICAL DATA ON ORDER
- INITIAL ANALYSES OF SPECTRAL DATA
  - 'SPECTROMETER DATA AT PURDUE AGRONOMY FARM
  - 'LANDSAT MSS DATA FOR SEGMENTS
- CORRELATIONS OF SPECTRAL DATA TO GRAIN YIELD
  - 'DATA SET DEPENDENT
  - 'ADJUSTMENTS TO METEOROLOGICALLY-BASED YIELD MODEL ESTIMATES
    - INITIAL TESTS USING SPECTROMETER DATA ACQUIRED IN 1978, 1979
- PERCENT INTERCEPTED SOLAR RADIATION VARIABLE
  - 'ESTIMATE OF "USEFUL" ENERGY TO CROP
  - 'POTENTIAL INTERFACES WITH YIELD AND EVAPOTRANSPIRATION MODELS
    - INITIAL TESTS USING SPECTROMETER DATA

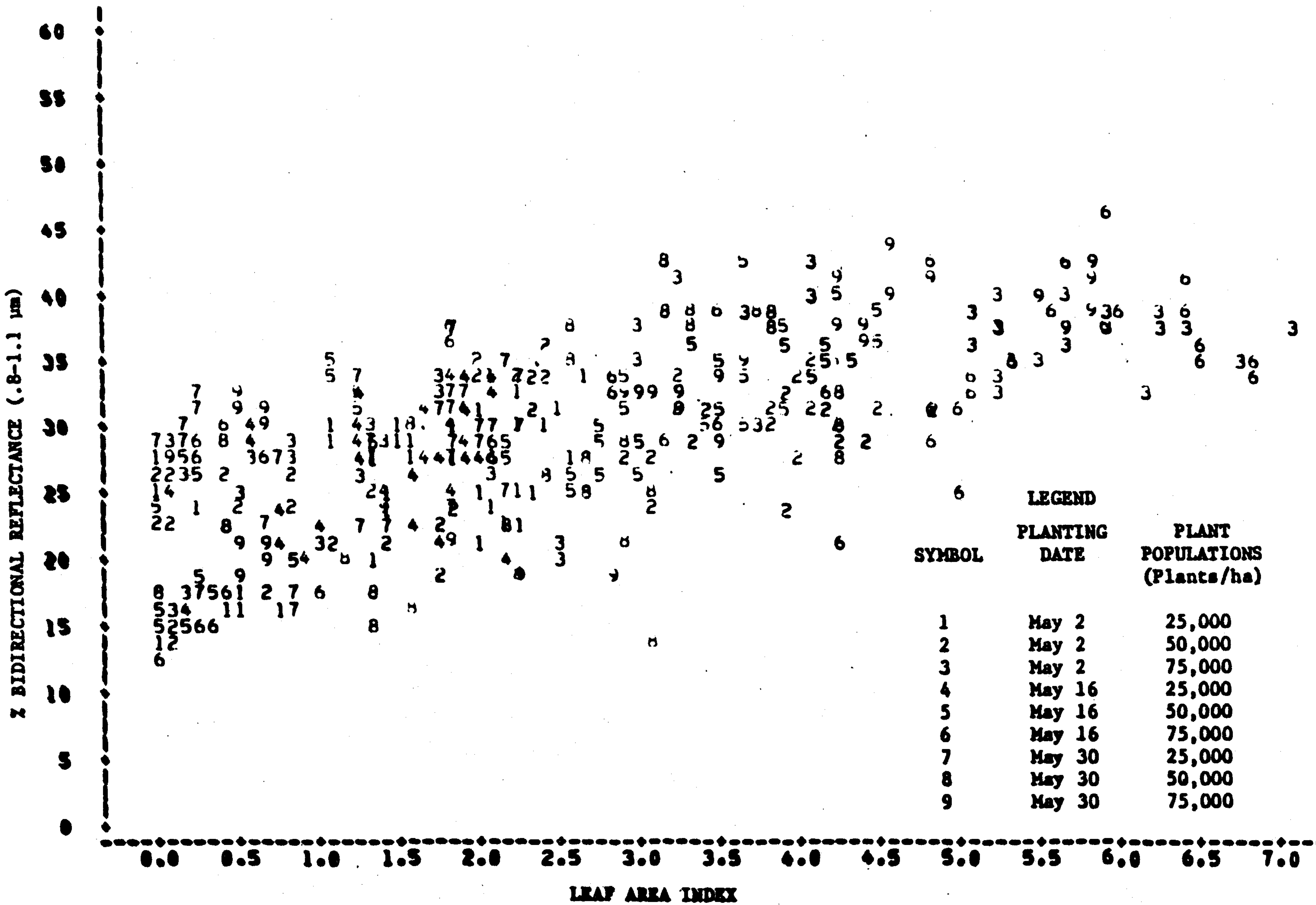
CORN CULTURAL PRACTICES, 1979

PURDUE AGRONOMY FARM



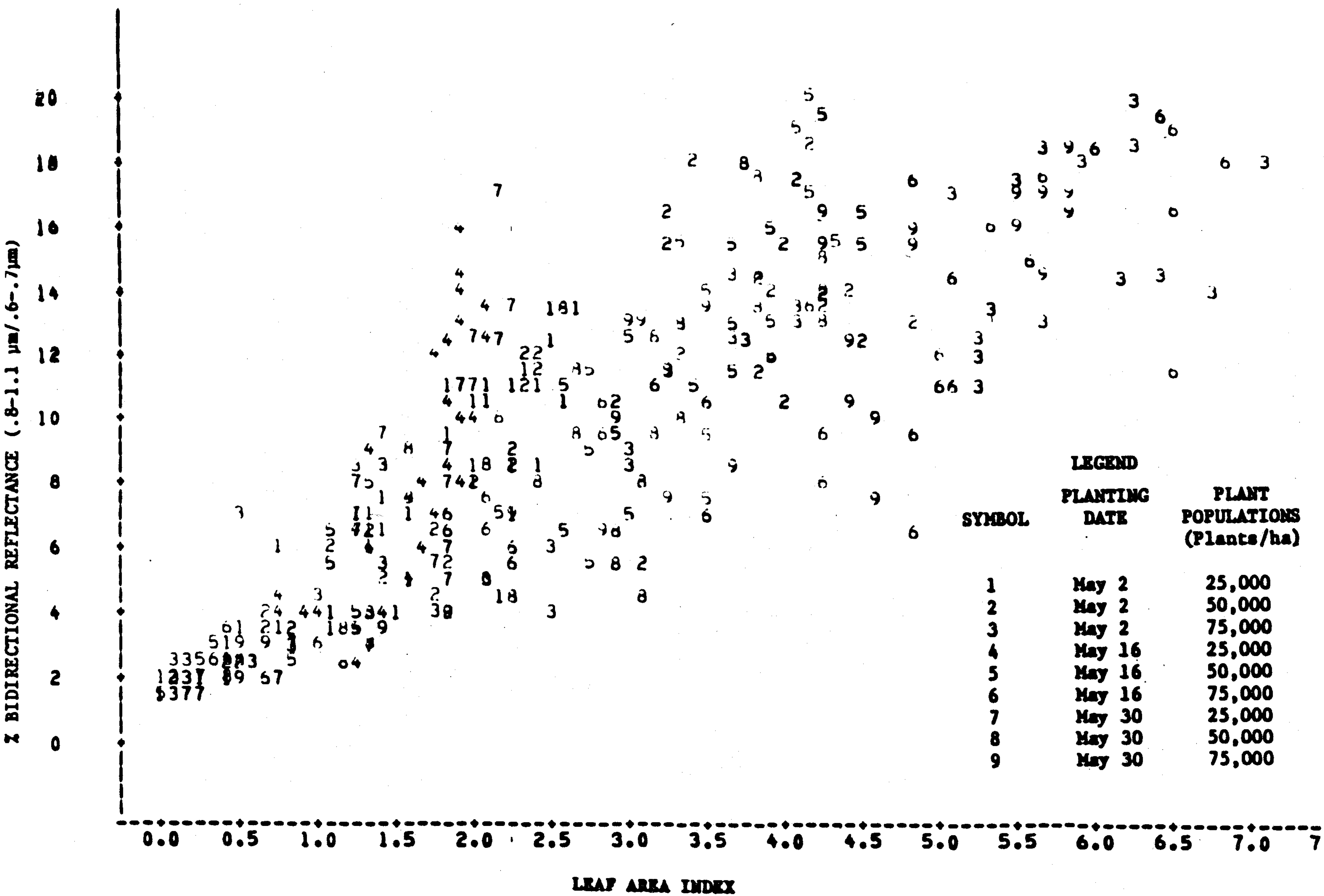
CORN CULTURAL PRACTICES, 1979

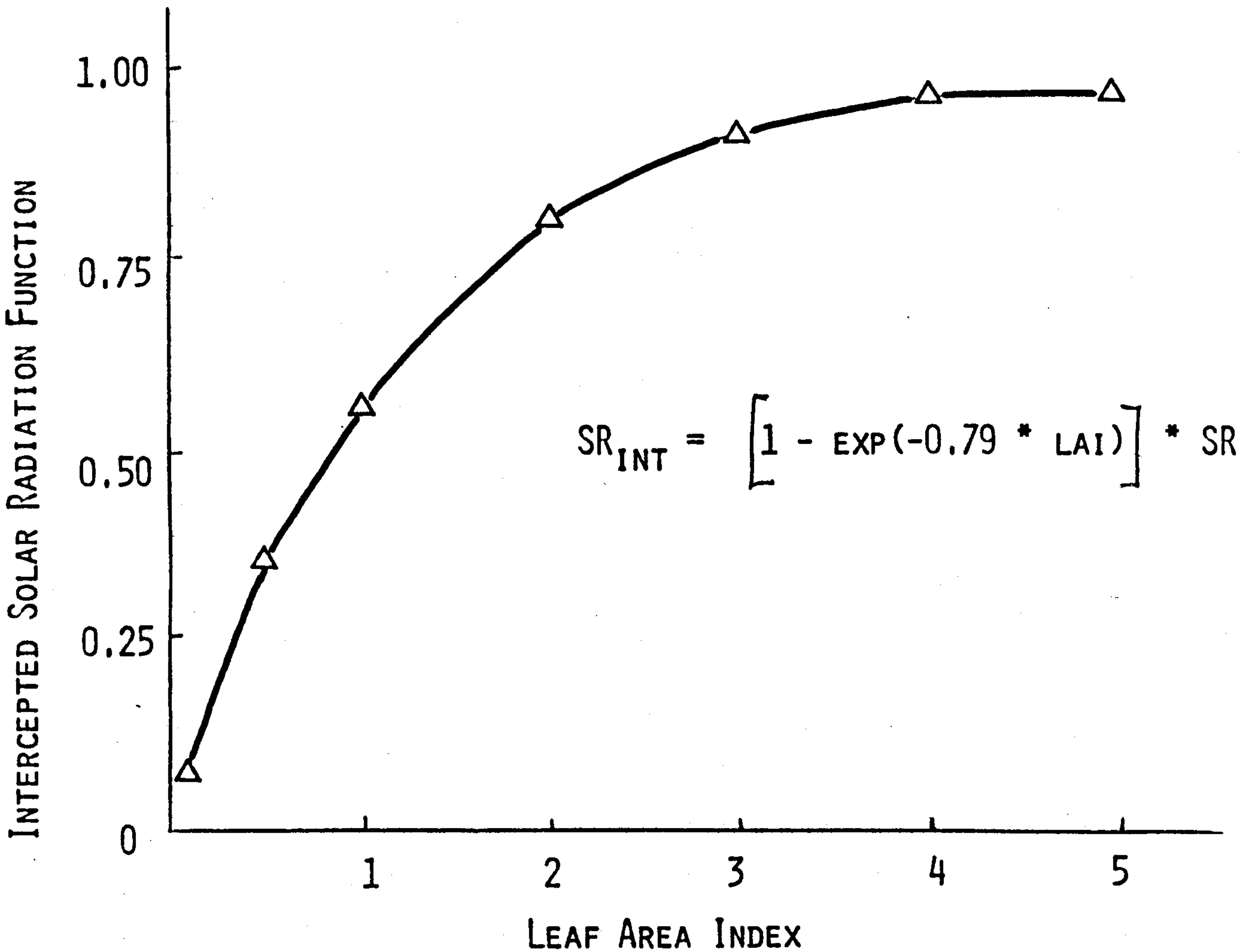
PURDUE AGRONOMY FARM



CORN CULTURAL PRACTICES, 1979

PURDUE AGRONOMY FARM

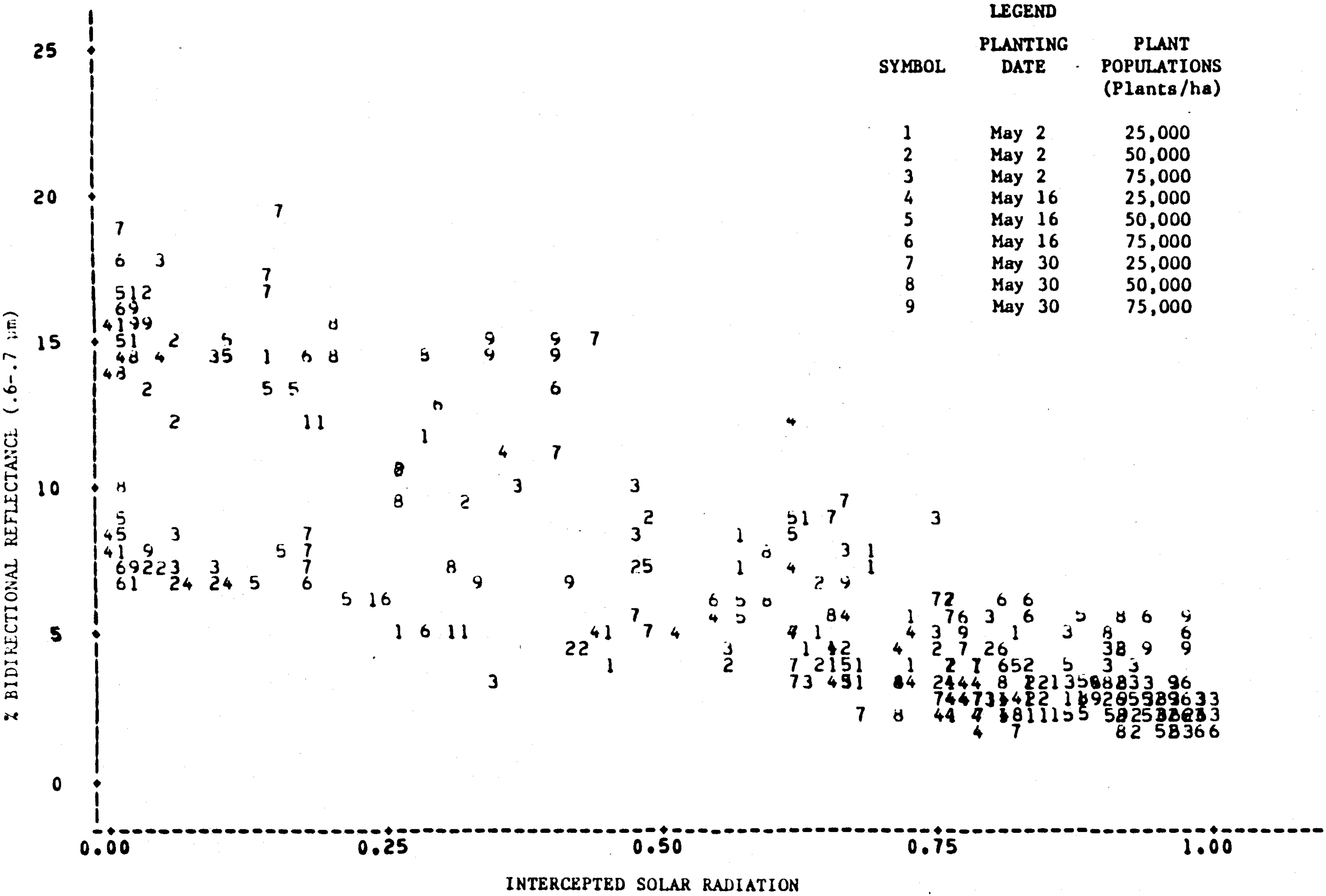




Linville, Dale and Hodges. 1978. Agron. J. 70:257-263

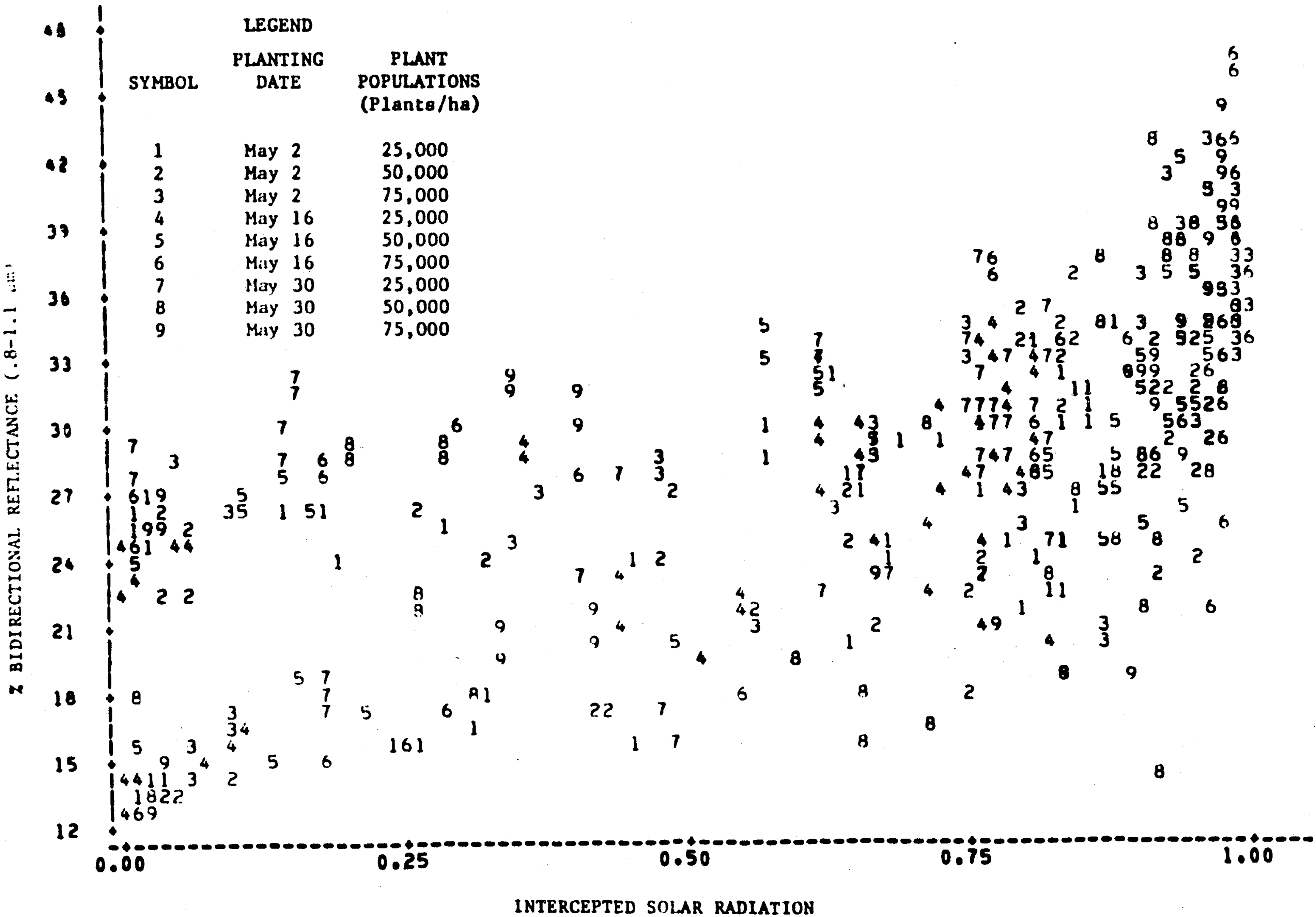
CORN CULTURAL PRACTICES, 1979

PURDUE AGRONOMY FARM



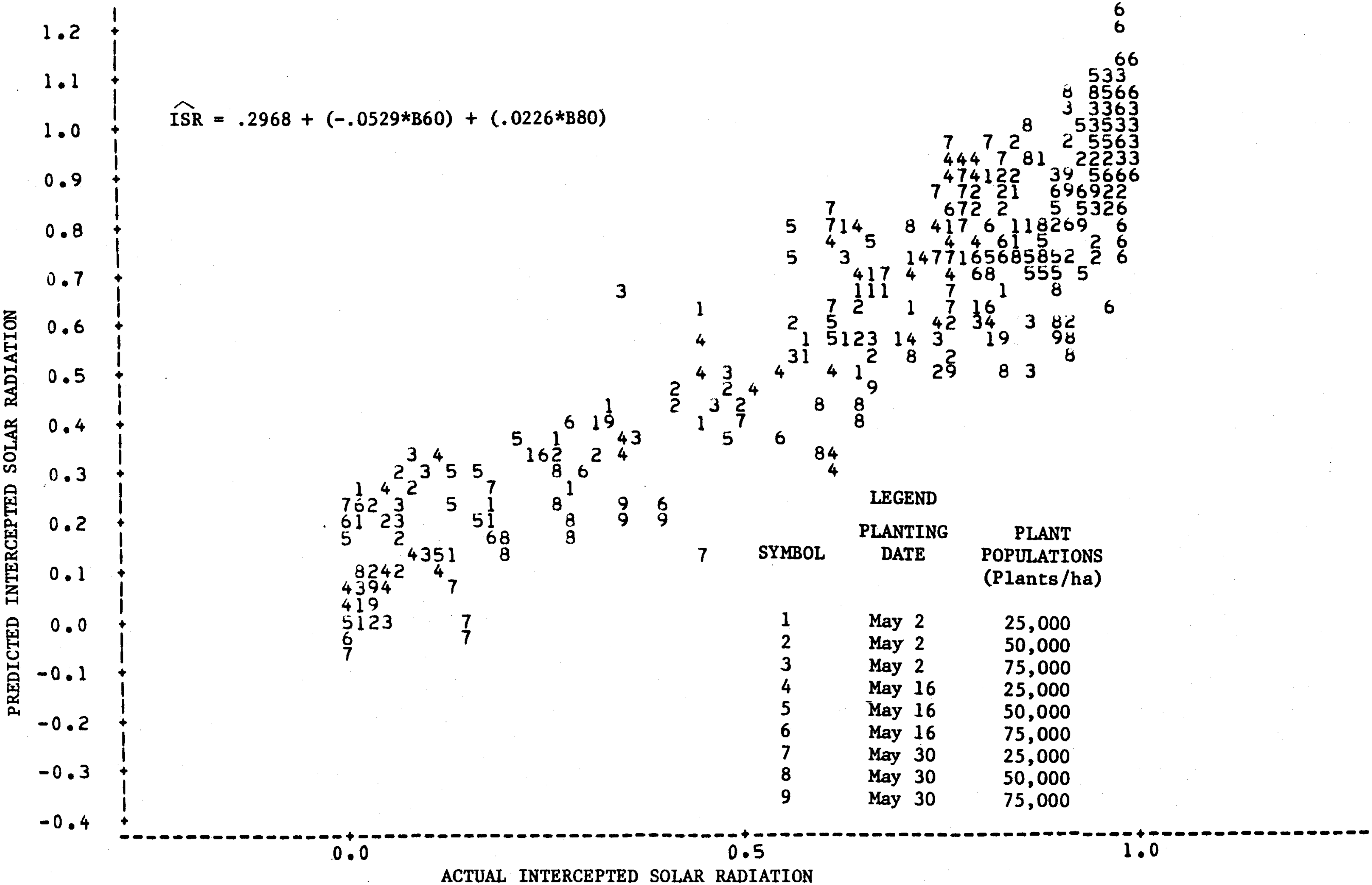
CORN CULTURAL PRACTICES, 1979

PURDUE AGRONOMY FARM



CORN CULTURAL PRACTICES, 1979

PURDUE AGRONOMY FARM



PLANS FOR NEXT QUARTER

- COMPLETE LITERATURE REVIES
- ASSEMBLE SPECTRAL AND METEOROLOGICAL DATA SETS
- CONDUCT INITIAL EVALUATIONS OF INTERCEPTED SOLAR RADIATION VARIABLE
    - SPECTROMETER DATA FROM PURDUE AGRONOMY FARM 1978, 1979
    - LANDSAT MSS DATA FOR SELECTED SEGMENTS IN 1978
- INITIAL EVALUATION OF SOIL PRODUCTIVITY INDICES
    - WASHINGTON COUNTY, MISSISSIPPI
- ASSEMBLE SOIL PRODUCTIVITY DATA SETS FOR CORN BELT

TASK 4A

APPLICATION AND EVALUATION OF LANDSAT TRAINING CLASSIFICATION, AND AREA ESTIMATION PROCEDURES FOR CROP INVENTORY

MARILYN M. HIXSON

OBJECTIVES

- COMPARE SEVERAL METHODS FOR OBTAINING TRAINING STATISTICS.
- RELATE CLASSIFICATION PERFORMANCE TO SCENE CHARACTERISTICS.
- ASSESS EFFECT OF SEPARATING THE FUNCTIONS OF SAMPLING FOR TRAINING AND SAMPLING FOR AREA ESTIMATION.

TRAINING PROCEDURES

- SAMPLE UNIT SIZE FOR TRAINING
  - VARIABLE SIZE UNITS (FIELDS) VS. FIXED SIZE UNITS (FIXED CELL SIZE)
  - COMPARISON MADE ON THREE SEGMENTS
  - NO SIGNIFICANT DIFFERENCE IN ACCURACIES WERE FOUND BETWEEN THE TWO METHODS.

- USE OF SPECTRAL/SPATIAL CLUSTERING ALGORITHM AS A TRAINING TOOL
  - PROCEDURE USES ECHO, UNSUPERVISED FOR TRAINING AND SUPERVISED FOR CLASSIFICATION
  - SOFTWARE DEVELOPMENT BY TASK 3A NOW SCHEDULED FOR COMPLETION BY JUNE 1

RELATIONSHIP OF SCENE CHARACTERISTICS AND CLASSIFICATION PERFORMANCE

• CLASSIFICATIONS

- ONE VISIBLE AND ONE NEAR IR BAND PER ACQUISITION
- ACQUISITIONS AROUND EMERGENCE AND AFTER TASSELING OF CORN
- MAXIMUM LIKELIHOOD CLASSIFIER
- CLASSIFICATIONS COMPLETED FOR 20 SEGMENTS AND PLANNED FOR 8-10 ADDITIONAL SEGMENTS

SEGMENTS CLASSIFIED TO DATE

STATE	COUNTY	SEGMENT NUMBER
ILLINOIS	OGLE	809
	IROQUOIS	824
INDIANA	BENTON	837
	HENRY	843
	TIPPECANOE	854
	WELLS	860
IOWA	MADISON	141
	CLINTON	800
	CALHOUN	862
	MONONA	881
	PALO ALTO	883
	POTTAWATTAMIE	886
	SHELBY	892
	WOODBURY	895

STATE	COUNTY	SEGMENT NUMBER
KENTUCKY	BALLARD	146
MISSOURI	GENTRY	209
	LINCOLN	215
MINNESOTA	GOOHDUE	184
	TRAVERSE	185
NEBRASKA	ANTELOPE	221

RELATIONSHIP OF SCENE CHARACTERISTICS AND CLASSIFICATION PERFORMANCE

- DATA BASE CONSTRUCTION
  - CLASSIFICATION VARIABLES ENTERED AS SEGMENTS COMPLETED
    1. CLASSIFICATION ACCURACY OF EACH COVER TYPE (CORN, SOYBEANS, "OTHER)
    2. OVERALL CLASSIFICATION ACCURACY
    3. VARIANCE REDUCTION FACTORS FOR CORN AND SOYBEANS
    4. PROPORTION ESTIMATES FOR CORN AND SOYBEANS (BOTH CLASSIFICATION AND SAE RESULTS)
  - AI LABELS FOR THOSE SEGMENTS ANALYZED AT JSC COMPLETE
  - PROPORTIONS OF PURE AND MIXED PIXELS DATA BASE CONSTRUCTION UNDERWAY
  - RESEARCH BEGUN ON FACTORS OF SOIL TYPE AND COMPLEXITY, METEOROLOGICAL VARIABLES, CROP MIXTURE

FULL-FRAME SAMPLING

- SIX OF SEVEN FULL-FRAME DIGITAL TAPES ORDERED ARE NOW IN-HOUSE
- STRATIFICATIONS TO BE CONDUCTED WITH FULL-FRAME IMAGERY
- ALL SEGMENTS IN STRATA WILL BE USED FOR CLASSIFIER TRAINING
- SEVERAL SAMPLING SCHEMES WILL BE COMPARED
- DETAILED ANALYSIS PLAN IS BEING DEVELOPED

PLANS FOR NEXT QUARTER

- PRELIMINARY EVALUATION OF ECHO AS A TRAINING AID
- COMPLETE SEGMENT CLASSIFICATIONS FOR SCENE CHARACTERISTICS STUDY
- CONTINUE ANALYSIS OF RELATIONSHIP OF CLASSIFICATION PERFORMANCE TO SCENE CHARACTERISTICS
- BEGIN ANALYSIS OF FULL-FRAME DATA

3. SAMPLING AND AGGREGATION RESEARCH

TASK 4B

DETERMINATION OF THE OPTIMUM LEVEL FOR COMBINING ACREAGE AND YIELD ESTIMATES

MARILYN M. HIXSON

OBJECTIVE

DETERMINE THE OPTIMAL LEVEL FOR COMBINING AREA AND YIELD TO ESTIMATE PRODUCTION

APPROACH

- OPTIMAL LEVEL TO BE ASSESSED UTILIZING CURRENT TECHNOLOGY
  - ANALYSIS OF LANDSAT MSS DATA OVER SAMPLE SEGMENTS FOR AREA
  - CCEA-TYPE REGRESSION MODELS FOR YIELD
- OPTIMIZATION FOR MULTIPLE CROPS CONSIDERED
  - IOWA FOR CORN AND SOYBEANS
  - NORTH DAKOTA FOR WHEAT
- SEVERAL LEVELS OF ESTIMATION CONSIDERED FOR BOTH ACREAGE AND YIELD
  - COUNTY
  - REFINED STRATUM
  - CROP REPORTING DISTRICT
  - STATE
  - OTHER UNIONS OF COUNTIES

STATUS

- IOWA CORN AND SOYBEAN AREA AND YIELD ESTIMATES FOR COUNTIES
  - OBTAINED FOR 1919-1978
  - CURRENTLY BEING ENTERED INTO COMPUTER DATA BASE
- IOWA METEOROLOGICAL DATA NEEDED ARE DAILY TEMPERATURE AND PRECIPITATION
  - DENSE ARRAY OF STATIONS IS REQUIRED
  - DATA FROM 1900-1978 HAS BEEN ORDERED AND IS EXPECTED SHORTLY (FROM IOWA GEOLOGICAL SURVEY)
  - OBJECTIVE SMOOTHING FUNCTION WILL BE USED TO OBTAIN COUNTY VALUES (FROM D. PITTS)
- NORTH DAKOTA WHEAT DATA FOR 1972-77 HAS BEEN OBTAINED; 1978 DATA WILL BE SUPPLIED WHEN ESTIMATES ARE FINALIZED
- AVAILABILITY OF NORTH DAKOTA METEOROLOGICAL DATA IS STILL UNKNOWN

PLANS FOR NEXT QUARTER

- COMPLETE HISTORICAL AREA AND YIELD DATA BASES FOR IOWA
- ACQUIRE AND ORGANIZE IOWA METEOROLOGICAL DATA; COMPUTE COUNTY ESTIMATES
- CONTINUE ACQUISITION OF A NORTH DKAOTA DATA BASE
- ASSESS VARIABILITY OF REFINED STRATA TO DETERMINE "OTHER UNIONS OF COUNTIES" TO BE TESTED
- BEGIN COMPUTATION OF CCEA-TYPE REGRESSION ESTIMATES AT THE VARIOUS LEVELS

4. DATA PROCESSING RESEARCH AND TECHNIQUES DEVELOPMENT

Task 2A

Determining the Effects of Misregistration

Paul E. Anuta

TASK 2A. DETERMINING THE EFFECTS OF MISREGISTRATION

OBJECTIVE

DEVELOP MATHEMATICAL MODEL TO REPRESENT TEMPORAL MISREGISTRATION USING FOURIER ANALYSIS AND IMAGE PROCESSING TECHNIQUES. THIS APPROACH WILL THEN BE COMPARED TO CONVENTIONAL CORRELATION TECHNIQUES.

ALSO DEVELOP A MATHEMATICAL MODEL TO RELATE CLASSIFICATION ERROR TO MISREGISTRATION. TEST ON EXAMPLE LACIE TEMPORAL DATA.

APPROACH AND TASKS

1. DEVELOP AND TEST MODEL FOR MISREGISTRATION

   - SPECIFY MODEL FOR MISREGISTRATION USING FOURIER TECHNIQUES
   - SELECT TEMPORAL DATA SETS AND TEST MODEL FOR VARYING MISREGISTRATION
   - COMPARE RESULTS TO CONVENTIONAL CORRELATION METHODS

2. DEVELOP AND TEST A MODEL FOR CLASSIFICATION ERROR DUE TO MISREGISTRATION

   - DEVELOP ERROR MODEL BASED ON ESTIMATED NOISE VARIANCE DUE TO MISREGISTRATION
   - EVALUATE MODEL ON SEGMENT DATA USING ACAP OR OTHER ERROR-DETERMINATION METHOD

RESULTS IN QUARTER

- TEN SEGMENTS SELECTED FOR REGISTRATION ANALYSIS AND TESTING OF TECHNIQUES.

- MATHEMATICAL DEVELOPMENT OF METHOD FOR ESTIMATING MISREGISTRATION USING FOURIER ANALYSIS CONTINUED. OPTIMUM REGISTRATION PROCESSOR USING CONVOLUTIONAL PROCESSING WAS IDENTIFIED FROM PREVIOUS RESEARCH FOR COMPARISON.

- TIPPECANOE COUNTY SEGMENT 854 CORRELATIONS WERE BEGUN TO ESTIMATE FRACTIONAL MISREGISTRATION USING CORRELATION COEFFICIENT AND CUBIC INTERPOLATION OF DISCRETE CROSS CORRELATION FUNCTION.

- FOURIER TRANSFORM PROCESSING OF REFERENCE AND DIFFERENCE IMAGES BEGUN. PROBLEMS ENCOUNTERED WITH LARS DHSYS 2-D FFT PROCESSOR.

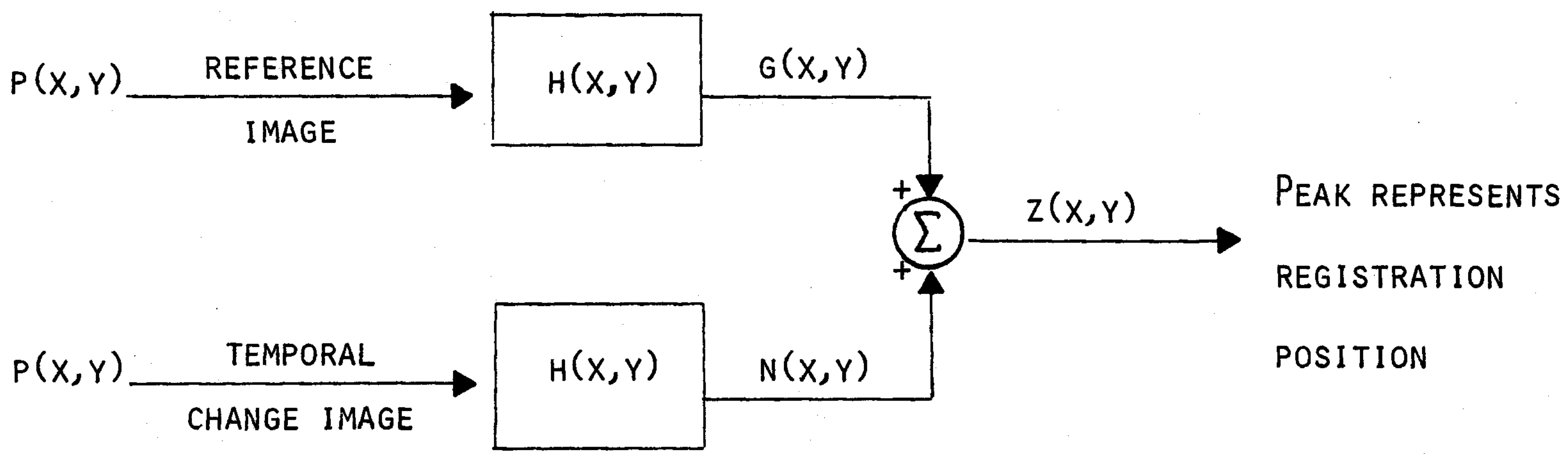
TEST SEGMENTS FOR MISREGISTRATION EFFECTS STUDY

Test segments were chosen to encompass a variety of field sizes, shapes, and crop types. Ten were chosen as good samples of these characteristics. The segments are:

Segment Number	Location	Characteristics	No. Acquisitions
854	Tippecanoe Co., Ind.	Medium field sizes. North oriented.	14
146	Ballard Co., Ky.	Small fields. Random orientation.	6
843	Henry Co., Ind.	Small fields. North oriented.	16
837	Benton Co., Ind.	Medium to large fields. North orientation.	11
139	Kissouth Co., Iowa	Large fields.	15
812	Bolivar Co., Miss.	Large fields. Random orientations.	13
185	Traverse Co., Minn.	Large fields, plus strip fields.	16
241	Deuel Co., S.D.	Large fields and strip.	16
144	Wapello Co., Iowa	Mixed large, medium with river valley.	16
867	Emmet Co., Iowa	Large fields.	16

ANALYTICAL SOLUTION FOR VARIANCE OF REGISTRATION ERROR ESTIMATE

- MODEL FOR REGISTRATION PROCESSOR



- G(X,Y) IS EXPANDED IN SECOND ORDER TAYLOR SERIES:

$$G(X,Y) = G(\tilde{X},\tilde{Y}) + G_X\,[X-\tilde{X}] + G_Y(\tilde{X},\tilde{Y})[X-\tilde{X}]$$

$$+\, G_{XY}(\tilde{X},\tilde{Y})[X-\tilde{X}][Y-\tilde{Y}] + \tfrac{1}{2}G_{XX}(\tilde{X},\tilde{Y})[X-\tilde{X}]^2$$

$$+\tfrac{1}{2}G(\tilde{X},\tilde{Y})[Y-\tilde{Y}]^2$$

WHERE: H(X,Y) IS THE REGISTRATION PROCESSING FILTER

- VARIANCE EXPRESSIONS BECOME:

$$VAR[\hat{X}-\tilde{X}] = \frac{G_{XY}^2 \overline{N_Y^2} - 2G_{XY} \overline{N_X N_Y} + G_{YY}^2 \overline{N_X^2}}{[G_{XX} G_{XY} - G_{XY}^2]^2}$$

SIMILARLY FOR Y.

- CHOOSING THE MATCHED FILTER FOR H(X,Y) THE VARIANCE IS:

$$H(U,V) = \frac{F^*(U,V)e^{-J2\pi(U\tilde{X}+V\tilde{Y})}}{S_{\Delta P}(U,V)}$$

$$VAR[\hat{X}-\tilde{X}] = \frac{-G_{XY}^2}{B_Y^2\ SNR} + B_X^2\ SNR$$

WHERE: B_X = EFFECTIVE BANDWITH OF INPUT IMAGE $= \dfrac{4\pi^2 \iint U^2 \dfrac{|F(U,V)|^2}{S_{\Delta P}(U,V)} DUDV}{\iint \dfrac{|F(U,V)|^2}{S_{\Delta P}(U,V)} DUDV}$

SIMILARLY FOR Y.

$$SNR = \text{SIGNAL TO NOISE RATIO} = \frac{|F(u,v)|^2}{S_{\Delta P}(u,v)} \, DUDV$$

- THE VARIANCE EXPRESSION SIMPLIFIES UNDER CERTAIN ASSUMPTIONS TO:

$$\overline{(\hat{X}-\tilde{X})^2} = \frac{1}{B_X^2 \, SNR}$$

$$\overline{(\hat{X}-\tilde{Y})^2} = \frac{1}{B_Y^2 \, SNR}$$

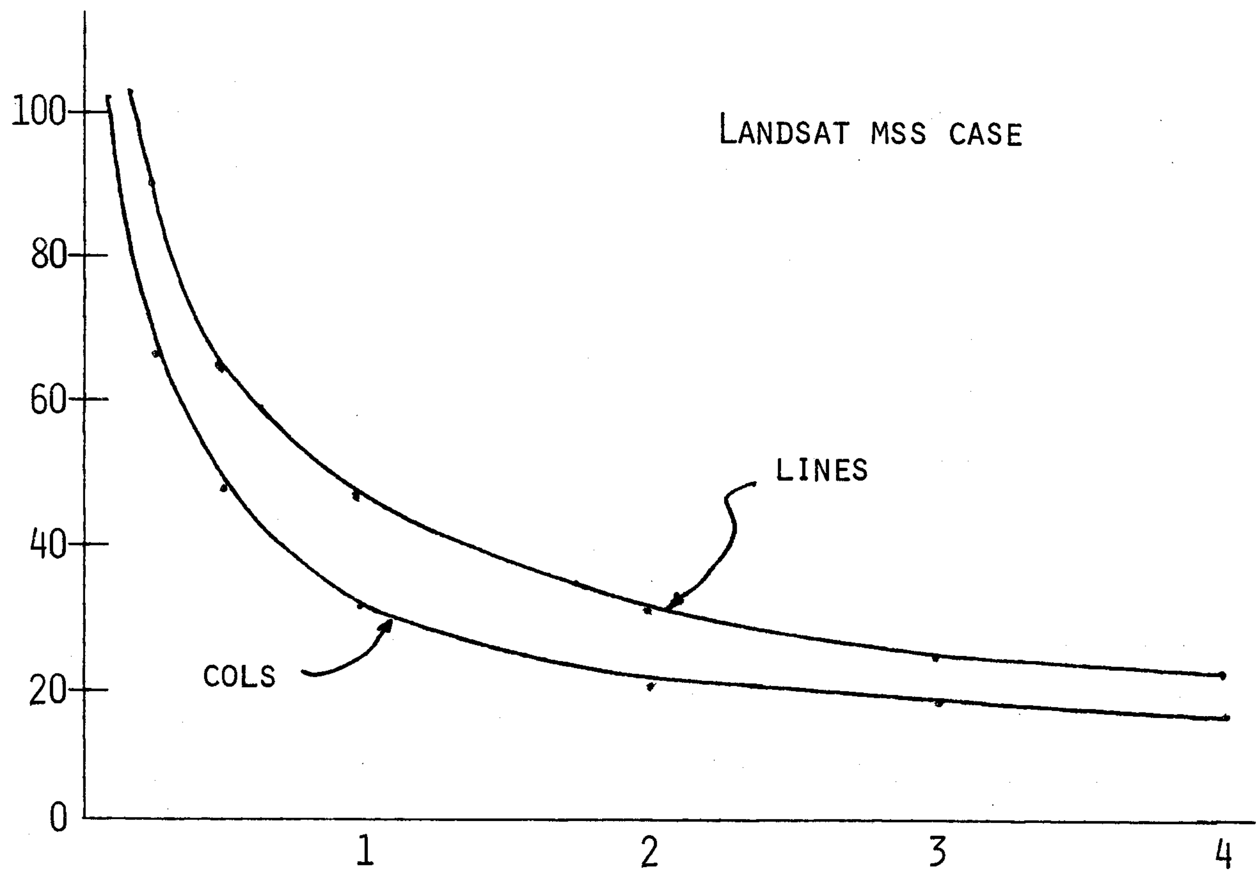
FOR THE LANDSAT CASE, THE EXPRESSIONS FOR STANDARD DEVIATION BECOME:

$$\text{LINE ERROR} = \sqrt{\overline{(\hat{Y}-\tilde{Y})^2}} = \frac{44.1}{\sqrt{SNR}}$$

$$\text{COLUMN ERROR} = \sqrt{\overline{(\hat{X}-\tilde{X})^2}} = \frac{33.1}{\sqrt{SNR}}$$

PLOT OF ERROR PRESENTED IN FIGURE 1.

FIGURE 1. STANDARD DEVIATION OF ESTIMATED MISREGISTRATION USING MATCHED FILTER REGISTRATION PROCESSOR



SIGNAL-TO-NOISE RATIO

(REFERENCE IMAGE ENERGY OVER DIFFERENCE IMAGE ENERGY)

ESTIMATION OF MISREGISTRATION BY ANALYSIS OF TEMPORAL DIFFERENCE SPECTRUM

- TEMPORAL CHANGE MODELED AS REFERENCE PLUS DIFFERENCE IMAGE

$$P_{T_2}(I,J) = P_{T_1}(I,J) + \Delta P_{T_1,T_2}(I,J)$$

WHERE:

$P_T(I,J)$ IS THE IMAGE PIXEL VALUE AT TIME T FOR ROW I AND COLUMN J

$\Delta P_{T_1,T_2}(I,J)$ IS THE CHANGE FROM TIME T_1 TO T_2

- ANALYTICAL ANALYSIS OF MISREGISTRATION BASED ON CONTINUOUS IMAGE. TIME 2 IMAGE ASSUMED MISREGISTERED BY δX COLUMNS AND δY ROWS WITH RESPECT TO TIME 1 IMAGE.

$$P_{T_2}(X,Y) = P_{T_1}(X+\delta_X, Y+\delta_Y) + \Delta P_{T_1,T_2}(X+\delta_X, Y+\delta_Y)$$

- FREQUENCY CONTENT OF IMAGES OBTAINED FROM TWO-DIMENSIONAL FOURIER TRANSFORM:

$$P_{T_2}(U,V) = \iint_{-\infty}^{\infty} P_{T_2}(X,Y)\, e^{-J2\pi(UX+VY)}\, DXDY$$

SUBSTITUTING THE EXPRESSION FOR P_{T_2} WE HAVE:

$$P_{T_2}(u,v) = P_{T_1}(u,v)e^{J2\pi(u\delta_X+v\delta_Y)} + \Delta P_{T_1,T_2}(u,v)e^{J2\pi(u\delta_X+v\delta_Y)}$$

WHERE: THE CAP P REPRESENTS THE FOURIER TRANSFORM. U,V ARE THE FREQUENCY VARIABLES IN CYCLES PER METER.

- THE DIFFERENCE SPECTRUM WITH MISREGISTRATION IS THEN:

$$P_{T_2}(u,v) - P_{T_1}(u,v) = P_{T_1}(u,v)\left[e^{J2\pi(u\delta_X+v\delta_Y)}-1\right] + \Delta P_{T_1,T_2}(u,v)e^{J2\pi(u\delta_X+v\delta_Y)}$$

THE MAGNITUDE SQUARED OF THE DIFFERENCE SPECTRUM IS:

$$\left|P_{T_2}(u,v) - P_{T_1}(u,v)\right|^2 = \left|P_{T_1}(u,v)\right|^2\left[2-2\cos 2\pi(u\delta_X+v\delta_Y)\right] + \left|\Delta P_{T_1,T_2}(u,v)\right|^2$$

$$+ P_{T_1}(u,v)\,\Delta P^*_{T_1,T_2}(u,v) - P_T(u,v)\,\Delta P^*_{T_1,T_2}(u,v)e^{-J2\pi(u\delta_X+v\delta_Y)}$$

$$+ \Delta P_{T_1,T_2}(u,v)P^*_{T_1}(u,v) - \Delta P_{T_1,T_2}(u,v)P^*_{T_1}(u,v)e^{J2\pi(u\delta_X+v\delta_Y)}$$

- THE ANALYTICAL MODEL IS BASED ON PREVIOUS EVIDENCE[1] THAT THE LANDSAT AGRICULTURAL SCENE AND THE TEMPORAL DIFFERENCE IMAGE HAVE A MARKOF OR NEGATIVE EXPONENTIAL AUTOCORRELATION. THE ACF IS THEN OF THE FORM:

$$R(\tau_X, \tau_Y) = A^2 e^{-\alpha|-\tau_X|-\beta|\tau_Y|}$$

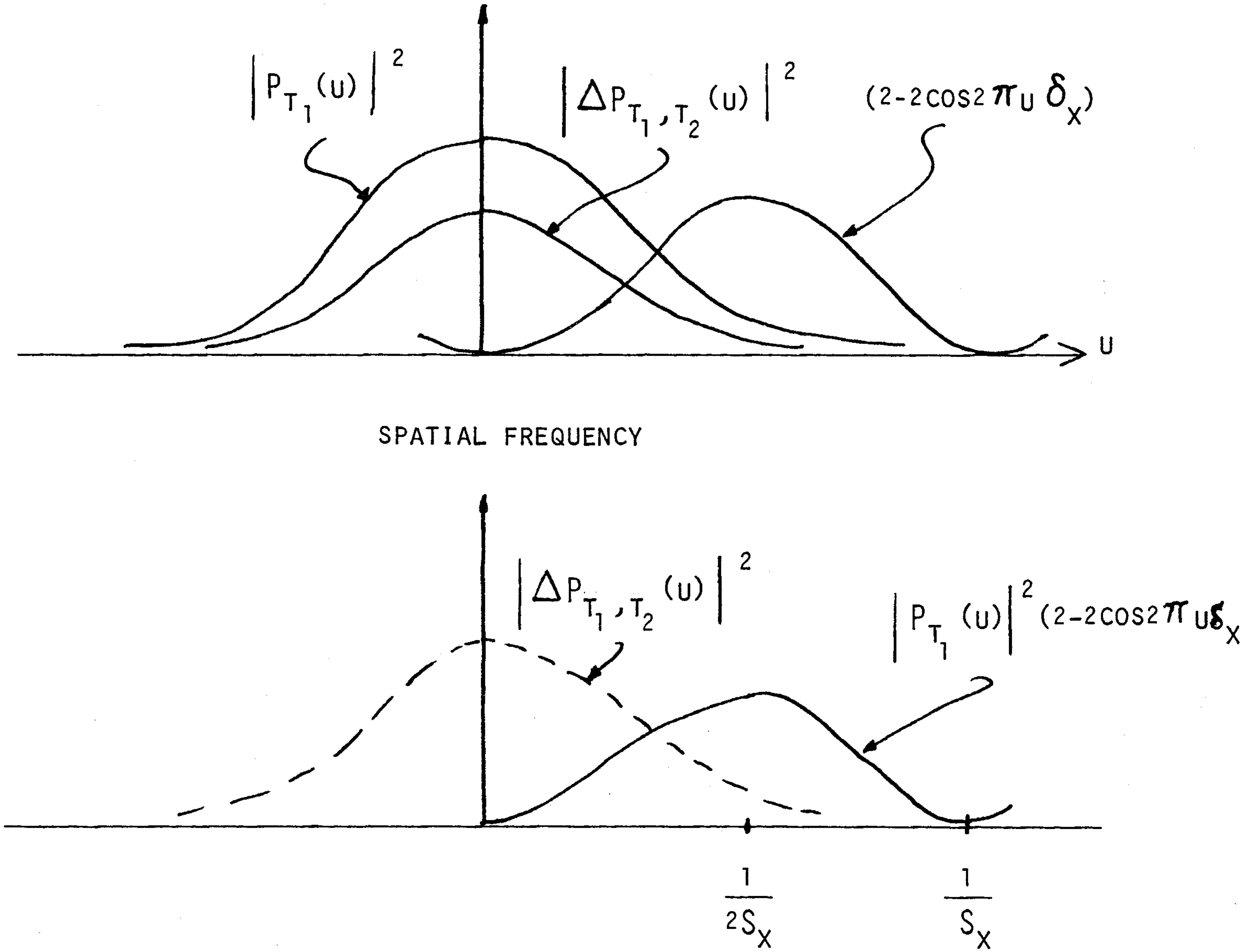
AND THE SPECTRAL DENSITY:

$$S(U,V) = A^2 \left[\frac{2\alpha}{\alpha^2+(2\pi U)^2}\right]\left[\frac{2\beta}{\beta^2+(2\pi V)^2}\right]$$

- A SKETCH OF THE DIFFERENCE SPECTRUM IN ONE-DIMENSION NEGLECTING CROSS TERMS IS SHOWN IN FIGURE 2.

[1] M. SVEDLOW, C. MCGILLEM, P. ANUTA, "ANALYTICAL AND EXPERIMENTAL DESIGN AND ANALYSIS OF AN OPTIMAL PROCESSOR FOR IMAGE REGISTRATION," LARS INFORMATION NOTE 090776, SEPT. 1976.

FIGURE 2. TEMPORAL DIFFERENCE SPECTRUM WITH MISREGISTRATION



PLANS FOR NEXT QUARTER

- COMPLETE DEVELOPMENT OF MISREGISTRATION MODEL.
- DEBUG 2-D FOURIER TRANSFORM PROGRAM AND COMPUTE REFERENCE (P_{T_1}) AND DIFFERENCE ($\Delta P_{T_1,T_2}$) TRANSFORMS FOR TEST SEGMENTS.
- WRITE SOFTWARE FOR ANALYSIS OF THE DIFFERENCE SPECTRUM AND PROCESS TEST CASES.
- COMPARE RESULTS FOR SPECTRAL DIFFERENCES METHOD TO CONVENTIONAL AND OPTIMUM CORRELATOR TECHNIQUES.

2A. Determining the Effects of Misregistration

	1979	1980										
	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
1. Prepare Implementation Plan												
2. Define and Acquire Test Data Sets												
3. Complete Definition of Misregistration Model												
4. Develop Software of Evaluation Model												
5. Analyze and Verify Misregistration Model												
6. Develop Model for Classification Error Due to Misregistration												
7. Reporting												

Task 2C

ADVANCED CLASSIFICATION METHODS

Philip H. Swain, David A. Landgrebe, Howard J. Siegel

TASK 2C1. MULTISTAGE CLASSIFICATION

OBJECTIVE

TO DEVISE MEANS FOR IMPROVEMENT IN CLASSIFICATION PERFORMANCE, ESPECIALLY FOR MORE COMPLEX DATA, THROUGH THE USE OF MULTISTAGE CLASSIFICATION TECHNIQUES.

Potential Benefits

1. More efficient use of classifier computation

2. More accurate classification for a given amount of computation

3. More effective use of multitemporal data

4. Development of flexible classifier models for incorporating multitype (sensor and ancillary) data

Near-term Objectives

A. DETERMINE SUITABLE FEATURE SELECTION METHODS

B. DEVELOP A SATISFACTORY TRAINING PROCEDURE

C. DEVISE A DECISION TREE DESIGN ALGORITHM

WORK ACCOMPLISHED

A. SIMULATION OF DATA SET*

B. SOME EXPERIMENTATION ON EFFECT OF THE MEASUREMENT COMPLEXITY ON ACCURACY

C. TRAINING PROCEDURE COMPLETED

D. INVESTIGATION OF DIFFERENT, PREVIOUSLY USED, ERROR ESTIMATORS

* SEE SEPARATE OVERLAY

SIMULATION OF DATA SET

- PROVIDES A COMPLETELY DOCUMENTED DATA SET
- REDUCES NUMBER OF VARIABLES IN DATA, PROVIDING MORE CONTROL
- PROVIDES BETTER UNDERSTANDING OF PARAMETERS AFFECTING DATA, AS ALL ASSUMPTIONS OF NORMALITY ARE MET

PLANS FOR NEXT PERIOD

A. INVESTIGATION OF "HUGHES PHENOMENA" IN GREATER DETAIL, WITH POSSIBLE UNDERSTANDING OF WHEN IT OCCURS QUANTITATIVELY

B. CONTINUATION OF DEVELOPMENT OF A TREE DESIGN APPROACH

C. DEPENDING ON "A," DEVELOPMENT OF A NEW FEATURE SELECTION TECHNIQUE

2C2. CONTEXTUAL CLASSIFICATION

POTENTIAL BENEFITS

1. INCORPORATION OF SPATIAL INFORMATION TO IMPROVE CLASSIFICATION ACCURACY

2. EXPLORATION OF USE OF POWERFUL MULTIPROCESSOR SYSTEM FOR EARTH RESOURCES DATA ANALYSIS

3. DEVELOPMENT OF METHODS FOR IMPLEMENTING AND EVALUATING IMAGE DATA ANALYSIS ALGORITHMS ON PARALLEL PROCESSING SYSTEM

4. EVALUATION OF CDC CYBER-IKON SYSTEM FOR CONTEXTUAL CLASSIFICATION

5. ANALYSIS OF WHICH ARCHITECTURAL FEATURES OF ADVANCED COMPUTER SYSTEMS ARE MOST IMPORTANT FOR EFFICIENT CONTEXTUAL (AND OTHER FORMS OF) CLASSIFICATION

OBJECTIVES

1. REFINE CONTEXT DETERMINATION AND REPRESENTATION METHODS
2. DEVELOP METHOD FOR DETERMINING THE OPTIMAL CONTEXTUAL CONFIGURATION
3. DEVELOP MORE EFFICIENT IMPLEMENTATION OF THE CONTEXTUAL CLASSIFIER FOR CONVENTIONAL COMPUTERS
4. INVESTIGATE INCLUSION OF NONSPECTRAL FEATURES
5. EVALUATE CYBER-IKON IMPLEMENTATION OF THE CLASSIFIER
    -- THROUGH SIMULATION
    -- ON REAL CYBER-IKON SYSTEM
6. CONSIDER LARGE-SCALE MULTIMICROPROCESSOR IMPLEMENTATIONS

SECOND QUARTER ACCOMPLISHMENTS

ALGORITHM DEVELOPMENT

1. CONTEXT MEASURE FOR PREDICTING BEST CONTEXT CONFIGURATION TESTED EXTENSIVELY ON ONE DATA SET; TESTS BEGUN ON SECOND DATA SET.

2. "POWER METHOD" FOR CLEANING UP CONTEXT ESTIMATION TESTED SIMILARLY.

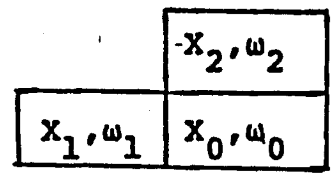
SEE "CONTEXT DISTRIBUTION ESTIMATION FOR CONTEXTUAL CLASSIFICATION OF MULTISPECTRAL IMAGE DATA," BY J. C. TILTON, P. H. SWAIN, AND S. B. VARDEMAN, LARS TECHNICAL REPORT 040280 (AGRISTARS REPORT NO. SR-P0-00444), APRIL 1980.

Discriminant: for $a \epsilon A$, $\underline{X} \epsilon X^{p}$

$$g_a(\underline{X}) = \sum_{\substack{\underline{\omega}, \\ \omega_i = a}} \left[\prod_{j=1}^{p} p(X_j | \omega_j) \right] p(\underline{\omega})$$

Example:

$p = 3$
2 classes (r,s)



$$g_s(\underline{X}) = \sum_{\substack{\underline{\omega} \\ \omega_i = s}} \left[\prod_{c=0}^{2} p(X_c | \omega_c) \right] p(\underline{\omega})$$

$$= p(X_0|s)p(X_1|r)p(X_2|r)p(s,r,r)$$

$$+ p(X_0|s)p(X_1|r)p(X_2|s)p(s,r,s)$$

$$+ p(X_0|s)p(X_1|s)p(X_2|r)p(s,s,r)$$

$$+ p(X_0|s)p(X_1|s)p(X_2|s)p(s,s,s)$$

CONTEXT MEASURE

If $\underline{\omega} \in \Omega^p$ (p-context array), write

$$p(\underline{\omega}) \cong G(\Omega^p)$$

Suppose $G(\Omega^p)$ can be factored:

$$G(\Omega^p) = G_1(\Omega^q) \cdot G_2(\Omega^{p-q})$$

Then the discriminant functions can also be factored:

$$g_a(\underline{X}) = g_1(X_0, X_1, \ldots, X_{q-1}, G_1(\Omega^q)) \cdot g_2(X_q, \ldots, X_{p-1}, G(\Omega^{p-q}))$$

where the second factor is common to all discriminant functions and may be dropped -- i.e., the p-q cells represented by this term are not contextually significant.

QUESTION: Test for factorability?

Proposed "context measure" (of factorability):

$$\Delta G_q^p = \sum_{i=1}^{m} \cdots \sum_{k=1}^{m} \left[G_1(\Omega^q) \cdot G_2(\Omega^{p-q}) - G(\Omega^p) \right]^2$$

If ΔG_q^p is large, then G is <u>not</u> factorable in this way.

POWER METHOD

Raising $G(\Omega^p)$ (cell-by-cell) to a power $\alpha > 1$ emphasizes large values, discriminating against smaller (less reliable) values.

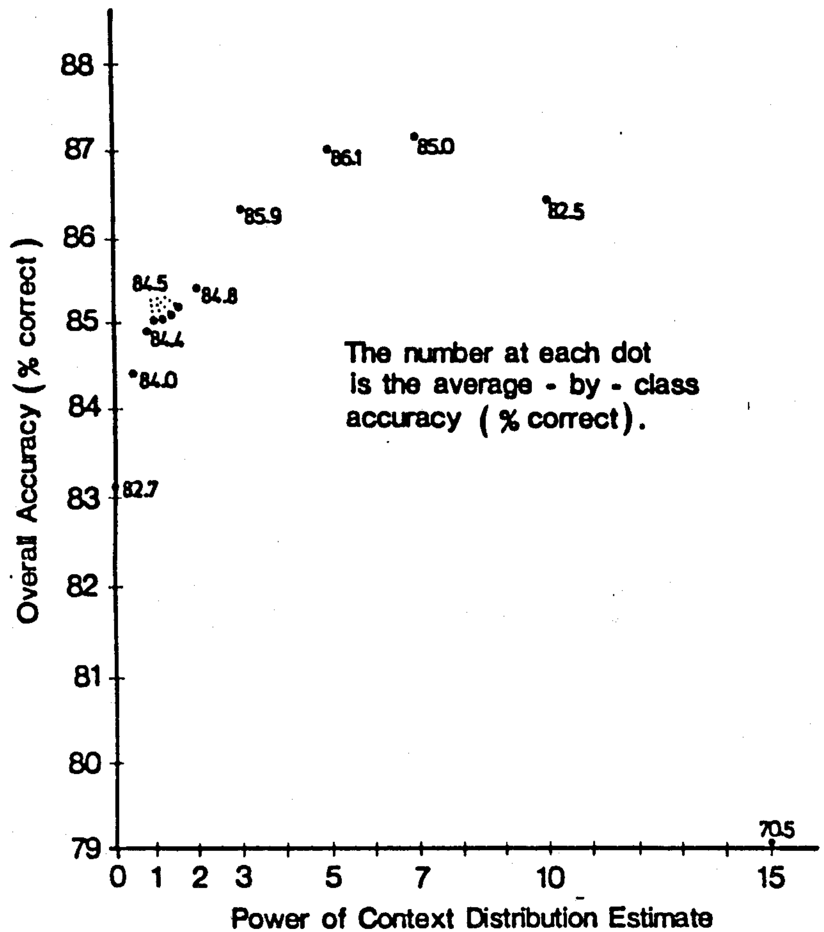


FIGURE 2. Power method results using two-nearest-neighbors (north and east) context on Bloomington, IN data set. Context distribution, $G(\underline{\theta}^P)$, estimated from uniform-priors no-context distribution.

SECOND QUARTER ACCOMPLISHMENTS (CONT.)

CYBER-IKON IMPLEMENTATION

3. EXPONENT RANGE PROBLEM SOLVED BY SOFTWARE IMPLEMENTATION OF MULTIPLE-PRECISION EXPONENT

4. COMPLETED TESTS OF MAXIMUM-LIKELIHOOD ALGORITHM ON CYBER-IKON SIMULATOR

5. LINEAR-NEIGHBORHOOD VERSION OF CONTEXTUAL CLASSIFIER IMPLEMENTED ON CYBER-IKON SIMULATOR, TESTS IN PROGRESS

6. CYBER-IKON WORK TO DATE EXTENSIVELY DOCUMENTED IN EE MASTER'S THESIS (TO APPEAR AS TECHNICAL REPORT)

PROBLEMS ENCOUNTERED

ALGORITHM DEVELOPMENT

1. PROPOSED CONTEXT MEASURE IS ONLY A WEAK PREDICTOR OF OPTIMAL CONTEXT CONFIGURATION; EVALUATION CONTINUING

2. "POWER METHOD" LOOKS PROMISING, BUT NOT THE FINAL ANSWER TO IMPROVING CONTEXT ESTIMATION

CYBER-IKON IMPLEMENTATION

3. WORK REQUIRED FOR CONTEXT CLASSIFIER IMPLEMENTATION ON SIMULATOR HAS DELAYED IMPLEMENTATION OF INTER-PROCESSOR COMMUNICATION

4. PDP-11/34 CONFIGURATION AT LARS IS NOT ADEQUATE FOR PRACTICAL EXECUTION OF CYBER-IKON SIMULATOR

5. NO PROGRESS TOWARD HARDWARE CYBER-IKON IMPLEMENTATION

PLANS FOR THIRD QUARTER

ALGORITHM DEVELOPMENT

1. CONTINUE EVALUATION OF "POWER METHOD" IN FULL BOOTSTRAP APPROACH TO CONTEXT DISTRIBUTION ESTIMATION

2. PURSUE SEARCH FOR PREDICTOR OF OPTIMAL CONTEXT CONFIGURATION

3. RESUME EVALUATION OF APPROXIMATE ALGORITHMS

4. INVESTIGATE USE OF INFORMATION CLASS CONTEXTUAL DISTRIBUTION IN PLACE OF SPECTRAL CLASS DISTRIBUTION

5. BEGIN CONSIDERATION OF HYBRID ALGORITHM FOR SELECTIVE APPLICATION OF CONTEXTUAL CLASSIFIER

PLANS FOR THIRD QUARTER (CONT.)

CYBER-IKON IMPLEMENTATION

6. COMPLETE TEST AND EVALUATION OF LINEAR-NEIGHBORHOOD CONTEXTUAL CLASSIFIER ON CYBER-IKON SIMULATOR

7. IMPLEMENT GENERALIZED NEIGHBORHOOD VERSION OF CONTEXTUAL CLASSIFIER ON CYBER-IKON SIMULATOR

8. ADD INTER-PROCESSOR COMMUNICATION FACILITIES TO THE CYBER-IKON SIMULATOR

9. PURSUE HARDWARE IMPLEMENTATION QUESTIONS

TASK 2E

AMBIGUITY REDUCTION FOR TRAINING SAMPLE LABELING

D.A. LANDGREBE

TASK 2E. AMBIGUITY REDUCTION FOR TRAINING SAMPLE LABELING

OBJECTIVE

TO DEVISE AND DETERMINE QUANTITATIVE AND OBJECTIVE MEANS FOR OPTIMALLY ARRIVING AT CLASSIFIER TRAINING DOT, FIELD, OR OBJECT LABELS USING REMOTELY SENSED OBSERVATIONS THEMSELVES TOGETHER WITH ANY OTHER TYPES OF ANCILLARY DATA AND KNOWLEDGE WHICH MAY BE AVAILABLE.

APPROACH RATIONALE

- Ancillary data may be subjective, imprecise and self-conflicting
- Approach to provide "convergence of evidence" rather than simple direct calculation
- Relaxation methods chosen for study

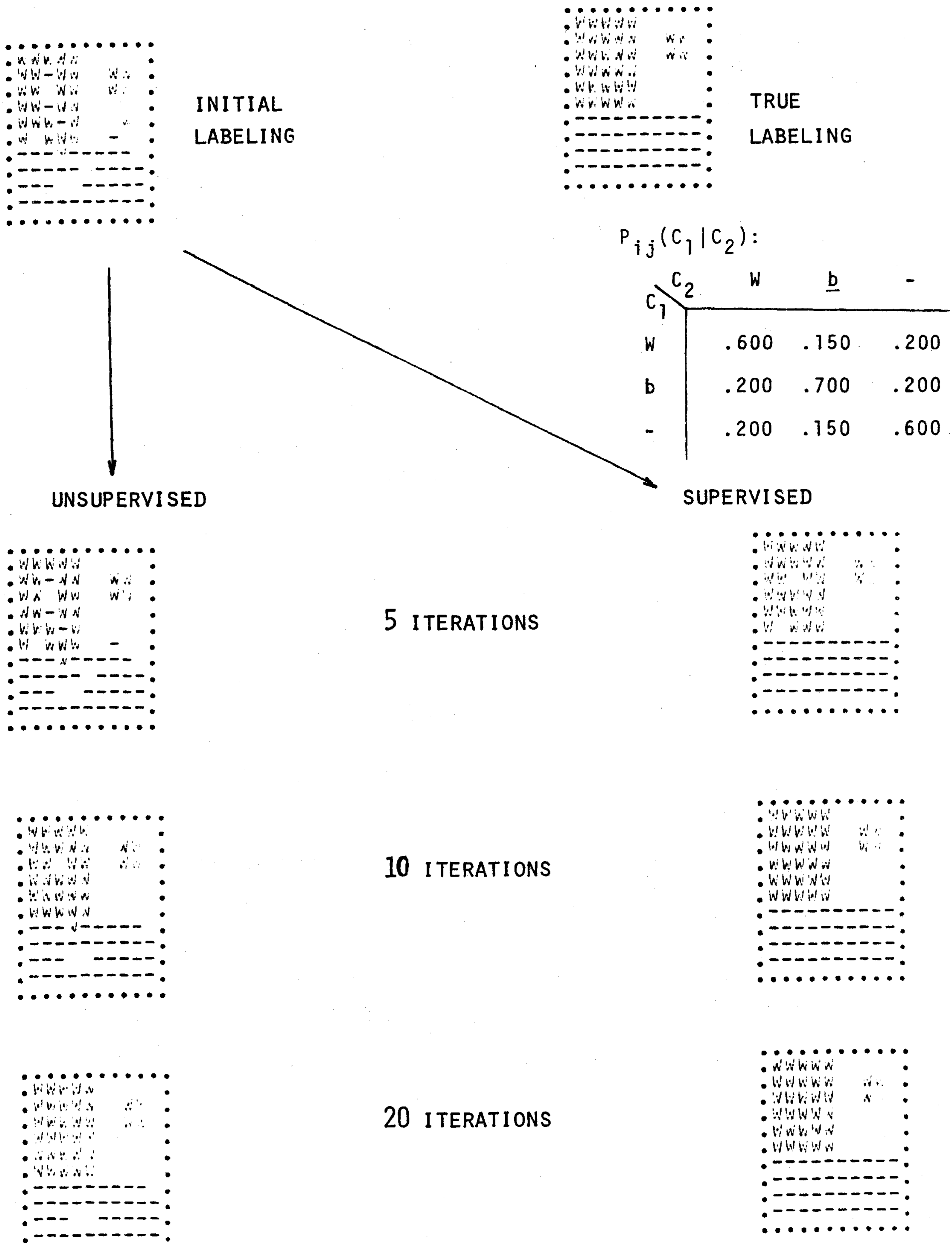
PREVIOUS TASK RESULTS

- REVIEW RELAXATION METHOD WORK IN PICTURE PROCESSING
- IMPLEMENT TRIAL SOFTWARE
- LABEL DEGRADATION IDENTIFIED AS A PROBLEM
- SOLUTION: RULES FOR SETTING NEIGHBOR WEIGHTS
- "SUPERVISION" A MECHANISM FOR INCORPORATING OTHER ANCILLARY DATA

CURRENT WORK

- EXTEND SOFTWARE TO MULTILABEL CASE
- TEST

TEST OF THREE CLASS RELAXATION



$P_{ij}(C_1|C_2)$:

C_1 \ C_2	W	b	-
W	.600	.150	.200
b	.200	.700	.200
-	.200	.150	.600

ANCILLARY DATA USED TO SUPERVISE
THE LABEL RELAXATION PROCEDURE

P(W)	=	.400	6 ROWS
		.200	4 ROWS
P(B)	=	.400	6 ROWS
		.200	4 ROWS
P(-)	=	.200	6 ROWS
		.600	4 ROWS

NEXT

- Further trials with multilabel
- Characterization of ancillary data classes
- Application scenario

REFERENCE REPORTS (DELIVERABLES)

[1] Richards, J. A., D. A. Landgrebe, and P. H. Swain, "Pixel Labeling by Supervised Probabilistic Relaxation", LARS Technical Report 022580, IEEE Transactions on Pattern Analysis and Machine Intelligence, to appear

[2] Richards, J. A., D. A. Landgrebe, and P. H. Swain, "On the Accuracy of Pixel Relaxation Labeling", LARS Technical Report 030180

5. COMPUTER PROCESSING AND DATA BASE SUPPORT

TASK 3A

COMPUTER PROCESSING SUPPORT

JAMES L. KAST

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 HAS INCLUDED:

* A COMPUTER AND SUPPORTING HARDWARE
* SOFTWARE
* DATA
* PERSONNEL
* PROCEDURES
* TRAINING

THE FULL IMPLEMENTATION OF A SHARED DATA PROCESSING ENVIRONMENT (NETWORK OR CENTRALIZED FACILITY) WOULD PROVIDE THE FOLLOWING POTENTIAL BENEFITS:

* THE OPPORTUNITY TO BETTER MOLD GEOGRAPHICALLY-DISPERSED RESEARCH GROUPS INTO A MORE INFORMED AND INTEGRATED 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, DATA ACQUISITION, DATA BASE AND CERTAIN COMPUTER SERVICES AT A SMALL NUMBER OF LOCATIONS (FREQUENTLY ONE).

JLK:12/4/79

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

* ACCESS TO THE SOFTWARE SUPPORTING THE TECHNIQUE;
* ACCESS TO HARDWARE WHICH SUPPORTS THE SOFTWARE;
* ACCESS TO THE DATA REQUIRED BY THE TECHNIQUE;
* A TECHNICAL UNDERSTANDING OF THE TECHNIQUE; AND
* KNOWLEDGE OF HOW TO OPERATIONALLY USE THE IMPLEMENTATION (SOFTWARE AND PROCEDURES).

JLK:12/4/79

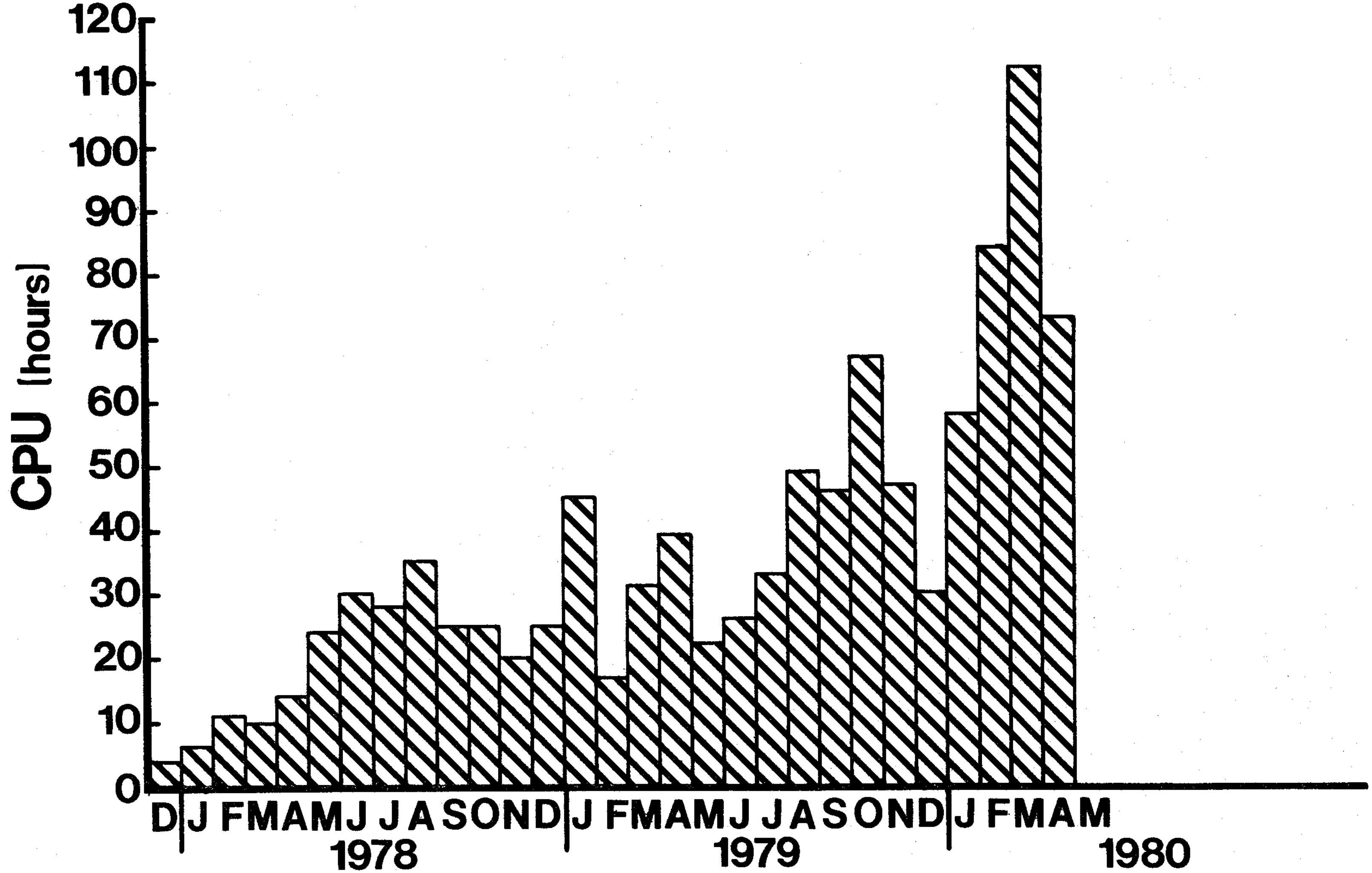
Goals for Support of ERSYS/EODLS

Expand the shared data processing environment to more fully include ERIM and FCPF.

Help prepare for the installation of a 4341-class computer at JSC/EOD.

Support the design and development of ERSYS

2/11/80



Computer Processing Support
3031-equivalent CPU Consumption

COMPUTER RESOURCES CONSUMED

	Dec '77	Nov '78	Nov '79	May '80
JSC Users	26	71	96	144
Total ID's	29	95	123	174
3031 CPU Hours, *year ending	23	231	458	1076

5/12/80

EODLS/ERSYS Support

Accomplishments:

*Ran ASTEP benchmarks on the 3031 under VS1, VM/VS1, VM/CMS (April)

*Reviewed and prepared benchmarks for distribution (May)

*Tested the effects of VMCF usage on the system (May)

*Reviewed and commented on ERSYS Systems Design Presentation (May)

*Hosted two IBM representatives for data base discussion & hands-on CMS experience (March)

*Attempted to identify major tasks requiring computational resources (April)

*Identified cost of documentation and standardization of LARS utility programs. (April)

*Identified training options and costs for a second CMS short course at JSC. (April)

5/12/80

EODLS/ERSYS SUPPORT (CONT.)

PLANS:

*SECURE FUNDING TO ALLOW ERSYS DEVELOPMENT TO PROCEED ON THE PURDUE MACHINE (JUNE)

*CONTINUE CONSULTING SUPPORT FOR ERSYS DEVELOPMENT

*ASSIST IN INSTALLATION OF ERSYS DBMS (AUGUST)

5/12/80

ASTEP Benchmark test conditions:

*Runs were made on an otherwise idle system

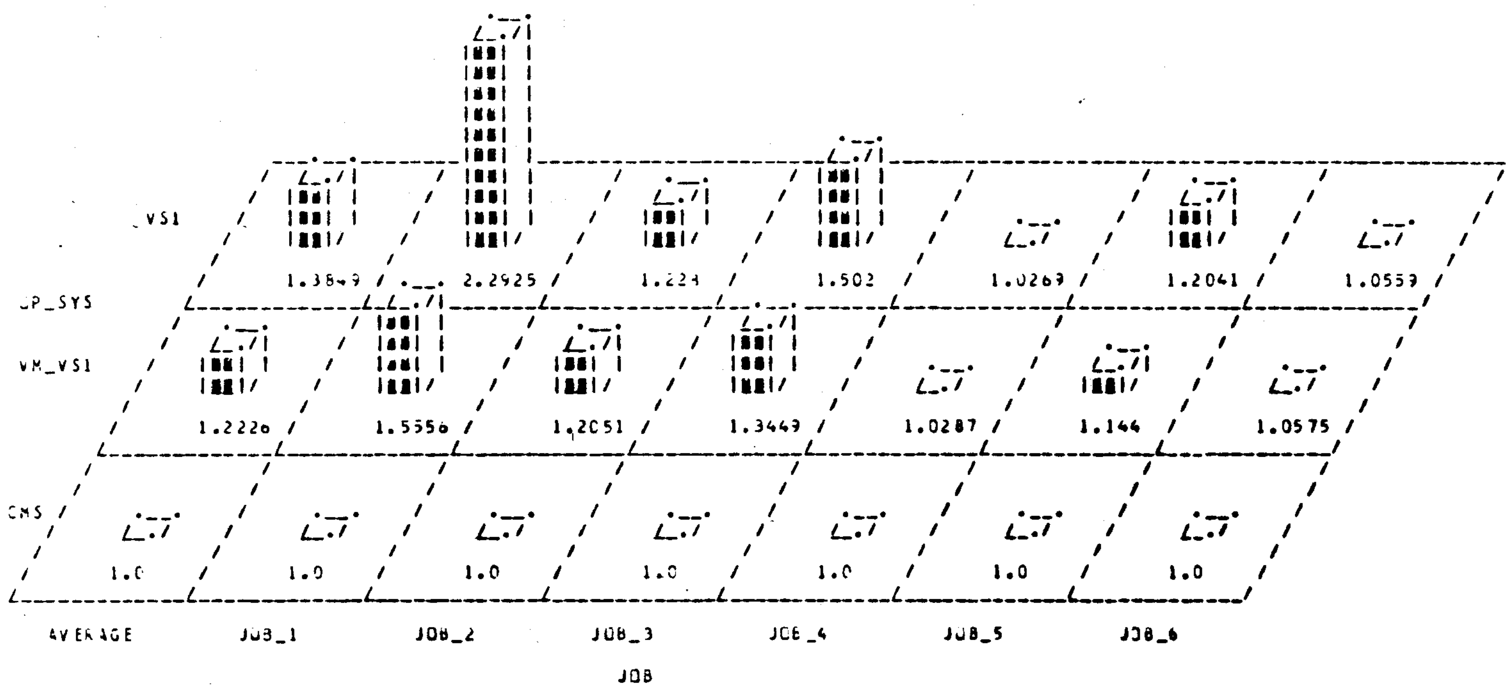
*Three operating system environments were compared.

- VM/CMS
- OS/VS1 running in a Virtual Machine
- OS/VS1 running in native mode on the real machine

*Total CPU utilization for each set of runs on the LARS 3031 was approximately 150 minutes

5/12/80

CHART OF EXECUTION TIMES MEASURED BY ASTEP ACROSS OPERATING SYSTEMS 20:51 THURSDAY, MAY 8, 1980



VMCF TESTING

*SEND/RECEIVE PROTOCOL USED

- SOURCE MACHINE SENT 256 BYTE MESSAGE CONTAINING SIZE OF BLOCK TO RETURN
- SINK MACHINE RETURNED BLOCK OF REQUESTED SIZE (256, 512, 1K, 2K, 10K, ..., 100K)
- 1000 REQUESTS WERE MADE AT EACH RETURN BLOCK SIZE

*INITIAL RUNS MADE IN A BUSY SYSTEM (19 ACTIVE USERS, 100% CPU UTILIZATION) INDICATED LITTLE IMPACT ON OTHER USERS.

*TIMING DATA WERE COLLECTED WITH ONE SOURCE AND ONE SINK MACHINE IN AN ESSENTIALLY IDLE SYSTEM - THROUGHPUT WAS ABOUT 2 MEG/SEC.

*QUANTITATIVE DATA ON EFFECT ON OTHER MACHINES IS YET TO BE GATHERED.

- SYNTHETIC WORKLOAD TO BE CONSTRUCTED WITH BUILT IN INSTRUMENTATION AND REPEATABILITY

THE SEND/RECV PROTOCOL

The SEND/RECV protocol defines a transaction calling for two-way transfer of data, as described in Figure 16. The SEND/RECV protocol uses the SEND/RECV, RECEIVE, and REPLY subfunctions. 146

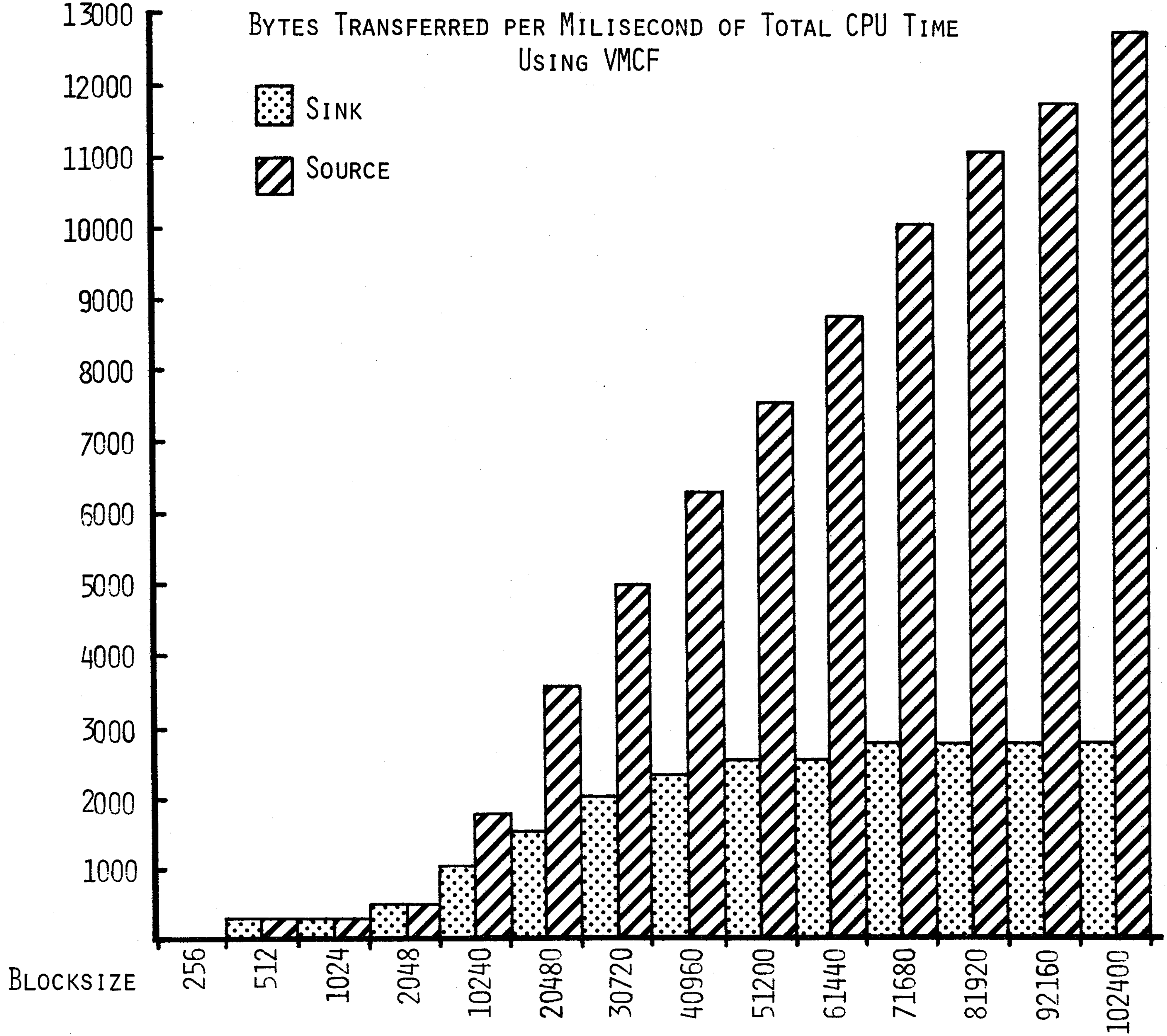
The source virtual machine initiates the transaction using the SEND/RECV subfunction. Using an external interrupt, CP notifies the sink virtual machine that there is a message waiting. The sink virtual machine uses the RECEIVE subfunction to cause the data to be transfered from the source virtual machine's storage to the sink virtual machine storage. The sink virtual machine now uses the REPLY subfunction to cause data to be transferred from its storage to the source virtual machine's storage. When the REPLY subfunction completes processing, CP causes an external interrupt in the source virtual machine, notifying it that the transaction is complete.

The SEND/RECV request requires that the source virtual machine specify the address and length of the data to be transferred and the address where data is expected from the REPLY subfunction. (Both addresses are in source virtual machine storage.) These addresses, along with the length of the data to be transferred, are specified via the VMCPARM parameter list, described below.

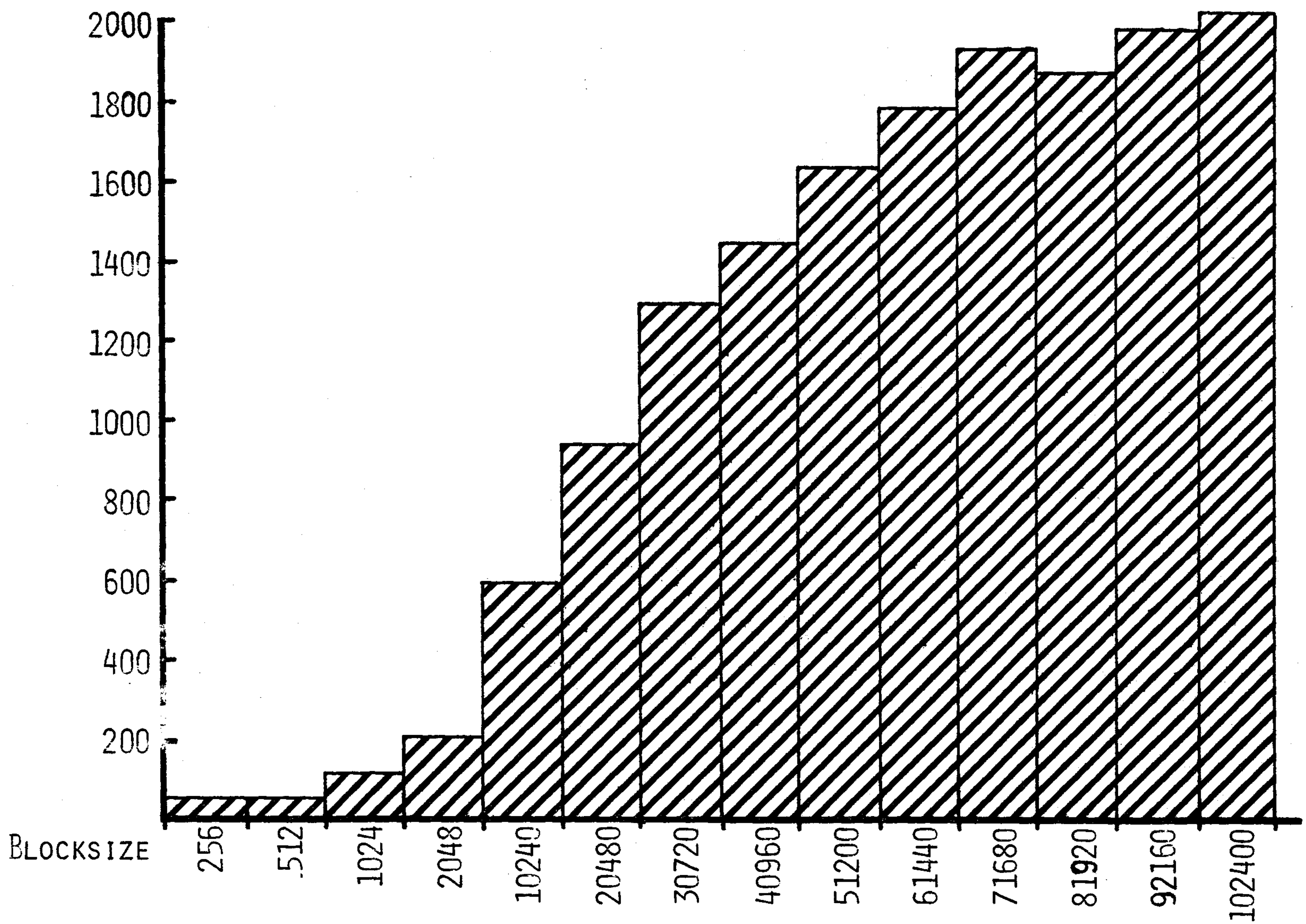
When RECEIVE is issued by the sink virtual machine in response to the SEND/RECV request, VMCPARM contains the address in sink virtual machine storage where data is to be received. Finally, when the REPLY request is issued, VMCPARM contains the address in the sink virtual machine storage from which data is to be transferred.

```
                     CONTROL PROGRAM
                   ┌───────────────────┐
                   |      DMKVMC       |
                   ├───────────────────┤
                   |       VMCF        |
                   |     Interface     |
                   |      Module       |
                   └───────────────────┘
                             |   |
        Source               |   |                Sink
        Virtual              |   |                Virtual
        Machine              |   |                Machine
                             |   |
                             |   |
     SEND/RECV-->----------->|   |
                             |   |
                             |   |--External Interrupt------>
                             |   |
                             |   |<--------<----------RECEIVE
                             |   |
        ----------------->Data Transfer------------------->
                             |   |
                             |   |<------------<---------REPLY
                             |   |
        <-----------------Data Transfer-------<------------
                             |   |
     <--External Interrupt--|   |
        (Final Response)     |   |
                             |   |
```

Figure 16. The SEND/RECV Protocol


Bytes Transferred per Milisecond of Total CPU Time
Using VMCF
Sink
Source
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
Blocksize
256
512
1024
2048
10240
20480
30720
40960
51200
61440
71680
81920
92160
102400

BYTES TRANSFERRED PER MILISECOND OF ELAPSED TIME USING VMCF



HARDWARE

ACCOMPLISHMENTS:

- 33502 DISK INSTALLATION (APRIL)
- 3705 EXPANSION (MARCH)
- EIGHT ADDITIONAL PORTS INSTALLED FOR JSC USAGE (MAY)
- FOUR PORTS AND PHONE LINE INSTALLED FOR ERIM (MAY)
- DECISION TO SUPPORT 3330 DISKS REVERSED (APRIL)

RELATED ACCOMPLISHMENTS:

- EQUIPMENT RECEIVED FOR THE LARS IMAGE ANALYSIS STATION

PLANS:

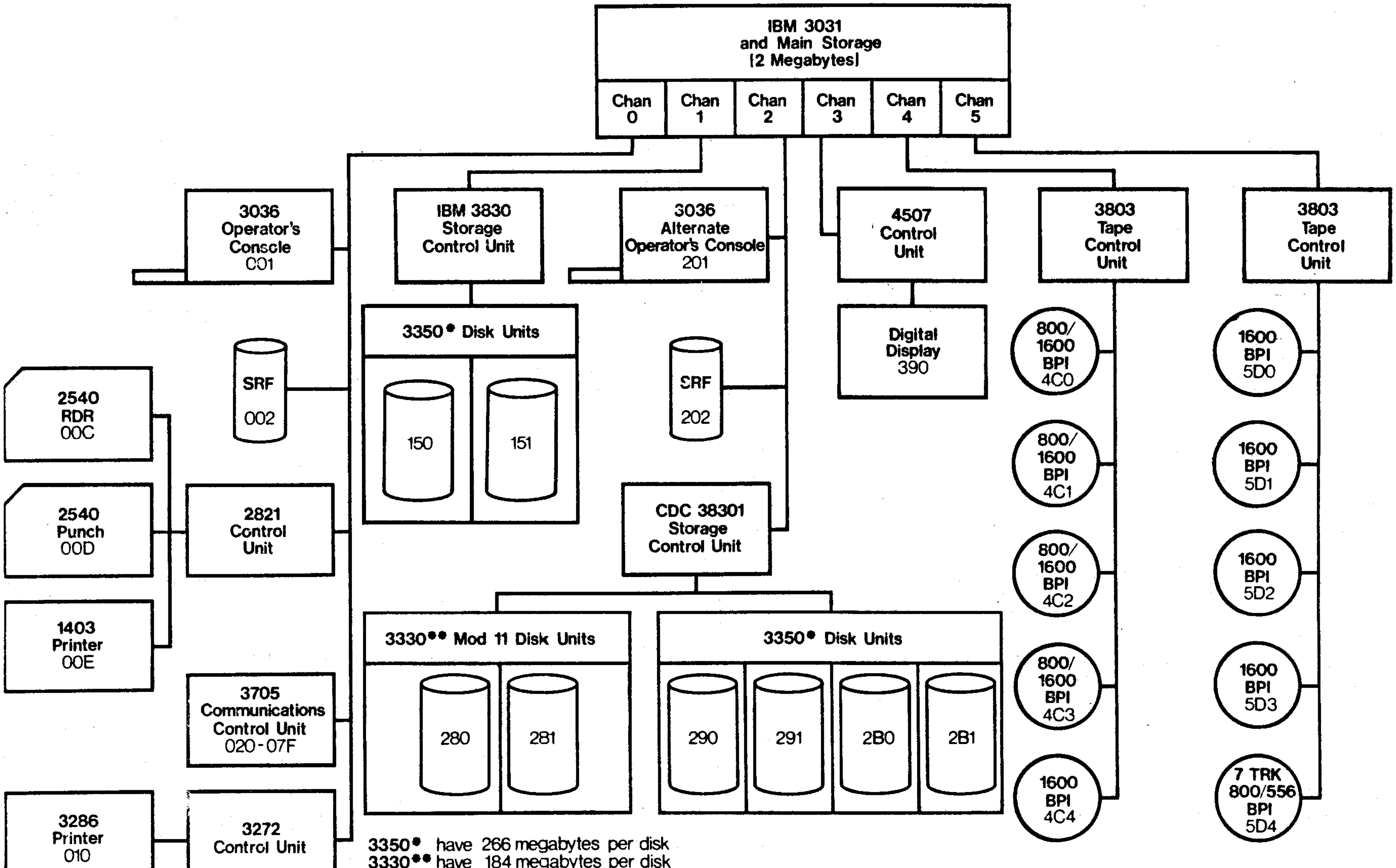
- SECURE DEFENSE PRIORITY FOR ACQUISITION OF A NEW MAINFRAME AT LARS (SEPT)
- INSTALL ERIM/LARS/JSC/OTHER NETWORKING CAPABILITY (JAN '81)

RELATED PLANS:

- RE-ORGANIZE & UPGRADE COMMUNICATIONS HARDWARE AT LARS (JUNE-JULY)
- TAPE SYSTEM UPGRADE TO HANDLE 6250 BPI (NOV)
- RE-ORGANIZE MACHINE ROOM FOR EVENTUAL MACHINE REPLACEMENT (OCT)
- INSTALL NEW MAINFRAME AT LARS (FEB '81)

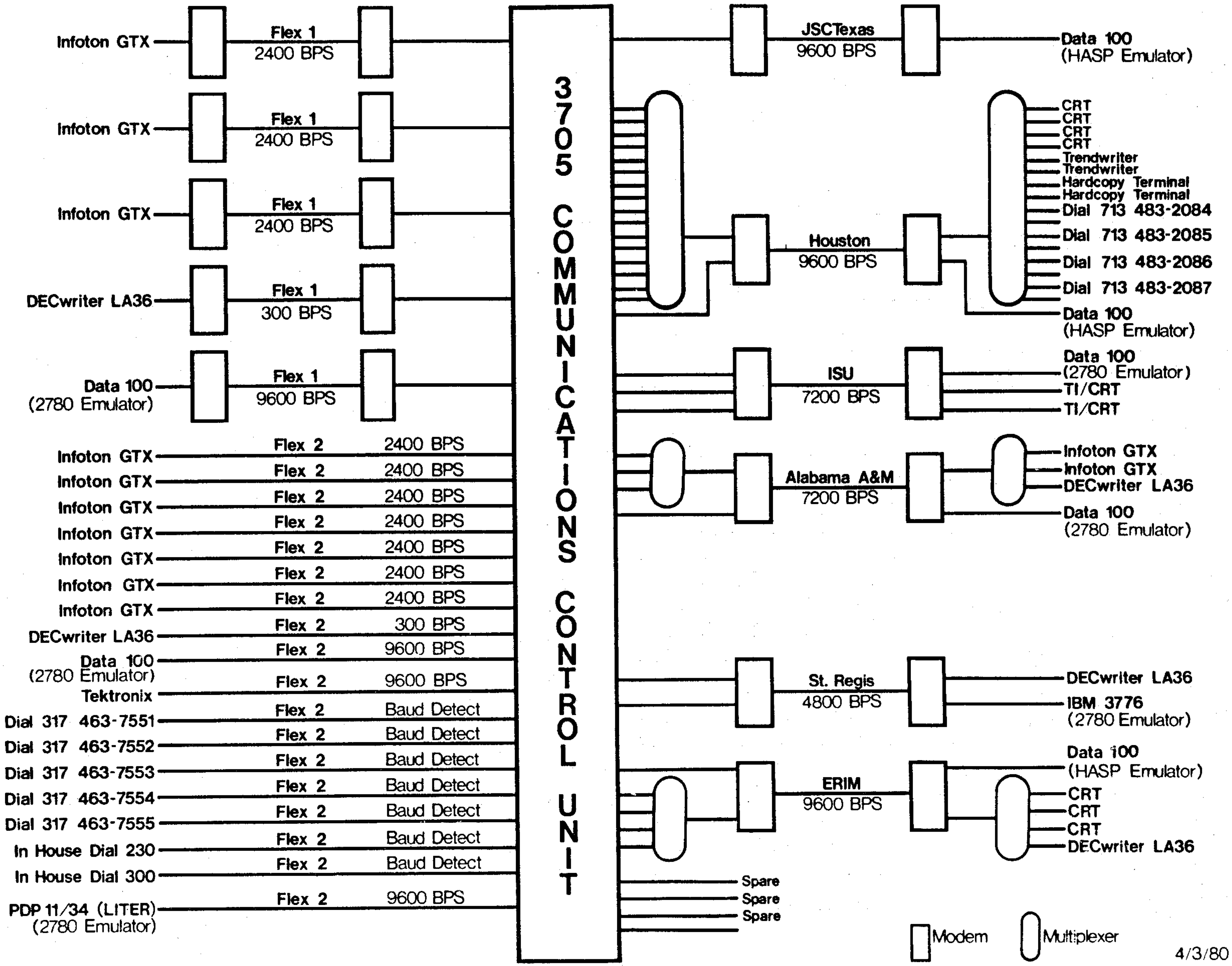
5/12/80

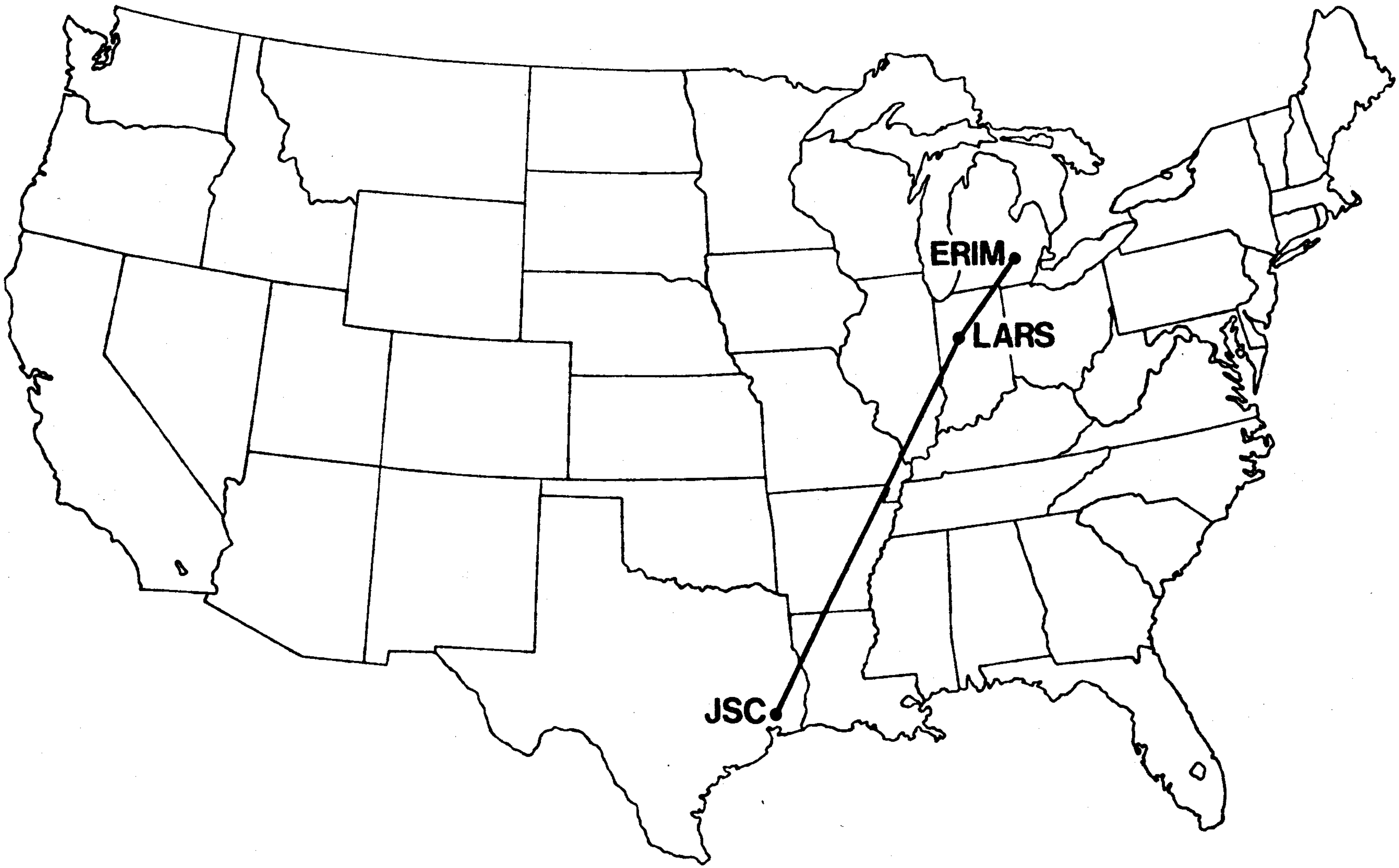
3031 Hardware Configuration



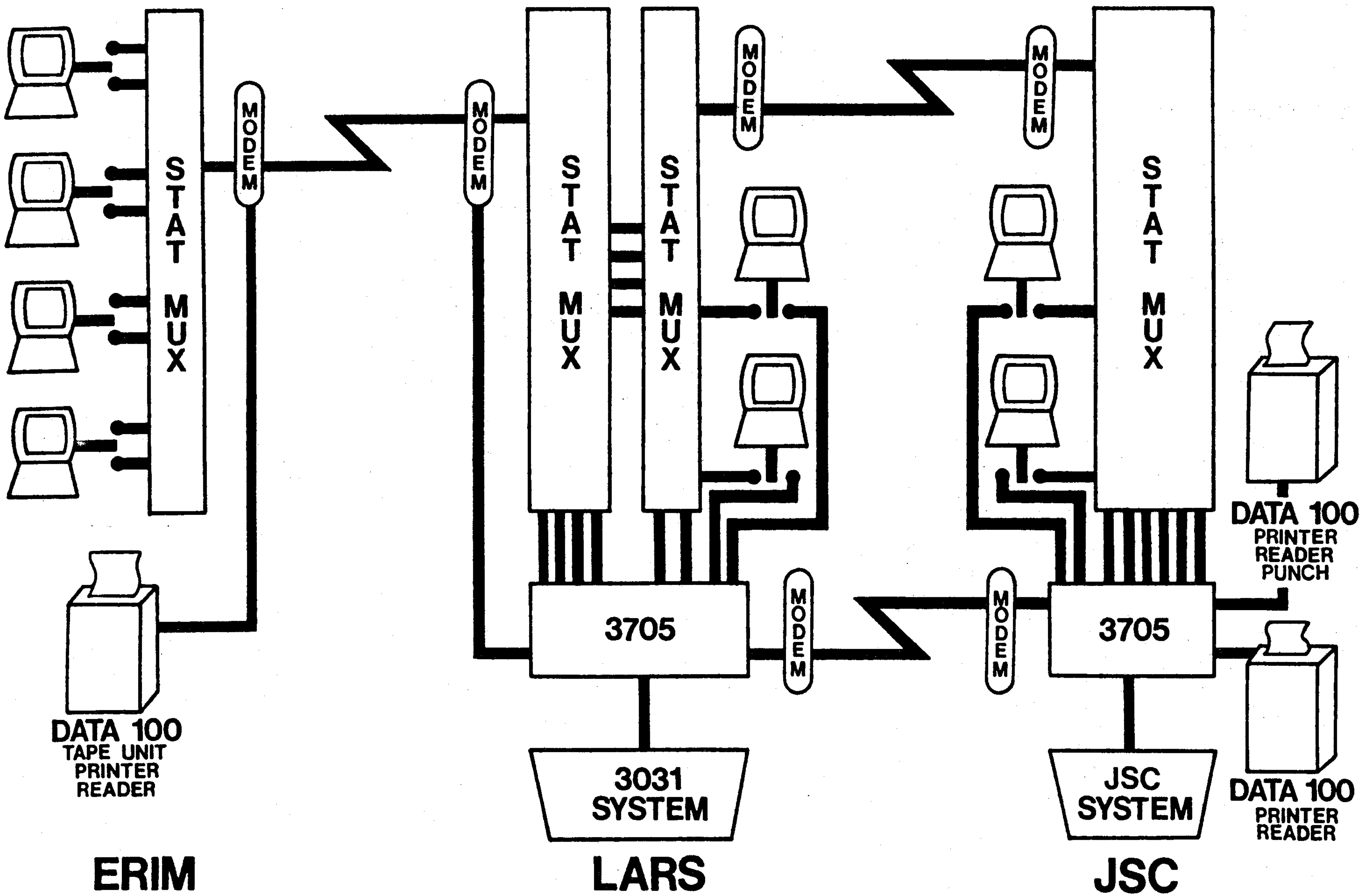
4/3/80

17


3705 COMMUNICATIONS CONTROL UNIT
Infoton GTX
Flex 1
2400 BPS
Infoton GTX
Flex 1
2400 BPS
Infoton GTX
Flex 1
2400 BPS
DECwriter LA36
Flex 1
300 BPS
Data 100
(2780 Emulator)
Flex 1
9600 BPS
Infoton GTX
Flex 2
2400 BPS
Infoton GTX
Flex 2
2400 BPS
Infoton GTX
Flex 2
2400 BPS
Infoton GTX
Flex 2
2400 BPS
Infoton GTX
Flex 2
2400 BPS
Infoton GTX
Flex 2
2400 BPS
Infoton GTX
Flex 2
2400 BPS
DECwriter LA36
Flex 2
300 BPS
Data 100
(2780 Emulator)
Flex 2
9600 BPS
Tektronix
Flex 2
9600 BPS
Dial 317 463-7551
Flex 2
Baud Detect
Dial 317 463-7552
Flex 2
Baud Detect
Dial 317 463-7553
Flex 2
Baud Detect
Dial 317 463-7554
Flex 2
Baud Detect
Dial 317 463-7555
Flex 2
Baud Detect
In House Dial 230
Flex 2
Baud Detect
In House Dial 300
Flex 2
Baud Detect
PDP 11/34 (LITER)
(2780 Emulator)
Flex 2
9600 BPS
JSCTexas
9600 BPS
Data 100
(HASP Emulator)
CRT
CRT
CRT
CRT
Trendwriter
Trendwriter
Hardcopy Terminal
Hardcopy Terminal
Dial 713 483-2084
Dial 713 483-2085
Dial 713 483-2086
Dial 713 483-2087
Houston
9600 BPS
Data 100
(HASP Emulator)
ISU
7200 BPS
Data 100
(2780 Emulator)
TI/CRT
TI/CRT
Alabama A&M
7200 BPS
Infoton GTX
Infoton GTX
DECwriter LA36
Data 100
(2780 Emulator)
St. Regis
4800 BPS
DECwriter LA36
IBM 3776
(2780 Emulator)
ERIM
9600 BPS
Data 100
(HASP Emulator)
CRT
CRT
CRT
DECwriter LA36
Spare
Spare
Spare
Modem
Multiplexer
4/3/80


ERIM
LARS
JSC

EOD TERMINAL NETWORK



SOFTWARE

ACCOMPLISHMENTS:

*CONSTRUCTED A BARE-MACHINE OS/VS1 SYSTEM (MARCH)

*INSTALLED EDITION 7, MOD 1 OF IMSL (APRIL)

*IDENTIFIED STATUS OF THE LARS UTILITY SOFTWARE OF INTEREST TO JSC (APRIL)

*MODIFIED CSMP TO RUN UNDER CMS (APRIL)

*INSTALLED SAS RELEASE 79.3 IN TEST MODE (MAY)

*UPDATED EP, CP, CP ACCOUNTING, ETC. FOR JSC & ERIM PORT EXPANSIONS (MAY)

*COMPLETED REPROGRAMMING OF RESOURCE REQUEST SYSTEM (MAY)

RELATED ACCOMPLISHMENTS:

*INSTALLED VM RELEASE 6, PLC 8 (APRIL)

PLANS:

*PRODUCE A USER-FRIENDLY TAPE TRANSFER CAPABILITY (JUNE)

*DEVELOP A DISK ACCOUNTING SYSTEM FOR JSC (JULY)

*INSTALL RSCS NETWORKING (DEC)

5/12/80

SOFTWARE (CONT)

RELATED PLANS:

- *PRESENT BATCH SYSTEM DESIGN (JUNE)
- *INSTALL NEW BATCH SYSTEM (NOV)
- *ACQUIRE SAS GRAPH (JULY)

RT&E DATA BASE

ACCOMPLISHMENTS:

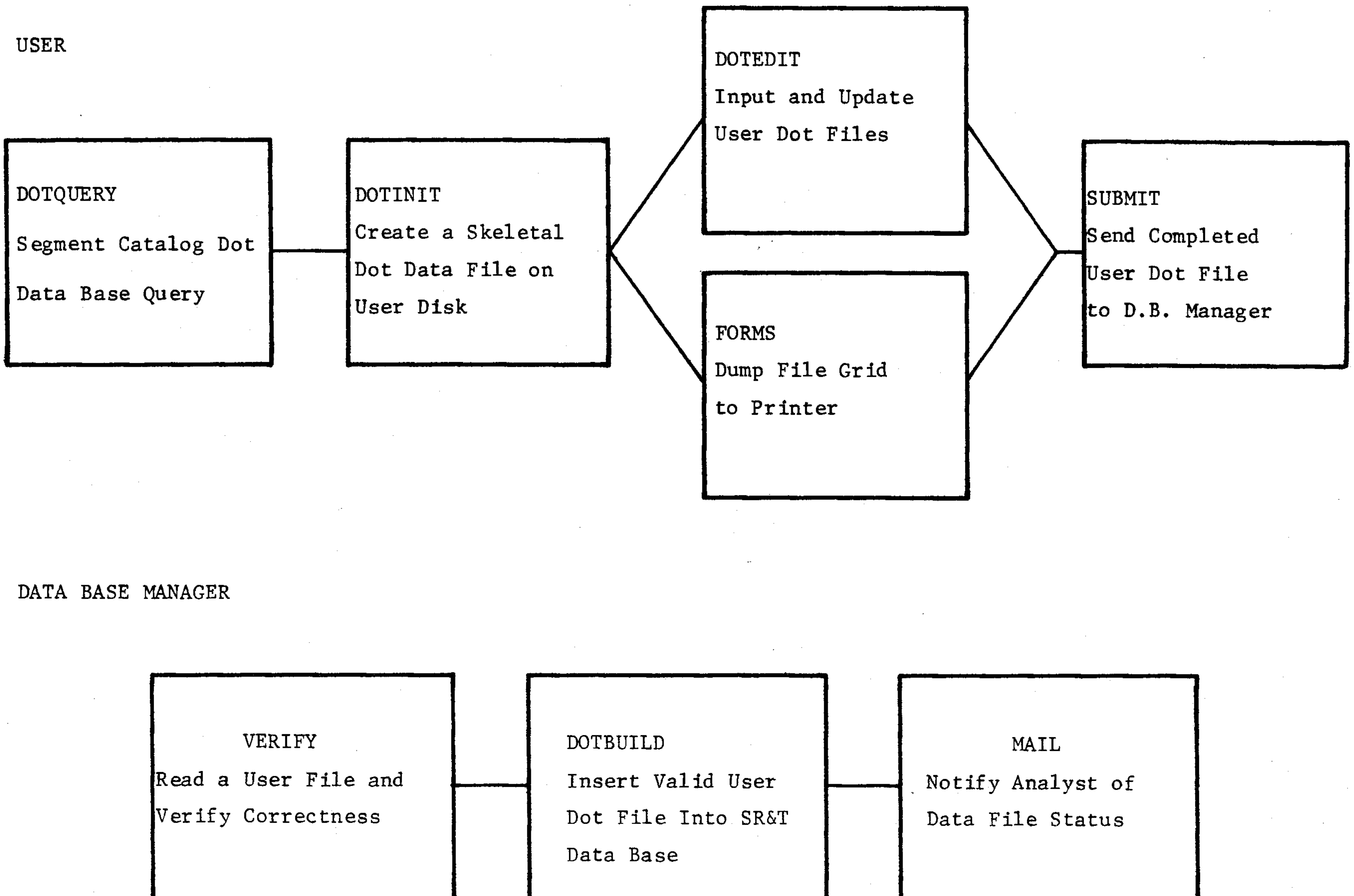
- *RECEIVED, VERIFIED, AND ENTERED THE US CALENDAR YEAR 1978 SEGMENT DATA (MARCH)
- *DESIGNED AND IMPLEMENTED THE DOT GROUND INVENTORY SYSTEM (MAY)
- *DESIGNED TECHNIQUE FOR INVERTING HISTORICAL MET SYNOPTIC DATA RECEIVED & VERIFIED 1975 MET DATA (MAY)
- *MODIFIED SEGMENT CATALOG ORGANIZATION TO REDUCE MAINTENANCE COSTS (MAY)
- *REORGANIZED TAPE LIBRARY (MARCH)

PLANS:

- *RECEIVE, VERIFY, AND ENTER CROP YEAR 2979 IMAGE DATA (JULY)
- *INVERT SELECTED MET SYNOPTIC DATA (JUNE)
- *COMPLETE DOT GROUND INVENTORY SYSTEM AND TRAIN JSC PERSONNEL (JUNE)
- *INVESTIGATE INCLUSION OF GEOGRAPHIC VARIABLES INTO SEGMENT CATALOG (AUG)

5/12/80

Dot Inventory System Flow



DOT DATA BASE

USER CALLABLE SUBROUTINES WILL BE PROVIDED TO ALLOW ANALYSIS PROGRAMS DIRECT ACCESS TO DOT DATA:

CRPNAM

CRPNAM WILL READ IN THE CROPS NAMES CODES LIST STORED ON THE DATA BASE DISK. THE LABEL INDEXES PASSED IN GETDOT POINT TO THESE ENTRIES.

DOTFO

DOTFO SEARCHES THE RT&E DATA BASE FOR SELECTED INFORMATION CONCERNING THE SEGMENT NUMBER SPECIFIED.

GETDOT

THIS SUBROUTINE WILL SEARCH THE SEGMENT CATALOG FOR THE SPECIFIED DOT LABEL FILE AND FILL ARRAYS WITH LABEL INFORMATION.

Consulting, Training & Communication

Accomplishments:

*Presented a Short Course at ERIM (May)

*Visiting Consultant Trip (April)

*Contributed Articles to SCANLINES & SRTNEWS

*Hosted ERIM hands-on CMS visit

Plans:

*Complete CMS Tape/Slide presentations (July)

*Visiting Consultant Trip (June)

*Dot Data Base user instruction (June)

*Publish Major Operating and Applications Systems Modifications in SRTNEWS and SCANLINES

*Host JSC and/or IBM personnel wishing to acquire direct experience with the policies, procedures and techniques LARS uses to maintain and upgrade its VM system

5/12/80

EVALUATION

* THE COMPUTER PROCESSING SUPPORT TASK HAS SERVED AS A "PILOT" FOR THE CONCEPT OF A SHARED DATA PROCESSING ENVIRONMENT FOR THE RESEARCH OF REMOTE SENSING OF AGRICULTURE.

* THIS TASK HAS PROVIDED EVIDENCE THAT SUCH AN ENVIRONMENT PROVIDES:
  - USER ACCESS, AT ALL USER LOCATIONS, TO THE DATA, SOFTWARE AND DOCUMENTATION CONTAINED IN THE SHARED ENVIRONMENT.
  - SHARING EXPENSIVE HARDWARE COMPONENTS AT A COST ADVANTAGE.
  - SHARING OF SOFTWARE ALLOWING FLEXIBILITY IN SOFTWARE MAINTENANCE, ALTERATION, AND AUGMENTATION AT A COST ADVANTAGE OVER INDEPENDENT, NON-COMPATIBLE SYSTEMS.
  - EASE OF TRAINING USERS AND SHARING NEW TECHNIQUES THROUGH STANDARD DATA FORMATS, TERMINOLOGY, AND COMMUNICATIONS CHANNELS.

JLK:12/4/79

Issues

*TEKTRONIX hook-up at JSC would allow SASGRAPH usage.

*IBM FSD & NASA personnel should be stationed at LARS for a month to six weeks to learn how the LARS computer facility is maintained (Systems, organization, procedures, etc.)

*Status on Cost Extensions (Current Met Data Base, ERSYS Development, etc.)

*Usage Transition Plans for 1980 are needed.

*Steps should be taken to limit usage and/or secure more funding.

*When will Documentation standards and programming conventions be established for ERSYS?

*What is the long-term role of the LARS Computer Facility for AgRISTARS?

*An AgRISTARS data processing network including USDA & possibly NOAA should be investigated.

*Advanced planning for equipment and funding is needed.

5/12/80

TASK 3B

FIELD RESEARCH DATA BASE MANAGEMENT & DISTRIBUTION

LARRY BIEHL AND NANCY FUHS

3B. FIELD RESEARCH DATA BASE MANAGEMENT & DISTRIBUTION

OVERALL OBJECTIVE

ASSURE TIMELY AVAILABILITY TO RESEARCHERS OF THE JOHNSON SPACE CENTER FIELD RESEARCH DATA STORED AT PURDUE/LARS.

3B. FIELD RESEARCH DATA BASE MANAGEMENT & DISTRIBUTION

SPECIFIC OBJECTIVES FOR 1980 (AND COMPLETION DATE OR TARGET COMPLETION DATE)

1. DISTRIBUTE FIELD RESEARCH DATA FOR ALL APPROVED REQUESTS

2. MAINTAIN AND UPDATE PRESENT DATA BASE

   - INCLUDE BALANCE OF 1979 DATA (5/30/80)

   - INCLUDE AVAILABLE 1980 (11/30/80)

   - ADD ADDITIONAL IDENTIFICATION INFORMATION TO SOILS DATA (7/1/80)

   - ADD ADDITIONAL IDENTIFICATION INFORMATION TO CROP DATA (11/30/80)

3. REVISE AND UPDATE FIELD RESEARCH CATALOG (7/15/80 & 11/30/80)

SPECIFIC OBJECTIVES FOR 1980 (AND COMPLETION DATE OR TARGET COMPLETION DATE) CON'T.

4. SOFTWARE DEVELOPMENT & DOCUMENTATION

- PROCESSING SOFTWARE
  - REVISE FSS SOFTWARE FOR MORE EFFICIENT HANDLING OF THE DATA (COMPLETED 3/1/80)
  - UPDATE DOCUMENTATION FOR PROCESSING SOFTWARE (8/31/80)
  - REVISE CLEVENGER SPECTROMETER SYSTEM SOFTWARE (6/15/80)
- ANALYSIS SOFTWARE
  - COMPLETE LARSPEC USER'S MANUAL (COMPLETED 2/1/80)
  - EXPAND LARSPEC PUNCH CAPABILITY FOR IDENTIFICATION RECORD DATA (5/30/80)
  - ADD DECWRITER TERMINAL AS MEDIUM RESOLUTION GRAPHICS DEVICE (COMPLETED 5/1/80)
  - ADD CAPABILITY TO LARSPEC TO PLOT DIFFERING WAVELENGTH RESOLUTION DATA ON SAME GRAPH (7/31/80)

ACCOMPLISHMENTS FOR THIS QUARTER

1. 1979 HAND COUNTY, S. DAKOTA FSS DATA AVAILABLE

2. 1979 (MAY THRU AUGUST) WEBSTER COUNTY, IOWA FSS DATA AVAILABLE

3. DECWRITER TERMINAL ADDED AS MEDIUM RESOLUTION GRAPHICS OUTPUT DEVICE FOR LARSPEC AND GCS USERS.

4. CONCLUDED THAT IT IS BEST NOT TO PROCESS THE FSS DATA INTO FINER WAVELENGTH BANDS.

5. REVIEW NASA/JSC CONCLUSION FOR ANOMOLY IN FSS DATA AROUND .7 μM

SUMMARY OF FIELD RESEARCH TEST SITE LOCATIONS AND MAJOR CROPS

Test Site	Crop Year 1975	1976	1977	1978	1979
Finney Co., KS	Winter Wheat	Winter Wheat	Winter Wheat		
Williams Co., ND	Spring Wheat	Spring Wheat	Spring Wheat		
Hand Co., SD	---	Spring Wheat Winter Wheat	Spring Wheat Winter Sheat	Spring Wheat Winter Wheat	Spring Wheat Winter Wheat
Tippecanoe Co., IN	---	---	---	Corn Soybeans	Corn Soybeans Winter Wheat
'U.S. & Brazil'	---	---	---	'Soils'	---
Webster Co., IA					Corn Soybeans
McPherson Co., NE	---	----	---	---	Corn

Summary of Field Research Data Base

Instrument/Data Type	Crop Year(s) and Status 1975-1978 Complete	1979 Complete	1979 In Processing
Landsat MSS Whole Frame CCT (Frames)	124	---	---
Aircraft Multispectral Scanner (dates/flightlines)	46/301	1/5	7/
Helicopter Mounted Field Spectrometer (dates/observations)			
Field Averages	74/6870	13/787	5/
Individual Scans	74/114,829	13/14,426	5/
Truck Mounted Field Spectrometer (dates/observations)			
NASA/JSC FSAS	45/813	---	---
Purdue Exotech 20C	99/7055	25/897	---
NASA/ERL Exotech 20D	45/645	---	---
Truck Mounted Field Multiband Radiometer (dates/observations)			
Purdue Exotech 100	32/6077	26/7947	---

PLANS FOR NEXT QUARTER

1. DATA DISTRIBUTION

   - 1979 WEBSTER CO., IA, HAND CO., SD, AND MCPHERSON CO., NE AIRCRAFT SCANNER DATA WILL BE MADE AVAILABLE FOR RESEARCHERS
   - REQUESTED DATA WILL BE DISTRIBUTED TO GODDARD INSTITUTE FOR SPACE STUDIES

2. DATA BASE MAINTENANCE

   - ADDITIONAL IDENTIFICATION INFORMATION WILL BE ADDED TO THE SOILS DATA
   - PLANS WILL BE DEVELOPED FOR PROCEDURE TO CORRECT THE FSS DATA FOR ANOMOLY AROUND 0.7 μM

3. CATALOG

   - CATALOG WILL BE UPDATED

4. DATA BASE SOFTWARE

   - EXPANDED LARSPEC IDENTIFICATION INFORMATION PUNCH CAPABILITY IMPLEMENTED.
   - LARSPEC USERS MANUAL WILL BE REVISED FOR ABOVE PUNCH CAPABILITY.
   - CAPABILITY FOR LARSPEC TO PLOT DIFFERING WAVELENGTH RESOLUTION DATA ON SAME GRAPH WILL BE IMPLEMENTED
   - REVISED CLEVENGER SPECTROMETER PROCESSING SOFTWARE COMPLETED.