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LARGE AREA ★ CROP INVENTORY ★ EXPERIMENT

LACIE

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BRIEFING MATERIALS FOR TECHNICAL PRESENTATIONS

VOLUME A

THE LACIE SYMPOSIUM

OCTOBER 1978

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(E79-10030) BRIEFING MATERIALS FOR TECHNICAL PRESENTATIONS, VOLUME A: THE LACIE SYMPOSIUM (NASA) 239 p HC A11/MF A01 CSCL 02C G3/43

N79-14458 THRU N79-14479 Unclas 00030

NASA
National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058

CONTENTS

EXPERIMENT DESIGN SESSION

SYSTEM IMPLEMENTATION AND OPERATIONS SESSION

DATA PROCESSING SYSTEMS DESIGN SESSION

EXPERIMENT RESULTS SESSION

SUPPORTING RESEARCH AND TECHNOLOGY (SRT) SESSION

USDA APPLICATION TEST SYSTEM (ATS) SESSION

EXPERIMENT DESIGN OVERVIEW

C. Hallum, JSC

NASA-S-78-16795

EXPERIMENT DESIGN SESSION

NASA-S-78-16796

EXPERIMENT DESIGN SESSION

- EXPERIMENT DESIGN – ITS ROLE IN LACIE
  - LACIE DID HAVE A COHERENT DESIGN APPROACH – TENDENCY WAS ALONG CLASSICAL LINES
    - – SUPPORTED ADVANCING THE TECHNOLOGY TO A LEVEL READY FOR INCLUSION IN A FUTURE OPERATIONAL SYSTEM
    - – LACIE DESIGN STRUCTURED AN EXPERIMENTAL SYSTEM WITH MECHANISMS FOR:
      - IDENTIFYING THE STATE-OF-THE-ART TECHNOLOGY (FROM ESTABLISHED PROCEDURES) TO PERMIT CROP INVENTORYING USING SATELLITE AND METEOROLOGICAL BASED DATA
      - PERFORMING NECESSARY TESTS AND EVALUATIONS TO ASSIST IN DETERMINING WHAT THE STATE-OF-THE-ART PROCEDURES ARE AND HOW THEY PERFORM
      - SUBJECTING THE OVERALL DESIGNED SYSTEM TO A QUASI-OPERATIONAL ENVIRONMENT FOR FINAL PERFORMANCE ASSESSMENTS AND SUBSEQUENT REFINEMENTS/IMPROVEMENTS

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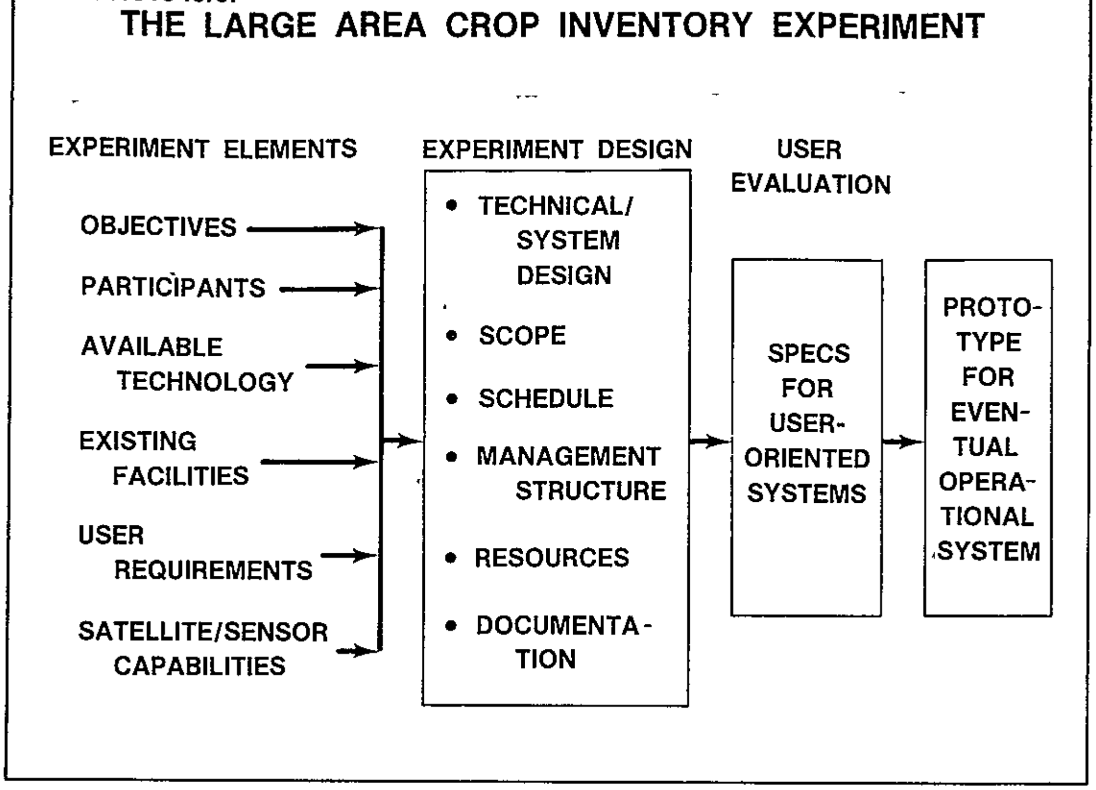

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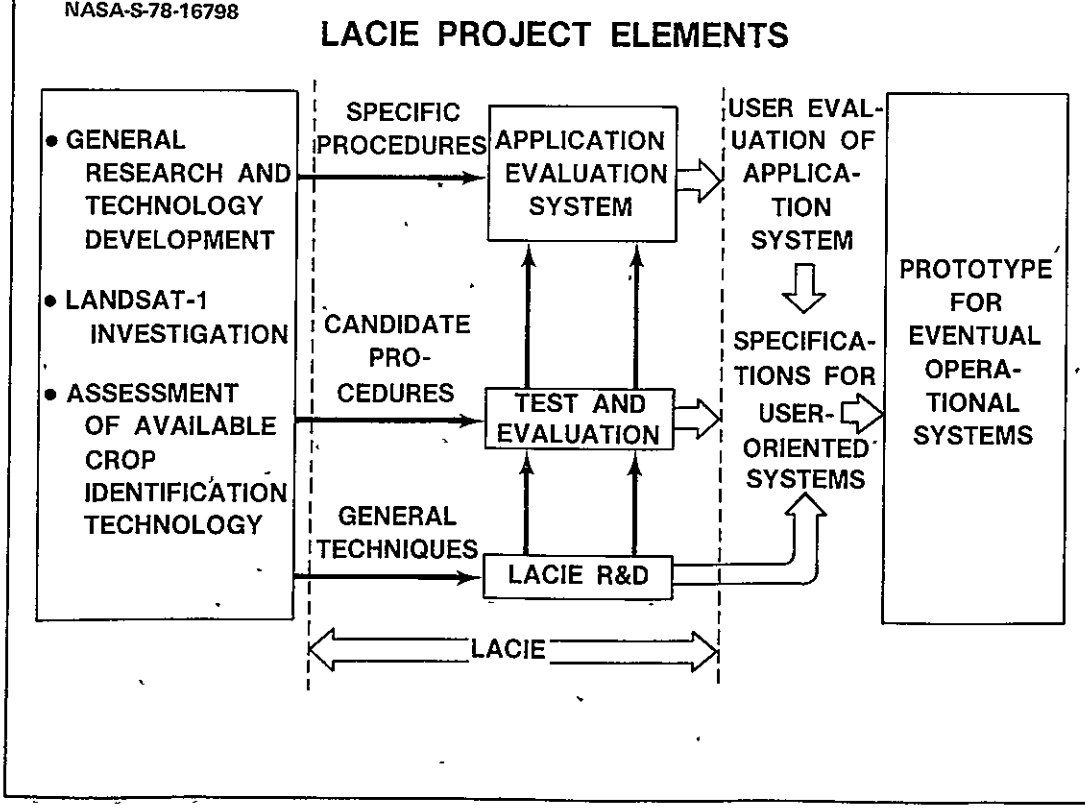

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EXPERIMENT DESIGN SESSION OVERVIEW

- LACIE TECHNICAL COMPONENT DESIGN
  - SEPARATE METHODOLOGIES DEVELOPED IN LACIE FOR AREA AND YIELD ESTIMATION
    - – RATIONALE
      - PREDOMINATELY DICTATED BY EXISTING TECHNOLOGY
        - – YIELD AND CROP ID ESTIMATION TECHNOLOGIES HAD BEEN DEVELOPED AS SEPARATE ENTITIES – THE TECHNOLOGY FOR ESTIMATING PRODUCTION DIRECTLY FROM REMOTELY SENSED AND METEOROLOGICAL DATA WAS NONEXISTENT
        - – TEST AND EVALUATION EFFORTS FOR IMPROVING EXISTING TECHNOLOGIES WERE MOST EFFICIENTLY SUPPORTED BY KEEPING AREA AND YIELD SEPARATED
          - HISTORICAL AREA AND YIELD DATA AVAILABLE ONLY AS SEPARATE ENTITIES

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EXPERIMENT DESIGN SESSION OVERVIEW

- LACIE TECHNICAL COMPONENT DESIGN (CONT)
  - AREA ESTIMATION SUPPORTED BY:
    - – SAMPLING AND AGGREGATION COMPONENT – PRIMARY RESPONSIBILITY: DESIGN FOR SAMPLING AND AGGREGATION SCHEME
    - – CLASSIFICATION AND MENSURATION COMPONENT – PRIMARY RESPONSIBILITY: DESIGN FOR MENSURATION OF WHEAT IN SAMPLING UNITS
    - – CROP DEVELOPMENT STAGE ESTIMATION COMPONENT – PRIMARY RESPONSIBILITY: SUPPORT DEVELOPMENT OF ANALYST AIDS
  - YIELD ESTIMATION COMPONENT – PRIMARY RESPONSIBILITY: DESIGN FOR MODEL SELECTION AND OPERATION
  - PRODUCTION ESTIMATED BY COMBINING AREA AND YIELD ESTIMATES
    - – ACCURACY ASSESSMENT COMPONENT – PRIMARY RESPONSIBILITY: DESIGN FOR EVALUATING THE PERFORMANCE OF AREA, YIELD, AND PRODUCTION

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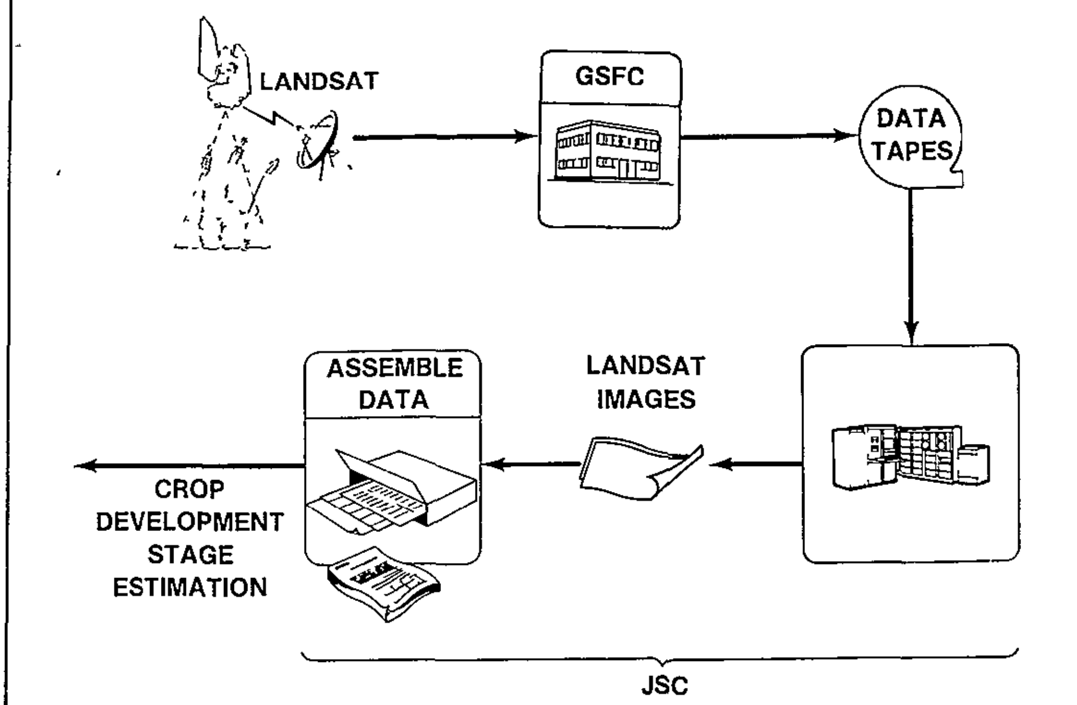
COMPONENT DESIGN RESPONSIBILITIES (CONT)



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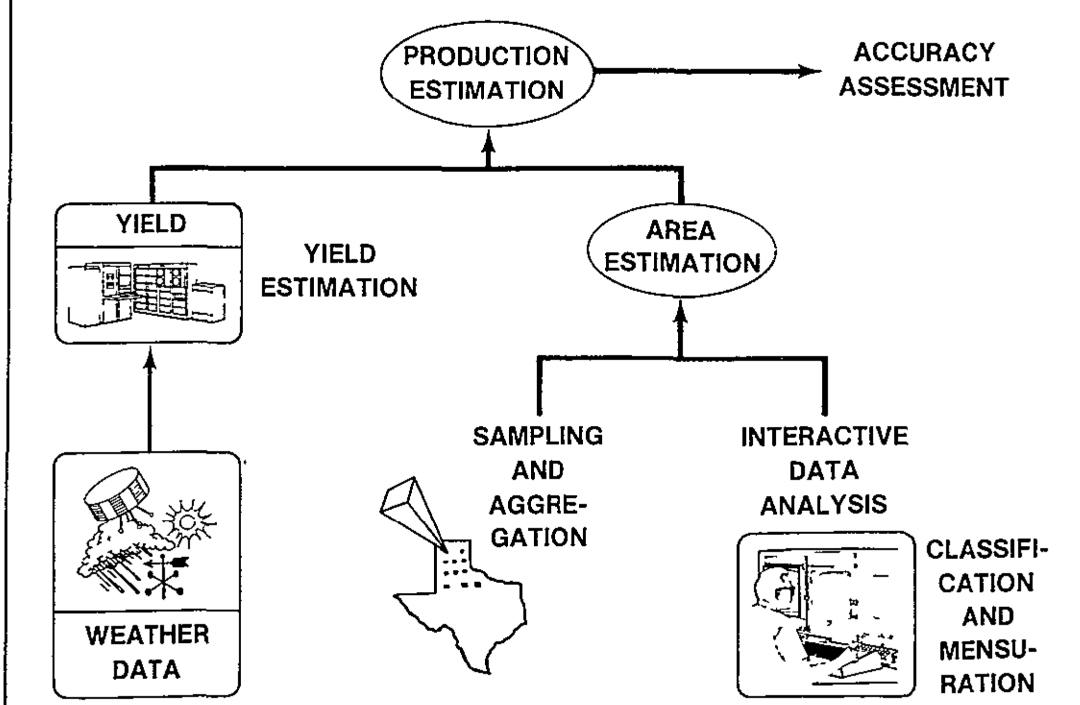
COMPONENT DESIGN RESPONSIBILITIES



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EXPERIMENT DESIGN SESSION

SAMPLING AND AGGREGATION IN LACIE

C Hallum, JSC

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SAMPLING, AGGREGATION, AND VARIANCE ESTIMATION FOR AREA, YIELD, AND PRODUCTION IN LACIE

NASA-S-78-16832

SAMPLING, AGGREGATION, AND VARIANCE ESTIMATION FOR AREA, YIELD, AND PRODUCTION IN LACIE

OUTLINE OF PRESENTATION

- INTRODUCTION CROP INVENTORY – A STATISTICAL SURVEY
- SAMPLING, ESTIMATION, AND AGGREGATION FOR AREA
  - CONFIGURATION AND GEOGRAPHICAL EXTENT OF SAMPLING UNIT
  - SAMPLE SELECTION PROCEDURE
  - ALLOCATION OF SEGMENTS
  - AREA ESTIMATION
- YIELD AND PRODUCTION ESTIMATION
- VARIANCE ESTIMATION
  - AREA VARIANCE ESTIMATION
  - YIELD VARIANCE ESTIMATION
  - PRODUCTION VARIANCE ESTIMATION
- SPECIAL PROBLEMS ENCOUNTERED IN LACIE SAMPLING AND AGGREGATION
- SUMMARY/CONCLUSIONS

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INTRODUCTION: CROP INVENTORY - A STATISTICAL SURVEY

- CROP INVENTORY EFFORTS – HEAVILY RELIANT ON SAMPLE SURVEY METHODOLOGY
  - RATIONALE
    - ACCURACY AND EFFICIENCY
    - A STRONG DEMAND FOR BREADTH AND TIMELINESS OF COVERAGE
    - RECENT ADVANCES IN SAMPLE SURVEY METHODOLOGY
  - TWO BASIC QUESTIONS ARISE
    - HOW TO SELECT THE "PART" FROM THE "WHOLE"
    - HOW TO GENERALIZE FROM THE SELECTED "PART" TO THE "WHOLE"
  - OVERALL PROBLEM – FIND THE COMBINATION OF SELECTION AND ESTIMATION PROCEDURES THAT
    - MAXIMIZES EFFICIENCY
    - ENSURES A SPECIFIED ACCURACY
    - FOR A FIXED COST

NASA-S-78-16834

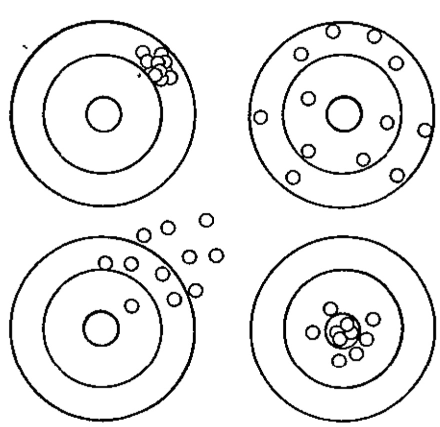
INTRODUCTION

CROP INVENTORY A STATISTICAL SURVEY

- ACCURACY REFERS TO PRECISION + BIAS

LARGE BIAS + HIGH PRECISION = LOW ACCURACY

SMALL BIAS + LOW PRECISION = LOW ACCURACY



LARGE BIAS + LOW PRECISION = LOW ACCURACY

SMALL BIAS + HIGH PRECISION = HIGH ACCURACY

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INTRODUCTION: CROP INVENTORY - A STATISTICAL SURVEY

- UNTIL RECENT EFFORTS OF SRS AND LACIE, THE PREDOMINANT METHOD OF ESTIMATION HAS BEEN ONE INVOLVING THE USE OF MAILED INQUIRIES
  - LACIE WAS FIRST ATTEMPT TO SURVEY AN IMPORTANT CROP (WHEAT) ON A LARGE (QUASI-GLOBAL) SCALE AT REPEATED INTERVALS OVER A WIDE RANGE OF CONDITIONS
    - EMPHASIS WAS ON MORE TIMELY AND ACCURATE ESTIMATES OF FOREIGN WHEAT AREA, YIELD, AND PRODUCTION ON A SCHEDULED BASIS THROUGHOUT THE GROWING SEASON

NASA-S-78-16836

INTRODUCTION: CROP INVENTORY - A STATISTICAL SURVEY

- QUESTIONS AWAITING ANSWERS AT THE OUTSET OF LACIE INCLUDED
  - CAN A SAMPLING STRATEGY FOR ACQUISITION OF LANDSAT DATA BE DESIGNED TO ACHIEVE THE REQUIRED ACCURACIES WITH A MANAGEABLE DATA LOAD?
  - HOW CAN THE GEOGRAPHIC WHEAT DISTRIBUTION BEST BE DETERMINED TO EFFICIENTLY SAMPLE?
  - WHAT SHOULD BE THE CONFIGURATION AND GEOGRAPHICAL EXTENT OF THE PSU TO EFFICIENTLY SUPPORT A PRESELECTED ACCURACY AND YET BE COST-EFFECTIVE?
  - DOES LOSS OF SEGMENT ACQUISITIONS DUE TO CLOUD COVER CAUSE EXCESSIVE ERRORS, SUCH AS BIAS?

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INTRODUCTION: CROP INVENTORY - A STATISTICAL SURVEY

- RATIONALE FOR INITIAL DESIGN
  - WOULD PERMIT U S. TO BE USED AS A "YARDSTICK" AND FOR R&D
  - METHODOLOGY FOR USING LANDSAT IMAGERY AND AGROPHYSICAL DATA WAS NOT SUFFICIENTLY DEVELOPED AT START OF PHASE I TO SELECT STRATA ALONG NATURAL BOUNDARIES
  - WOULD PROVIDE DATA OF SUFFICIENT QUANTITY AND QUALITY TO MEET REQUIRED PERFORMANCE LEVELS AND ALSO SATISFY THE EXISTING CONSTRAINTS
  - THE ALLOCATION SCHEME APPEARED TO PROVIDE THE MOST EFFICIENT UTILIZATION OF DATA AVAILABLE
    - APPEARED TO GIVE BETTER SEGMENT COVERAGE OF MAJOR PRODUCING AREAS
    - IMPROVED THE PROBABILITY OF AN ACCURATE ESTIMATE

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INTRODUCTION: CROP INVENTORY - A STATISTICAL SURVEY

- RESTRICTIONS ON LACIE DESIGN
  - USE ONLY DATA RELIABLY AVAILABLE IN FOREIGN AREAS (E.G , LANDSAT IMAGERY, DATA FROM MET STATIONS, NOAA SATELLITE DATA, AND PUBLISHED HISTORICAL DATA)
  - GODDARD'S REGISTRATION ACCURACY WAS ±1 PIXEL FOR AREAS NO LARGER THAN 25 MI ON A SIDE
  - THE VOLUME OF LANDSAT DATA THAT COULD BE STORED AND PROCESSED
  - LANDSAT DATA WERE NOT AVAILABLE IN PHASE I FOR USE IN SAMPLING FRAME GENERATION
  - CLOUD COVER
- OTHER LACIE SAMPLE DESIGN CHARACTERISTICS
  - CONCENTRATION WAS INITIALLY IN USGP WHEAT-GROWING REGIONS WHERE RELIABLE, INDEPENDENT SURVEY ESTIMATES AND GROUND TRUTH WOULD BE AVAILABLE
  - 4800 SEGMENTS WERE DIVIDED AMONG THE U.S AND SEVEN OTHER COUNTRIES

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SAMPLING, ESTIMATION, AND AGGREGATION FOR AREA

- CONFIGURATION AND GEOGRAPHICAL EXTENT OF SAMPLING UNIT
  - RECTANGULAR IN SHAPE AND 5 BY 6 N MI IN SIZE
  - RATIONALE
    - SUPPORTED ANALYSTS' NEEDS
      - SUFFICIENTLY LARGE TO PROVIDE THE ANALYST WITH A GOOD PERSPECTIVE OF THE SPATIAL AND TEXTURAL CHARACTERISTICS OF CROPS WITHIN A GIVEN LOCALITY
      - SUFFICIENTLY LARGE TO GIVE ANALYSTS A GOOD CHANCE OF SEEING THE VARIOUS CROPS OCCUPYING A SIGNIFICANT PORTION OF THE SCENE
    - PERMITTED REQUIRED SAMPLING PRECISION WITHOUT CREATING UNMANAGEABLE DATA LOAD
    - ENGINEERING CONSTRAINTS
      - GSFC HARDWARE/SOFTWARE RESTRICTIONS SUPPORTED THE HANDLING OF NOT MORE THAN 4800 SEGMENTS – DICTATED A SAMPLE SIZE OF APPROXIMATELY THAT SELECTED
      - GSFC COULD REGISTER TO WITHIN ± PIXEL FOR AREAS NO LARGER THAN 25 MI ON A SIDE
    - RECTANGULAR SHAPE PARTICULARLY AMENABLE FOR COMPUTER STORAGE AND MANIPULATION

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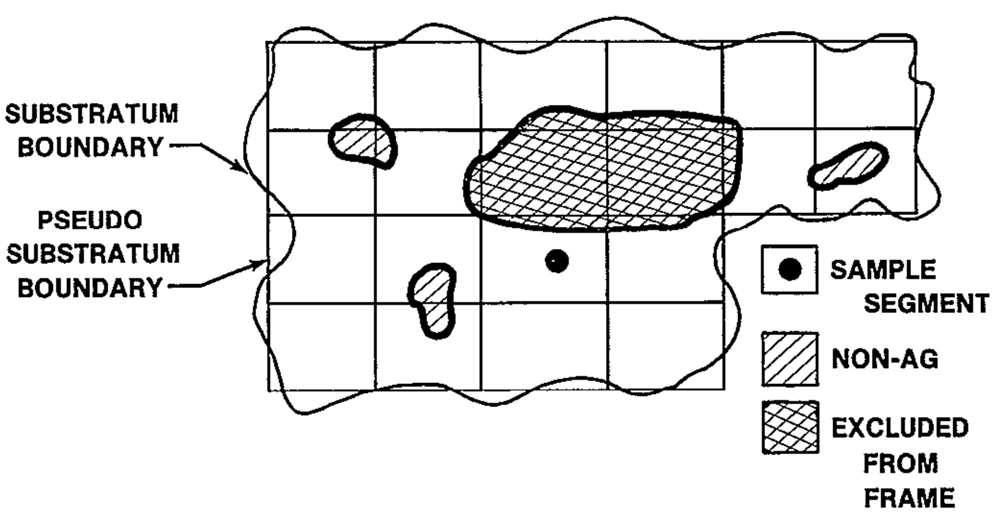
RELATIONSHIP OF SAMPLING FRAME TO A SUBSTRATUM



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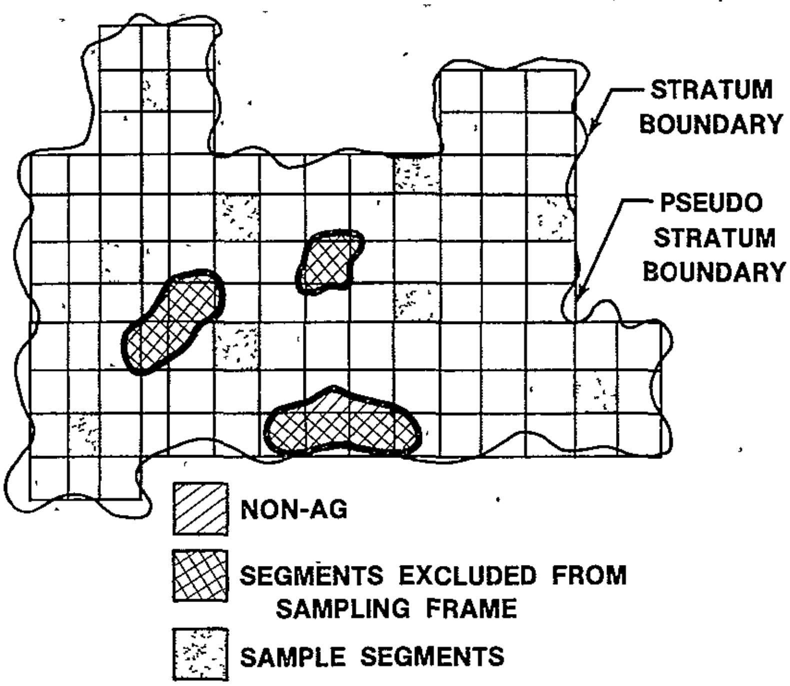
RELATIONSHIP OF SAMPLING FRAME TO A STRATUM



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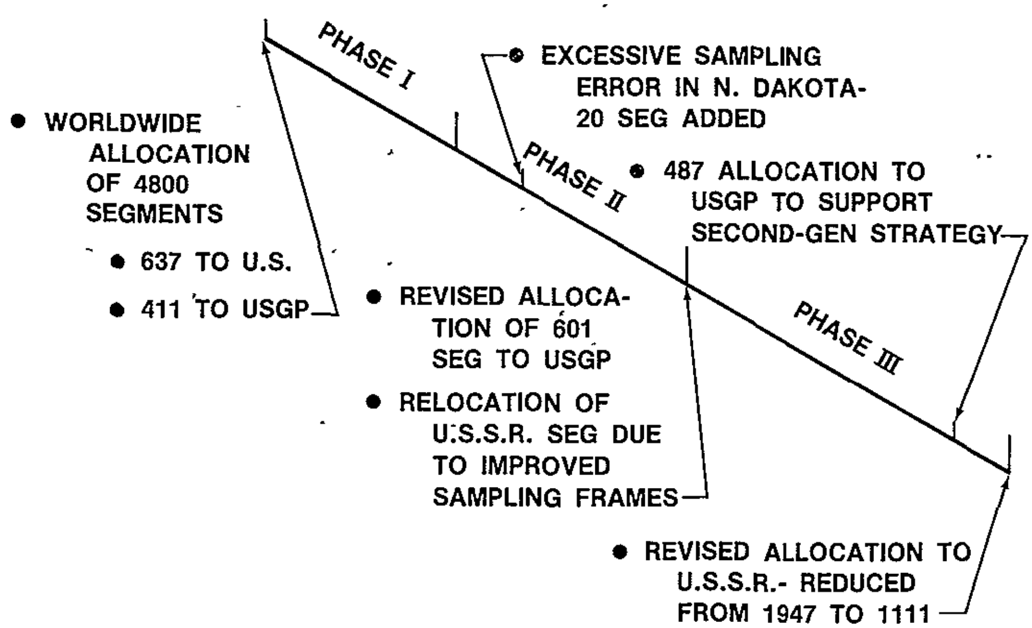
CHRONOLOGY OF ALLOCATION OF SEGMENTS



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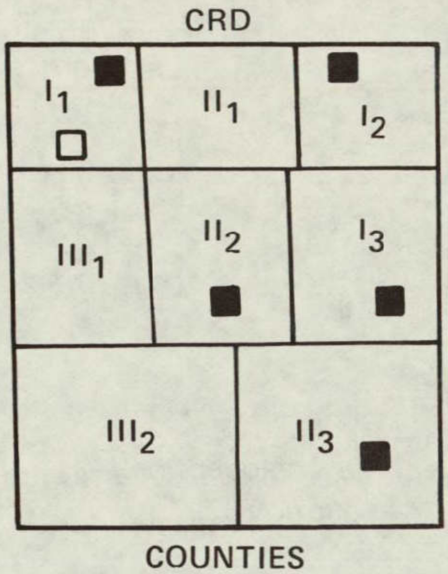
AREA ESTIMATION

- U.S. (SUBSTRATA-LEVEL COUNTRY)



$$\hat{A}_{I_2} = \bar{P}_{I_2} N_{I_2}$$

$$\hat{A}_{II} = \frac{\hat{A}_{II_2}}{\pi_2} + \frac{\hat{A}_{II_3}}{\pi_3}$$

$$\hat{A}_{III_2} = \left(\frac{\hat{A}_I + \hat{A}_{II}}{W_I + W_{II}} \right) W_{III_2}$$

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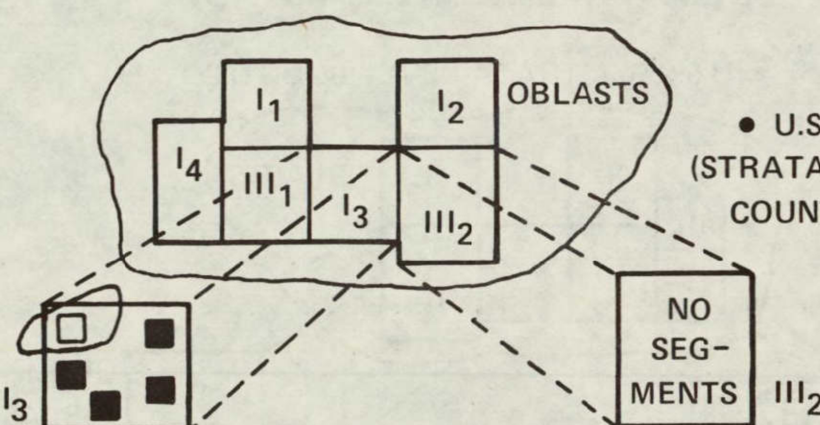
AREA ESTIMATION (CONT)

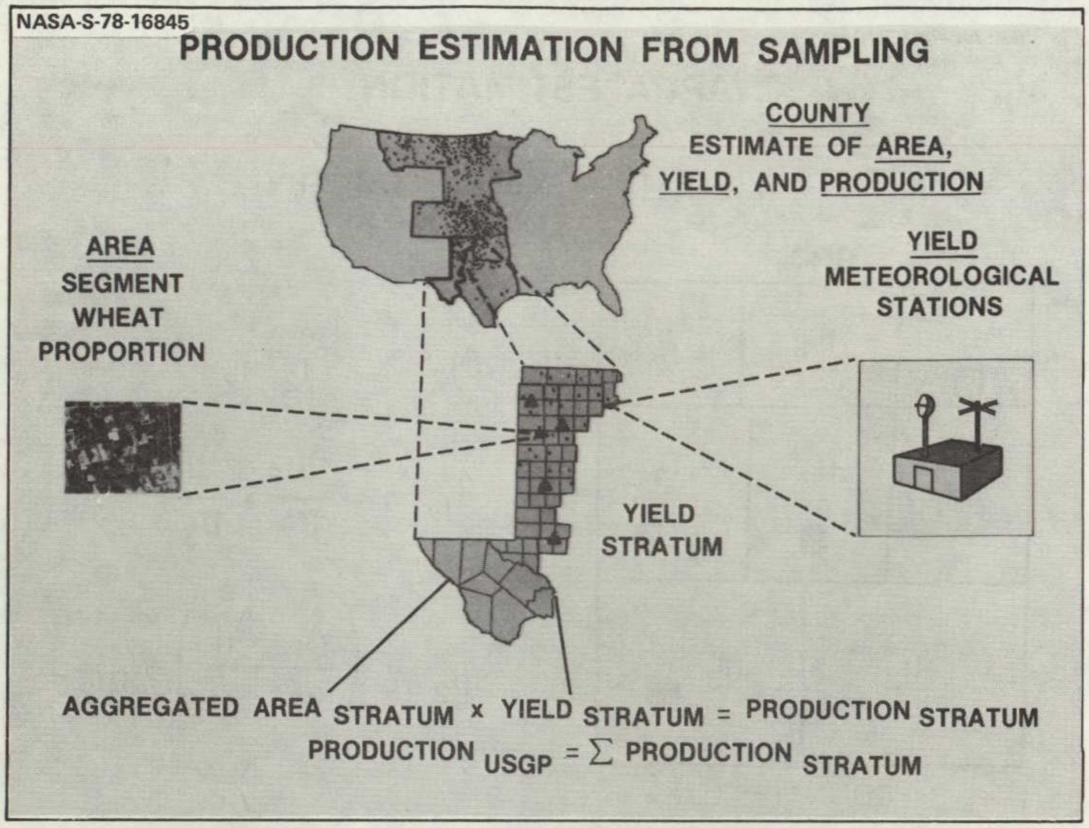
- U.S.S.R. (STRATA-LEVEL COUNTRY)



$$\hat{A}_{I_3} = \text{(AVG WH/AG SEG) (NO. AG SEG)}$$

$$= \bar{P}_{I_3} \times N_{I_3}$$

$$\hat{A}_{III_2} = \left(\frac{\hat{A}_{I_1} + \hat{A}_{I_2} + \hat{A}_{I_3} + \hat{A}_{I_4}}{W_{I_1} + W_{I_2} + W_{I_3} + W_{I_4}} \right) W_{III_2}$$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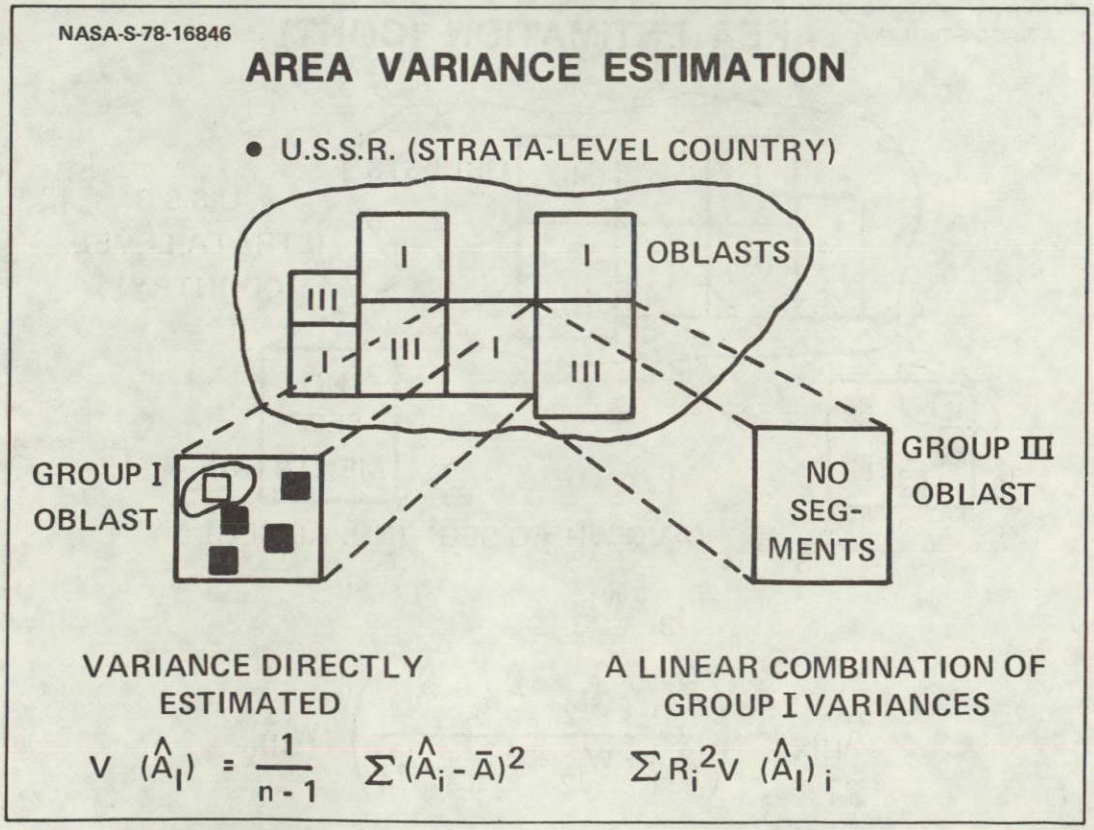
PRODUCTION ESTIMATION FROM SAMPLING
COUNTY
ESTIMATE OF AREA,
YIELD, AND PRODUCTION
AREA
SEGMENT
WHEAT
PROPORTION
YIELD
METEOROLOGICAL
STATIONS
YIELD
STRATUM
AGGREGATED AREA STRATUM x YIELD STRATUM = PRODUCTION STRATUM
PRODUCTION USGP = Σ PRODUCTION STRATUM


NASA-S-78-16846
AREA VARIANCE ESTIMATION
• U.S.S.R. (STRATA-LEVEL COUNTRY)
OBLASTS
GROUP I
OBLAST
NO
SEG-
MENTS
GROUP III
OBLAST
VARIANCE DIRECTLY
ESTIMATED
A LINEAR COMBINATION OF
GROUP I VARIANCES
$V(\hat{A}_I) = \frac{1}{n-1} \sum (\hat{A}_i - \bar{A})^2$
$\sum R_i^2 V (\hat{A}_I)_i$

NASA-S-78-16849

SPECIAL SAMPLING AND AGGREGATION PROBLEMS ENCOUNTERED

- CONSIDERABLE EFFORT WAS REQUIRED TO ESTABLISH DEGREE TO WHICH ALL ASSUMPTIONS ARE SATISFIED
- RESULTS FROM INITIAL SAMPLING STRATEGY DID NOT ADEQUATELY INDICATE PERFORMANCE LEVELS IN FOREIGN AREAS
- CROP TYPE ESTIMATION IN MIXED WHEAT AREAS
- NONRESPONSE DUE TO CLOUD COVER
- CLASSIFICATION AND YIELD PREDICTION BIAS
- INSTABILITY OF GROUP III RATIOS
- POOR ESTIMATION OF GROUP II "SIZES"
- POOR QUALITY SEGMENT-LEVEL ESTIMATES

NASA-S-78-16850

SUMMARY

- THE LACIE SAMPLING STRATEGY SUPPORTS THE FACT THAT A GOOD SAMPLING STRATEGY IS OF PARAMOUNT IMPORTANCE TO HAVING A COST-EFFECTIVE SYSTEM
  - CURRENT TECHNOLOGY PERMITS A SAMPLING ERROR OF APPROXIMATELY 2 PERCENT TO BE ACHIEVED BY SAMPLING APPROXIMATELY 2 PERCENT OF THE SAMPLING FRAME
  - THE GUIDING PRINCIPLE OF THE LACIE SAMPLING DESIGN WAS ONE ENDEAVORING TO MAXIMIZE EFFICIENCY FOR A FIXED COST
  - THE LACIE SAMPLING SCHEME ENDEAVORED TO PROVIDE THE MOST EFFICIENT UTILIZATION OF EXISTING DATA
  - TECHNOLOGY TO UTILIZE LANDSAT AND AGROMET DATA TO PERFORM A STRATIFICATION ALONG NATURAL BOUNDARIES

EXPERIMENT DESIGN SESSION

GROWTH STAGE ESTIMATION

V. Whitehead, JSC

NASA-S-78-16851

GROWTH STAGE ESTIMATION SYSTEM DESIGN

NASA-S-78-16852

GROWTH STAGE ESTIMATION SYSTEM DESIGN

- WHY NEEDED
- SELECTION
- SHORTCOMINGS OF SELECTED MODELS
- CHARACTERISTICS
  - BASIC MODEL
  - DORMANCY
  - STARTER
- RESULTING SYSTEM DESIGN

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NASA-S-78-16853

LACIE ADJUSTABLE CROP CALENDARS

GENERAL BACKGROUND

- VARIATION IN SEASONAL WEATHER CONDITIONS CAUSE YEAR-TO-YEAR AND SPATIAL SHIFTS IN PROGRESSION OF CROP DEVELOPMENT WHICH MUST BE ACCOUNTED FOR TO ALLOW:
  - ACCURATE INTERPRETATION OF LANDSAT IMAGERY BY LACIE ANALYSTS
  - ADJUSTMENT OF BIOWINDOW ACQUISITIONS TO MINIMIZE LANDSAT DATA REQUIREMENTS
  - INCORPORATION INTO IMPROVED YIELD MODELS
  - SIGNATURE EXTENSION IMPLEMENTATION

OBJECTIVE

- THE OBJECTIVE OF THE CROP CALENDAR DEVELOPMENT IS TO PROVIDE OPERATIONAL SUPPORT TO ALL APPLICABLE LACIE SUBSYSTEMS BY ADJUSTING CURRENT-YEAR CROP CALENDARS AS REQUIRED DURING THE GROWING SEASON, UTILIZING SYNOPTIC METEOROLOGICAL DATA ON A DAILY BASIS IN A CROP CALENDAR MODEL

NASA-S-78-16854

NORMAL CROP CALENDARS

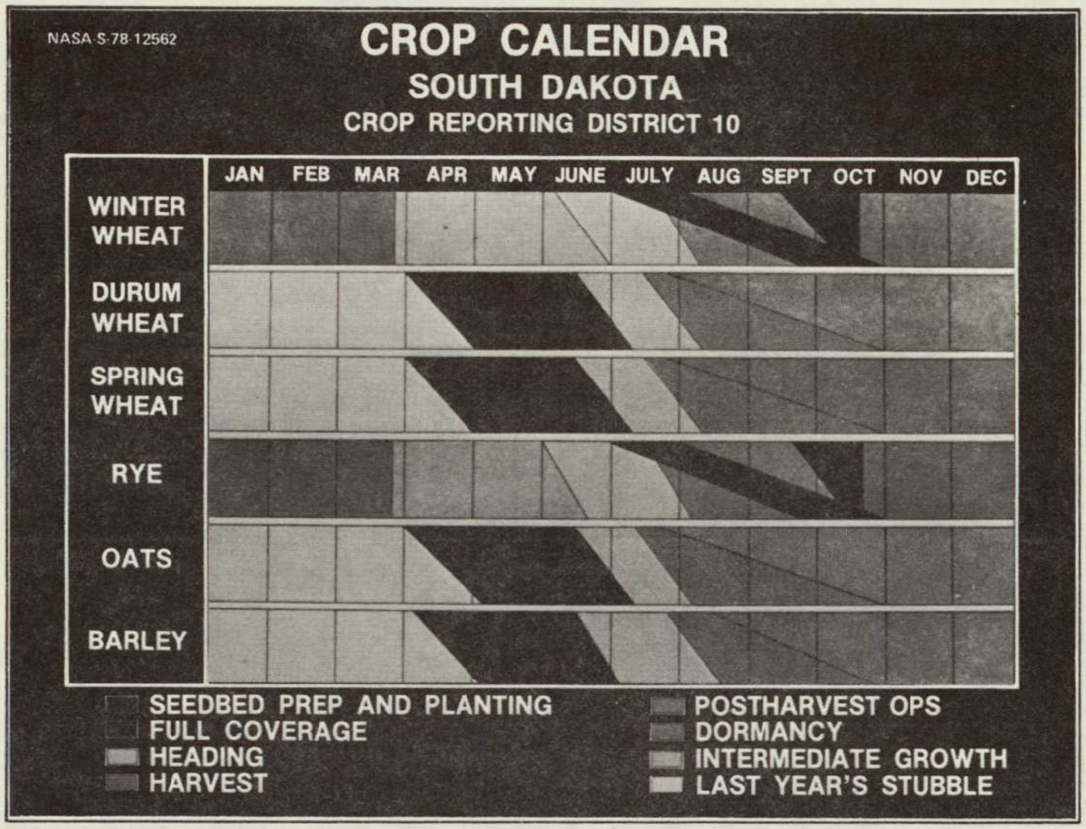
- PROVIDE A USEFUL DESCRIPTION OF HOW CROP STAGE OF DEVELOPMENT VARIES OVER LARGE AREAS

- PROVIDE A USEFUL DESCRIPTION OF RELATIVE STAGE OF DEVELOPMENT BETWEEN DIFFERENT CROPS IN A GIVEN LOCATION

- DO NOT ACCOUNT FOR YEAR-TO-YEAR CHANGES

EXAMPLE: STANDARD DEVIATION FOR ONE CRD IN OKLAHOMA

PLANTING	– 15 DAYS	SOFT DOUGH	– 10 DAYS
EMERGENCE	– 15 DAYS	RIPE	– 8 DAYS
JOINTING	– 13 DAYS	HARVEST	– 8 DAYS
HEADING	– 7 DAYS		



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PHENOLOGICAL MODELS

- DEFINITION: MATHEMATICAL PROCEDURE FOR CALCULATING DATES OF CROP DEVELOPMENT EVENTS BASED ON IN-SEASON ENVIRONMENTAL CONDITIONS
- GENERAL CONSTRAINTS:
  - UTILIZE ROUTINELY AVAILABLE AGROMETEOROLOGICAL DATA (TEMPERATURE, PRECIPITATION, WHEAT TYPE, ETC.)
  - FREE OF LOCATION SPECIFIC FUNCTIONS OF WEATHER VARIABLES
  - FLEXIBLE FOR EASY UPGRADING

NASA-S-78-16856

PHENOLOGICAL MODELS (CONT)

- MODELS AVAILABLE:
  - HEAT UNIT $R = f(T)$
  - PHOTOTHERMAL UNIT $R = f(T.L)$
  - ROBERTSON TRIQUADRATIC $R = V_1(V_2 + V_3)$

WHERE

R = DAILY RATE OF DEVELOPMENT AS FRACTION OF INTERVAL BETWEEN STAGES

T = TEMPERATURE

L = DAY LENGTH

$$V_1 = a_1(L - a_0) + a_2(L - a_0)^2$$

$$V_2 = b_1(T_X - b_0) + b_2(T_X - b_0)^2$$

$$V_3 = c_1(T_N - c_0) + c_3(T_N - c_0)^2$$

NASA-S-78-16857

MODEL SELECTION

RATIONALE FOR SELECTION OF ROBERTSON MODEL

- EMPIRICAL AND THEORETICAL EVIDENCE OF NON-LINEAR RESPONSES TO TEMPERATURE AND DAYLENGTH
- NUMBER OF PHASES AND RELATIVE INTERVAL LENGTHS IN THE CORRESPONDING SCALE
- PRELIMINARY SUCCESS OF THE COEFFICIENT SET FOR WINTER WHEAT
- TEST RESULTS (BMTS AVERAGE 28 PERCENT AND 14 PERCENT BETTER THAN THE HEAT UNIT AND PHOTOTHERMAL MODELS BETWEEN EMERGENCE AND HEADING)

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MODEL SELECTION (CONT)

DISADVANTAGES

- DATA REQUIREMENTS (MAX AND MIN TEMPERATURE WERE NOT ROUTINE IN THE NMC/WMO DATA BASES)
- JOINTING STAGE BASED ON OBSERVATIONS ON DISSECTED PLANTS
- PERIOD OF VEGETATIVE GROWTH BEFORE DORMANCY AND THE HANDLING OF DORMANCY POSED DEFINITE PROBLEMS
- COEFFICIENTS DERIVED FOR SPRING WHEAT VARIETY USED IN CANADA
- STARTUP PROCEDURES NOT DEFINED

NASA-S-78-16861

DORMANCY ADJUSTMENT

TO APPLY THE ACC TO WINTER WHEAT, FEYERHERM (1976) DEVELOPED MODIFICATIONS WHICH REFLECT THE EFFECT OF DORMANCY ON WINTER WHEAT. EACH DID FROM THE EMERGENCE TO THE HEADING STAGE IS MULTIPLIED BY A FACTOR CALCULATED FROM THE FOLLOWING EQUATION:

$$M = 0.5684 + 0.025081\ (ADTJ) - 0.006139\ (AAPR)$$

WHERE M = FEYERHERM'S MULTIPLIER

ADTJ = NORMAL AVERAGE DAILY TEMPERATURE FOR JANUARY

AAPR = NORMAL ANNUAL PRECIPITATION

THIS MULTIPLIER WAS DERIVED FOR WINTER WHEAT VARIETIES TYPICALLY PLANTED IN THE U.S. GREAT PLAINS DURING THE EARLY 1970's

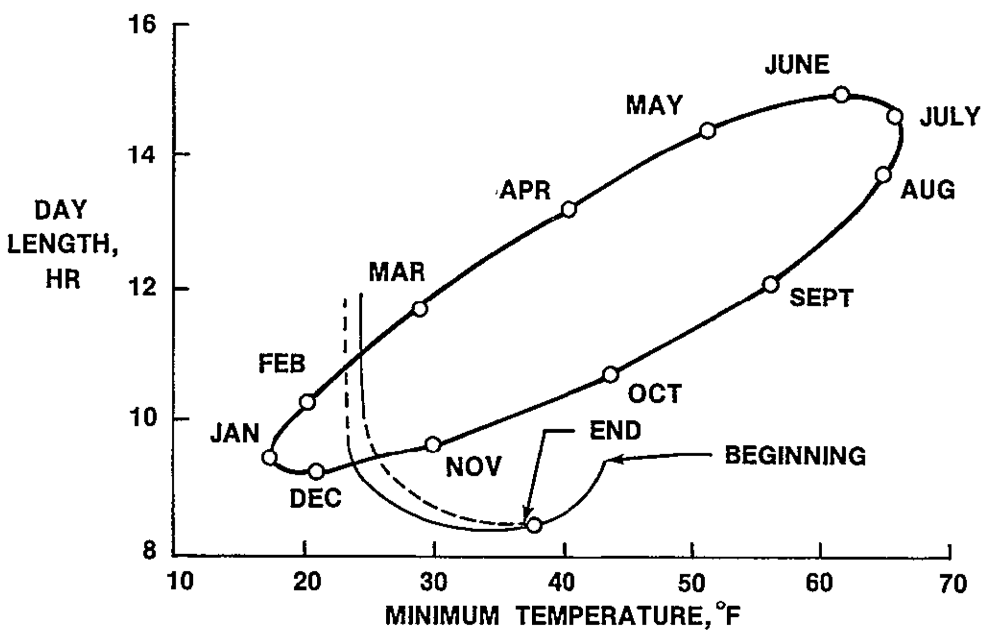
NASA-S-78-16862

STARTERS USED

- REPORTED PLANTING DATE
- END-OF-DORMANCY ESTIMATE (WINTER)
- FEYERHERM (SPRING)
- STUFF AND PHINNEY (SPRING)
- NORMAL PLANTING WITH DORMANCY MULTIPLIER (WINTER)

NASA-S-78-16863

DAY LENGTH VERSUS MINIMUM TEMPERATURE CLIMAGRAPH FOR DODGE CITY, KANSAS



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SPRING WHEAT STARTER MODEL

WORKDAY MODEL (FEYERHERM)

THE i^{th} CALENDAR DAY IS EITHER A NONWORKDAY, A PARTIAL WORKDAY, OR A WHOLE WORKDAY·

$$W_i = 0 \qquad TA_i \leq 32^\circ F$$
$$= (0\ 1)(TA_i - 32)^+\delta_i \qquad 32^\circ < TA_i \leq 42^\circ F$$
$$= 1\cdot\delta_i \qquad TA_i > 42^\circ F$$

WHERE $\delta_i \doteq 1$ IF ALL THE FOLLOWING PRECIP CONDITIONS ARE MET

PRECIPITATION ON DAY $i < 0\ 005(TA_i - 32)^+$

CUMULATIVE PRECIP ON DAY $(i-1)$ AND $i < 0\ 015(TA_i - 32)^+$

CUMULATIVE PRECIP ON DAYS $(i-2)$, $(i-1)$, AND $i < 0\ 025(TA_i - 32)^+$

CUMULATIVE PRECIP ON DAYS $(i-3)$, $(i-2)$, $(i-1)$ AND $i < 0.035(TA_i - 32)^+$

AND $\delta_i \doteq 0$ IF ONE OR MORE OF THE PRECEDING CONDITIONS FAIL TO HOLD

TA_i = DAILY AVERAGE TEMPERATURE ON DAY i (MEAN OF DAILY MIN AND MAX),

$(TA_i - 32)^+ = 0$ IF $TA_i < 32$

$= (TA_i - 32)$ IF $TA_i \geq 32$

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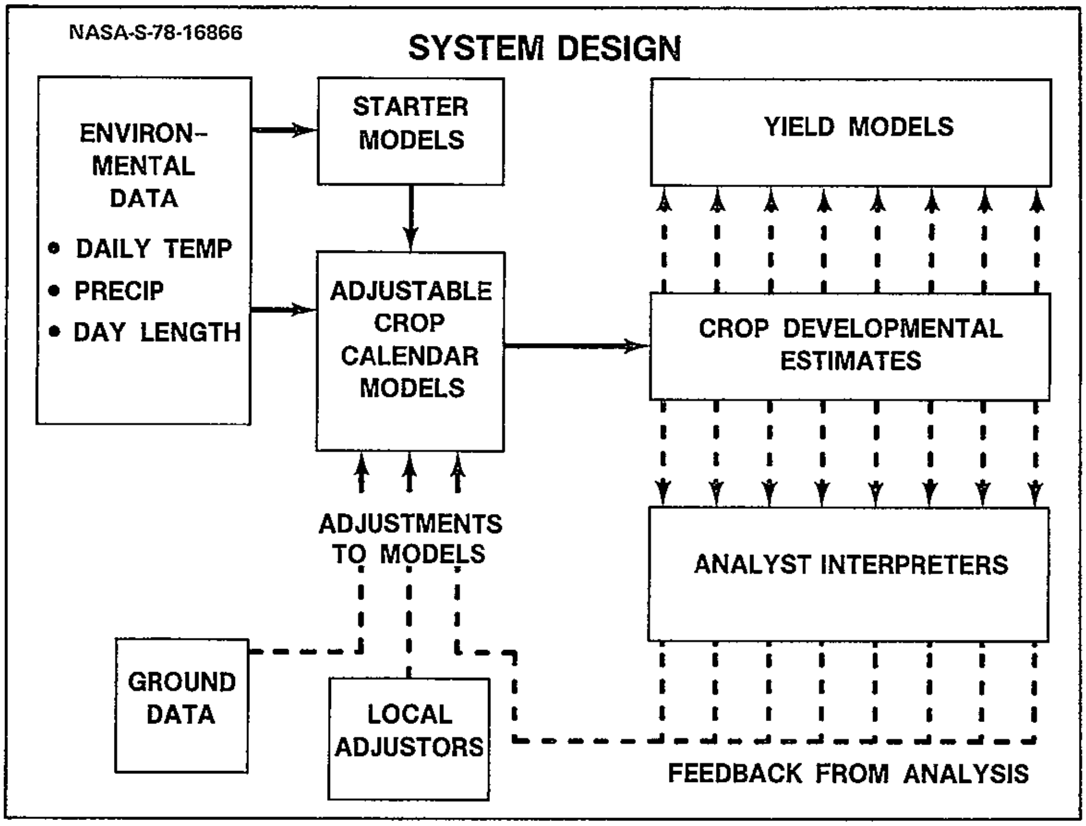
SPRING WHEAT STARTER MODEL (CONT)

STUFF AND PHINNEY MODEL

$$R = -0.77 + 0\ 045(T) - 0.032(P) - 0.053(N)$$

WHERE T = AVERAGE DAILY TEMP (°F) P = TOTAL DAILY PRECIP (IN)

N = NORMAL PLANTING DATE — ACTUAL DATE, AND
R = RATE OF PLANTING


NASA-S-78-16866
SYSTEM DESIGN
ENVIRON-
MENTAL
DATA
• DAILY TEMP
• PRECIP
• DAY LENGTH
STARTER
MODELS
ADJUSTABLE
CROP
CALENDAR
MODELS
YIELD MODELS
CROP DEVELOPMENTAL
ESTIMATES
ANALYST INTERPRETERS
ADJUSTMENTS
TO MODELS
GROUND
DATA
LOCAL
ADJUSTORS
FEEDBACK FROM ANALYSIS

EXPERIMENT DESIGN SESSION

WHEAT YIELD MODEL DEVELOPMENT

C. Sakamoto, NOAA

NASA-S-78-16567

DEVELOPMENT OF LACIE WHEAT YIELD PREDICTION MODELS

NASA-S-78-16568

LACIE REQUIREMENT FOR A YIELD MODEL

PREPARE ESTIMATES OF YIELD FOR AN AREA WHERE ACREAGE ESTIMATES ARE ALSO AVAILABLE IN ORDER TO ESTIMATE PRODUCTION WITHIN THAT AREA

BASIC PREMISE

CONSIDERABLE TECHNOLOGY FOR YIELD ESTIMATION EXISTED AND SHOULD BE TESTED FOR ITS ABILITY TO MAKE TIMELY, ACCURATE, OPERATIONAL ESTIMATES

CONSTRAINTS IN LACIE

- AVAILABLE DATA
- TIME AVAILABLE FOR MODEL IMPLEMENTATION
- NEED FOR BOTH EARLY-SEASON AND AT-HARVEST YIELD ESTIMATES

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NASA-S-78-16569

POTENTIAL APPROACHES TO CROP YIELD MODELING

- CAUSAL APPROACH
- STATISTICAL REGRESSION APPROACH
- ANALOG APPROACH

NASA-S-78-16570

SELECTION OF STATISTICAL REGRESSION APPROACH

- ADVANTAGES
  - HISTORIC DATA BASES OF YIELD AND WEATHER READILY AVAILABLE FOR U S. AND MANY FOREIGN AREAS
  - LIKELY DEVELOPMENT AND IMPLEMENTATION WITHIN LACIE TIME AND RESOURCE CONSTRAINTS
  - EARLY RESEARCH REVEALED THAT REGRESSION MODELS HAD SKILL IN CORRELATING MONTHLY WEATHER WITH CROP YIELD
  - USED GLOBALLY AVAILABLE INPUT DATA TO PRODUCE BOTH EARLY-SEASON AND AT-HARVEST ESTIMATES
- DISADVANTAGES
  - HIGH-QUALITY HISTORIC WEATHER AND YIELD DATA ARE NOT AVAILABLE FOR CERTAIN KEY FOREIGN AREAS
  - RESPONSE OF MODEL IS LIMITED BY HISTORIC EXTREMES AVAILABLE FOR MODEL DEVELOPMENT

NASA-S-78-16571

MODEL APPROACH

BASED ON HISTORICAL TIME SERIES
- U.S DATA BEGIN IN 1932
- FOR OTHER FOREIGN AREAS, DATA BEGIN 1933-58

USED MULTIPLE LINEAR REGRESSION AND A PRIORI KNOWLEDGE OF CROP RESPONSE TO SELECT PREDICTOR VARIABLES

ASSUMPTIONS IN MODEL DEVELOPMENT

- CROP IS IN SAME PHENOLOGICAL STAGE EACH MONTH EVERY YEAR AND IDENTICALLY SUSCEPTIBLE TO SAME WEATHER IMPACTS ON YIELD
- HOMOGENEITY OF WEATHER DEPARTURES FROM NORMAL OVER ENTIRE REGION BEING MODELED
- NO INTERACTIONS BETWEEN WEATHER AND TECHNOLOGY
- SHORT-PERIOD WEATHER FLUCTUATIONS AND EPISODIC EVENTS ARE AVERAGED OUT OVER LARGE AREAS

NASA-S-78-16572

MODEL FORM

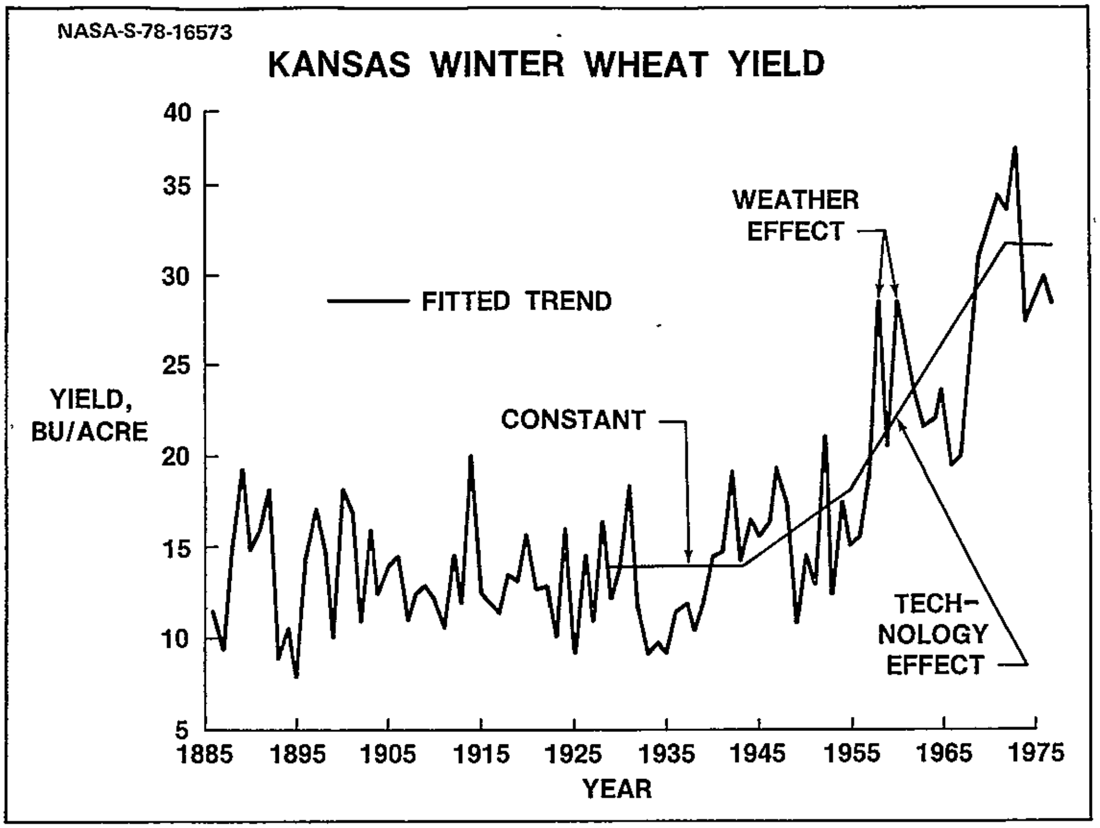
$$\hat{Y} = \text{CONSTANT} + \text{TREND} + \text{WEATHER EFFECTS}$$

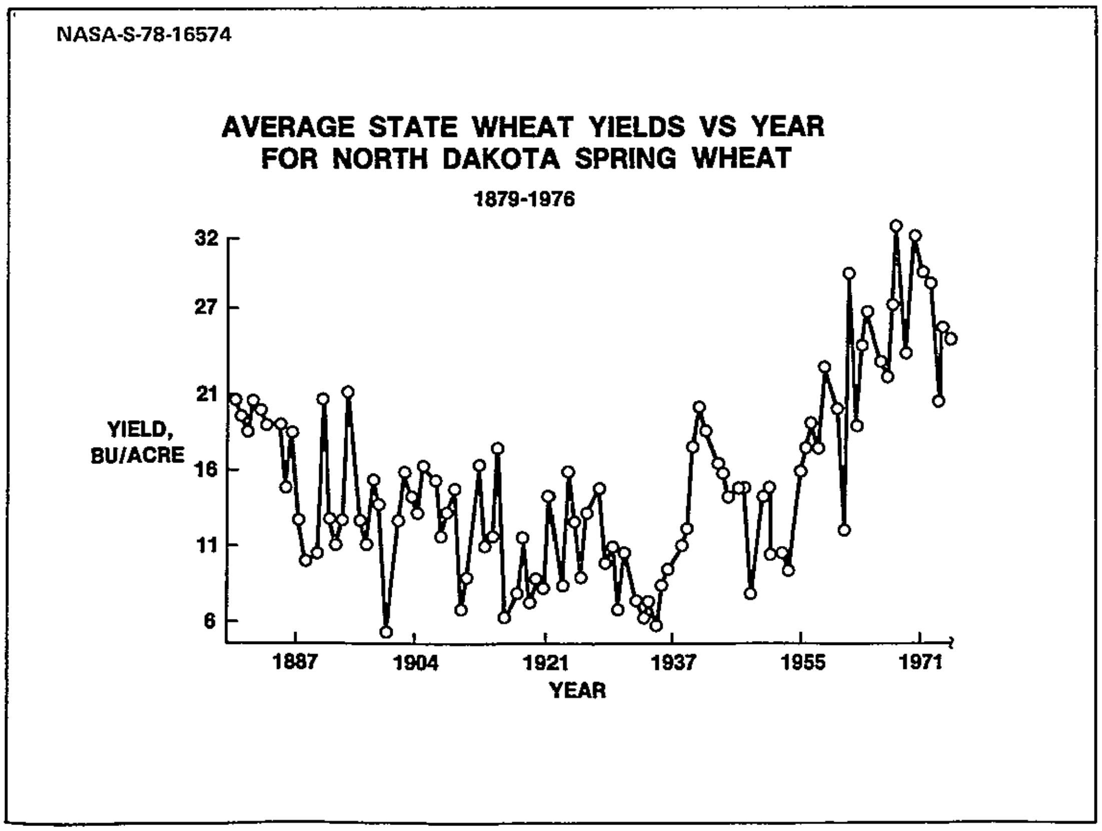
CONSTANT = THE BASE YIELD CHARACTERISTIC OF A REGION IN THE ABSENCE OF TECHNOLOGICAL ENHANCEMENT

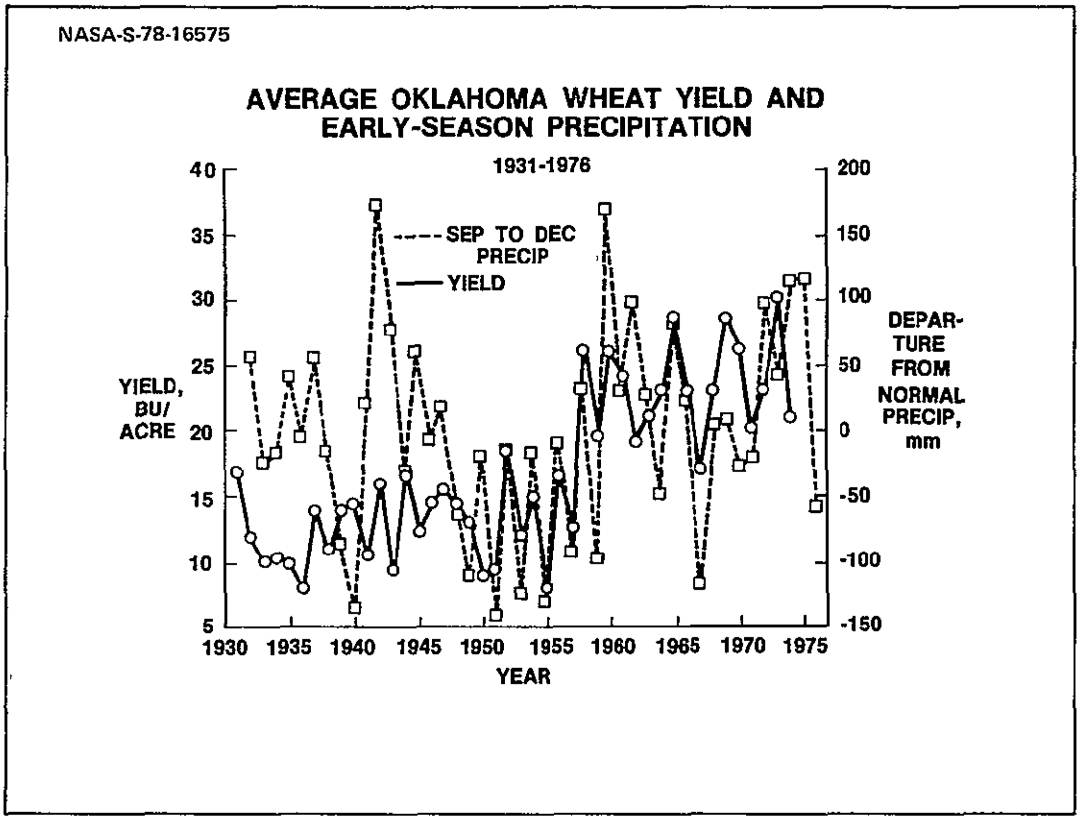
TREND = THE COMBINED EFFECT OF THE TECHNOLOGICAL IMPROVEMENTS ON YIELD – EXPRESSED AS A FUNCTION OF THE CHRONOLOGICAL YEAR

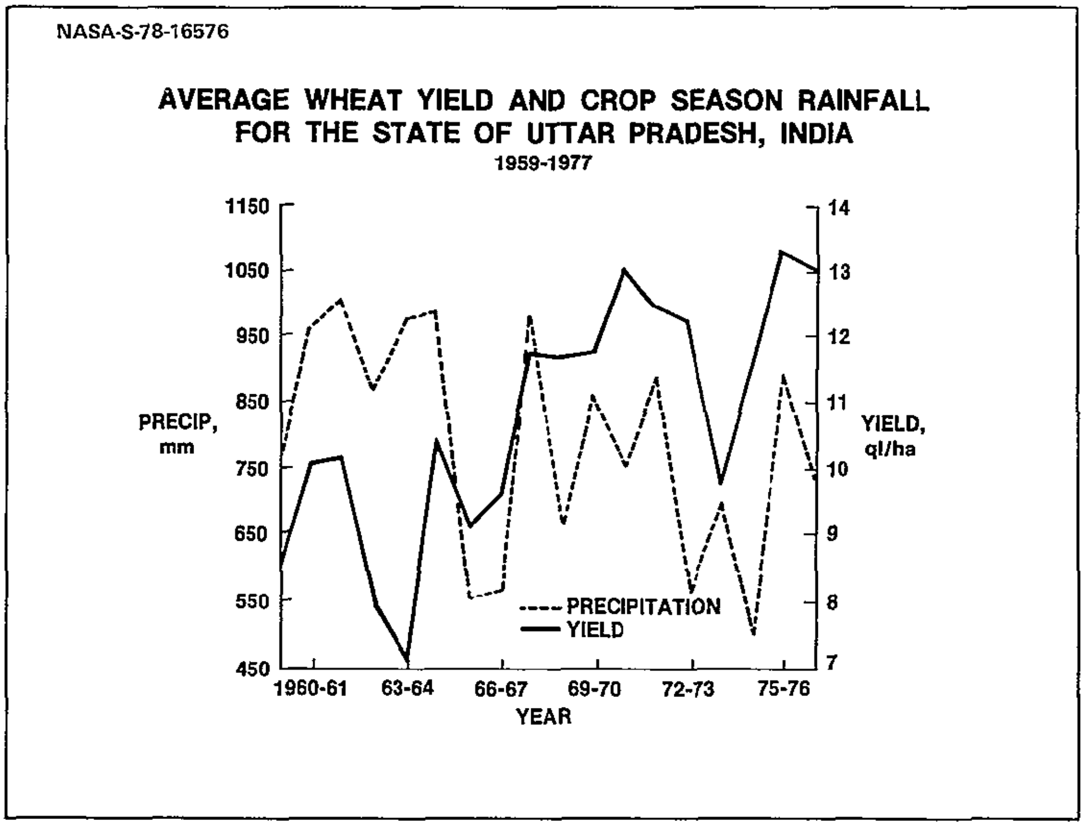
WEATHER EFFECTS = THE COMPONENT OF YIELD VARIATION ATTRIBUTABLE TO FLUCTUATIONS ABOUT THE LONG-TERM AVERAGE WEATHER IN A CROP REGION

BASED ON PREMISE THAT THERE IS A LEVEL OF YIELD GENERALLY DETERMINED BY LOCAL TECHNOLOGY AND SOIL CAPABILITY WITH YEAR-TO-YEAR FLUCTUATIONS ABOUT THAT LEVEL DUE TO WEATHER VARIATION


NASA-S-78-16573
KANSAS WINTER WHEAT YIELD
YIELD, BU/ACRE
FITTED TREND
WEATHER EFFECT
CONSTANT
TECH-NOLOGY EFFECT
40
35
30
25
20
15
10
5
1885
1895
1905
1915
1925
1935
1945
1955
1965
1975
YEAR


NASA-S-78-16574
AVERAGE STATE WHEAT YIELDS VS YEAR
FOR NORTH DAKOTA SPRING WHEAT
1879-1976
YIELD, BU/ACRE
32
27
21
16
11
6
1887
1904
1921
1937
1955
1971
YEAR


NASA-S-78-16575
AVERAGE OKLAHOMA WHEAT YIELD AND
EARLY-SEASON PRECIPITATION
1931-1976
SEP TO DEC PRECIP
YIELD
YIELD, BU/ ACRE
DEPARTURE FROM NORMAL PRECIP, mm
YEAR
40
35
30
25
20
15
10
5
200
150
100
50
0
-50
-100
-150
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975


NASA-S-78-16576
AVERAGE WHEAT YIELD AND CROP SEASON RAINFALL
FOR THE STATE OF UTTAR PRADESH, INDIA
1959-1977
PRECIP, mm
YIELD, ql/ha
PRECIPITATION
YIELD
YEAR
1150
1050
950
850
750
650
550
450
14
13
12
11
10
9
8
7
1960-61
63-64
66-67
69-70
72-73
75-76

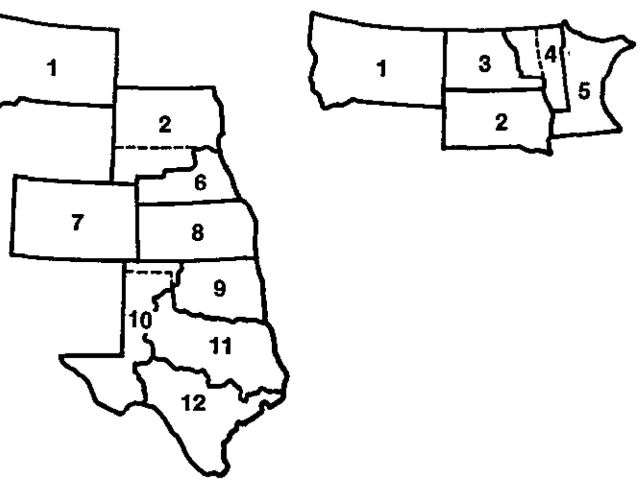
NASA-S-78-16577

MODEL REGIONS

- MODELS WERE DEVELOPED FOR REGIONS APPROXIMATELY STATE-SIZE THAT ARE RELATIVELY HOMOGENEOUS IN REGARD TO AGRICULTURAL PRACTICES AND POTENTIAL
- REGIONS ARE COMPOSED OF SUBUNITS SUCH AS CROP REPORTING DISTRICTS FOR WHICH AVERAGE WEATHER AND YIELDS WERE AVAILABLE OVER A HISTORIC PERIOD. IN THE U S., THIS BEGINS ABOUT 1932
- IN THE U.S.S R., THE MODELED REGIONS ARE SOMETIMES 10 TIMES LARGER THAN THOSE IN THE U.S.

NASA-S-78-16578

BOUNDARIES OF REGIONS FOR WHICH U.S. WHEAT YIELD MODELS WERE DEVELOPED



CCEA WINTER WHEAT MODEL BOUNDARIES

CCEA SPRING WHEAT MODEL BOUNDARIES

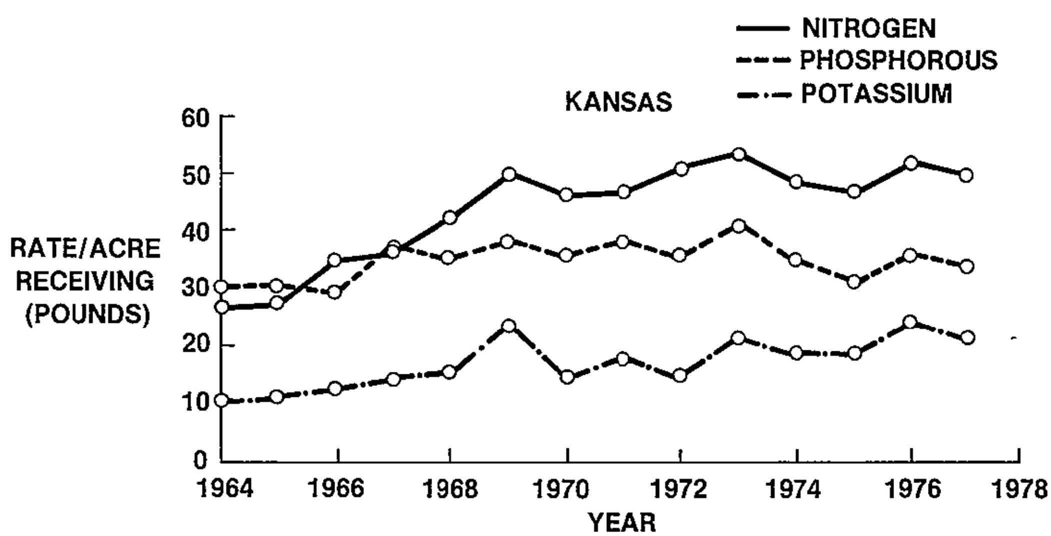
NASA-S-78-16579

MODELING OF TECHNOLOGICAL TREND

- OBSERVATIONS
  - SUSTAINED YIELDS ARE SIGNIFICANTLY HIGHER IN RECENT YEARS
  - MOST OF THE INCREASES CAME DURING THE PERIOD 1955-70
  - UPWARD TREND APPEARS TO HAVE LEVELED OFF IN RECENT YEARS
- LIKELY CAUSES –
  - TECHNOLOGY MODELED AS PIECEWISE LINEAR TREND
  - POSSIBLE INTERACTIONS EXIST BETWEEN WEATHER AND TREND

NASA-S-78-16580

RATE OF FERTILIZER APPLICATION FOR WHEAT



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MODEL DEVELOPMENT

- MODEL INPUTS ARE MONTHLY WEATHER VARIABLES FOR A REGION CALCULATED AS THE DEPARTURE FROM THEIR LONG-TERM AVERAGES
  - PRECIPITATION
  - TEMPERATURE
  - PRECIP-POTENTIAL ET
  - PRECIP/PET
  - DEGREE DAYS ABOVE 90° F
- MODEL FORM INCLUDES VARIABLES WHICH ARE SURROGATES FOR
  - TECHNOLOGY
  - MOISTURE STRESS

  DURING ASSUMED AVERAGE GROWTH STAGES
- BOTH LINEAR AND QUADRATIC TERMS ARE OFFERED AS CANDIDATE VARIABLES

NASA-S-78-16582

VARIABLE SELECTION IN MODEL

- AGRONOMIC SENSE WITH RESPECT TO THE KNOWN EFFECT OF THE VARIABLE ON YIELD AT THE ASSUMED PHENOLOGICAL STAGE
- STATISTICAL SIGNIFICANCE
- PERFORMANCE IN PREDICTING ON INDEPENDENT DATA

NASA-S-78-16583

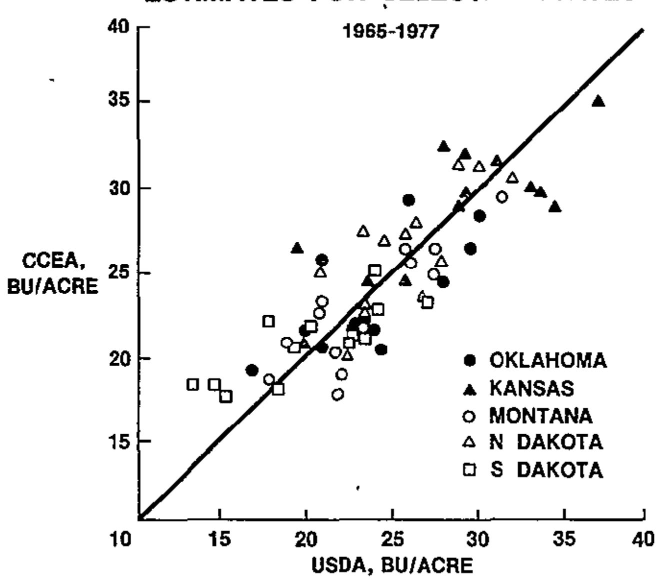
KANSAS WINTER WHEAT MODEL VARIABLES

VARIABLE	T STATISTIC	SIGNIFICANCE
OVERALL CONSTANT	15.31069	0.00000001
LINEAR TREND 1943-1955	4 04307	0.00054265
LINEAR TREND 1955-1972	9.69801	0.00000030
AUG-NOV PRECIP (DFN)	4.54036	0.00020159
MARCH PRECIP (DFN)	4 44636	0.00024162
MAY PRECIP — PET (DFN)	-1.43352	0.15954435
MAY PRECIP — PET (SDFN)	-1 04317	0.30609387
MAY DAYS > 90 DEG F	-2 86651	0.00737609
JUNE PRECIP (DFN)	-1.32841	0.19205976

R SQUARED	0.92775
ADJUSTED R SQUARE	0.91023
STANDARD ERROR	1.46242
STANDARD DEVIATION OF YIELDS	4.88097

NASA-S-78-16584

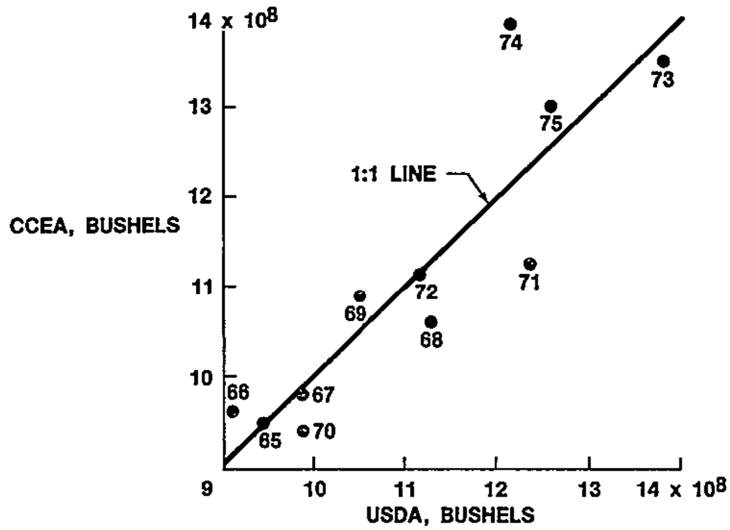
USDA WHEAT YIELD ESTIMATES VS CCEA MODEL ESTIMATES FOR SELECTED STATES



NASA-S-78-16585

USDA WHEAT PRODUCTION ESTIMATES VS CCEA ESTIMATES (USING REPORTED USDA ACREAGE)

1965-1975



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EARLY-SEASON ESTIMATION TECHNIQUE

- SEVERAL APPROACHES TO ANTICIPATING MONTHLY WEATHER BETWEEN TIME OF PREDICTION AND HARVEST
  - USE EXTENDED WEATHER FORECASTS
  - ASSUME NORMAL WEATHER
  - DEVELOP ADDITIONAL MODELS BASED ONLY ON EARLY-SEASON WEATHER
- AT-HARVEST MODELS WERE TRUNCATED BACKWARDS TO PRODUCE A SERIES OF NEW MODELS WHICH COULD BE USED EARLY IN THE SEASON

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KANSAS STATE WINTER WHEAT MODEL

VARIABLE	TRUNCATION NOV	MAR	MAY	JUN
OVERALL CONSTANT	7 93856	8 14029	9 64031	9 40812
LINEAR TREND 1943-55	.30267	23759	23530	24259
LINEAR TREND 1955-72	48160	.55176	.51971	.52790
AUG-NOV PREC (mm)	02082	.02068	.01820	01939
MAR PREC (mm)		05644	05582	.05664
MAY PREC – PET (mm)			-.01034	- 01211
MAY PREC – PET (mm)			- 00028	- 00017
MAY NUMBER DAYS ABOVE 32° C			- 29770	- 30083
JUN PREC (mm)				-.00745
R SQUARED	84268	89058	92388	92775
STANDARD ERROR (Q/Ha)	2 01095	1 69956	1 47877	1 46242
STANDARD VARIANCE (Q/Ha)	4 04392	2 88851	2 18676	2.13866

NASA-S-78-16588

MODEL EVALUATION

- METHODOLOGY
  - HISTORIC WEATHER DATA USED TO PRODUCE INDEPENDENT TEST RESULTS SEQUENTIALLY ON MOST RECENT 10 YEARS
- CRITERIA:
  - NO MORE THAN 2 OF THE 10 YEARS CAN BE OUTSIDE THE 10 PERCENT RELATIVE ERROR BOUND

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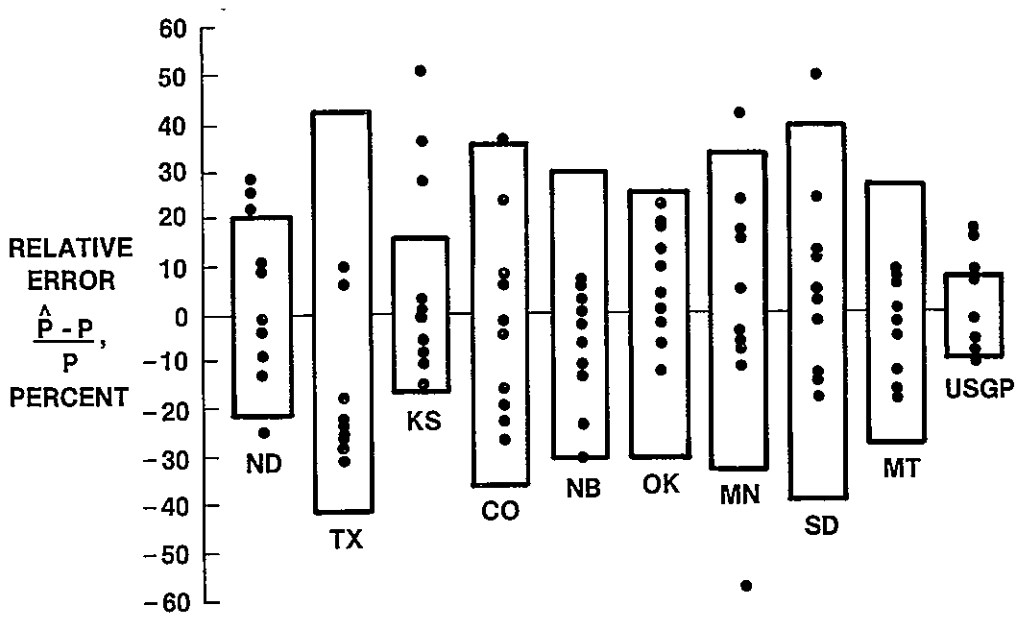
TEN-YEAR (1965-1974) YIELD MODEL EVALUATION



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PHASE I YIELD MODELS

- PROJECTED YIELD TREND STEADILY UPWARD
- ALLOWED FULL EFFECTS OF EXTREME PRECIPITATION AND TEMPERATURE
- HAD REGIONS COMMON TO MORE THAN ONE MODEL IN SEVERAL AREAS

NASA-S-78-16591

CHANGES AFTER PHASE I

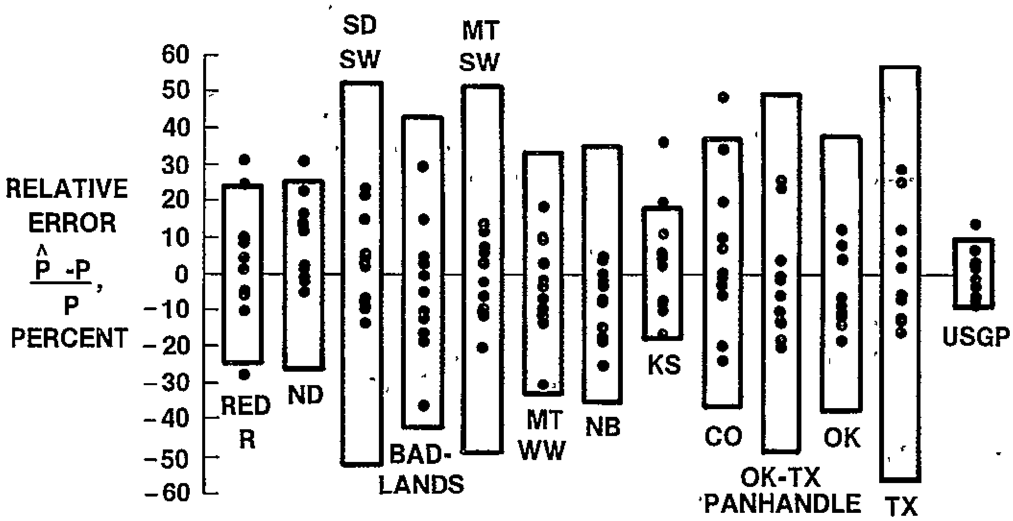
- UPWARD TREND LEVELED IN RECENT YEARS
- INPUT DATA CENSORED

  TEMPERATURE – BOUNDED BY 5 AND 95 PERCENTILE

  PRECIPITATION – BOUNDED BY 0 AND 90 PERCENTILE

NASA-S-78-16592

ELEVEN-YEAR (1965-1975) YIELD MODEL EVALUATION



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CHANGES AFTER PHASE II

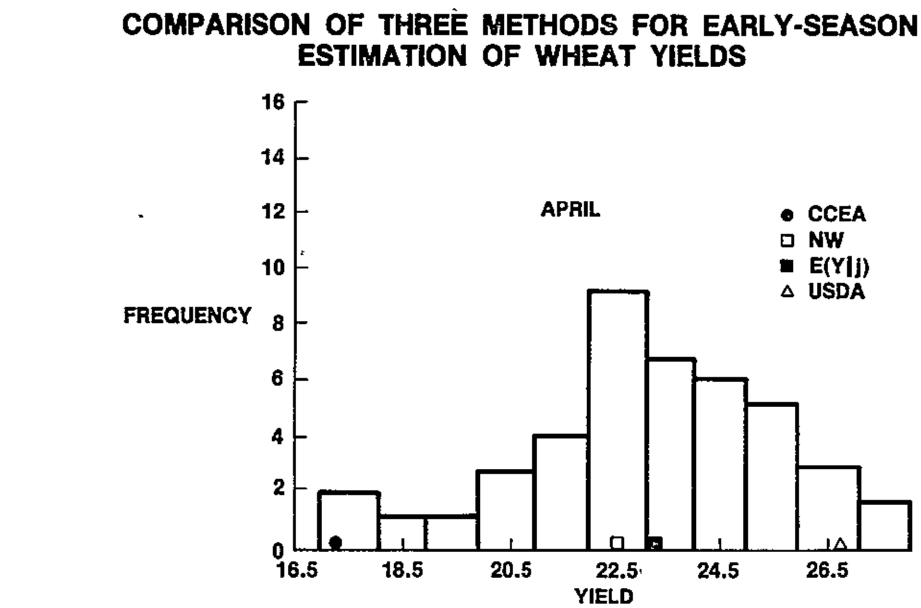
- REALINED DATA BASES TO ELIMINATE OVERLAP AND LIKELY CORRELATIONS
- CREATED NEW YIELD MODEL FOR MINNESOTA

NASA-S-78-16594

POTENTIAL AREAS OF IMPROVEMENT IN CROP YIELD MODELING

- USE ADJUSTABLE CROP CALENDAR TO ELIMINATE ERRONEOUS APPLICATION OF WEATHER WHEN CROP STAGE SIGNIFICANTLY DEPARTS FROM NORMAL
- IMPROVE ESTIMATE OF PLANT AVAILABLE WATER THROUGH A SOIL WATER BUDGET
- USE MINIMUM TEMPERATURE AS A VARIABLE TO CAPTURE LIKELY EFFECT OF COLD INJURY TO WINTER WHEAT
- MODEL AGRONOMIC AND ECONOMIC INFLUENCES ON TECHNOLOGICAL TREND
- IMPROVE TECHNIQUES FOR MAKING EARLY-SEASON YIELD ESTIMATES

NASA-S-78-16595



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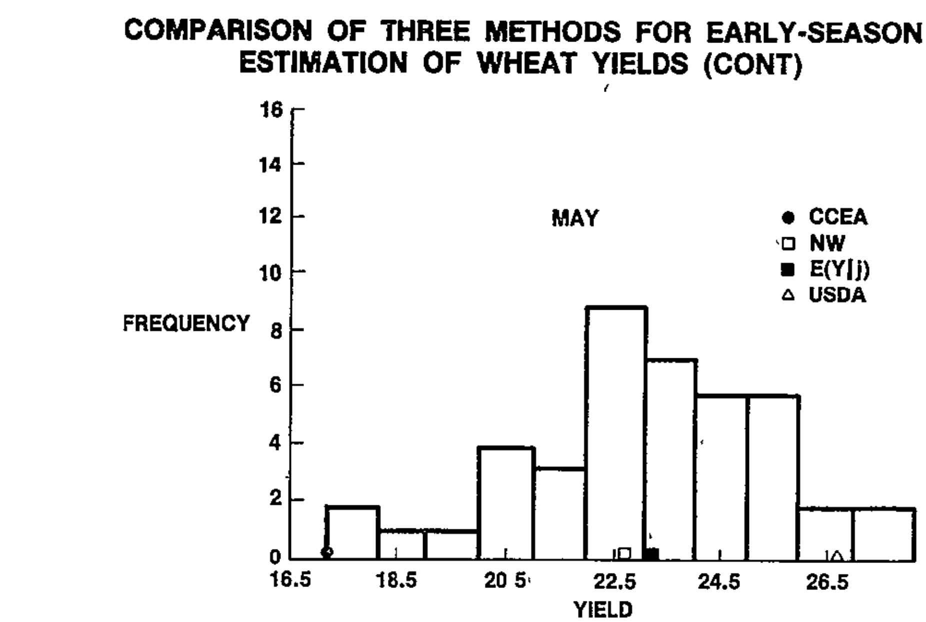

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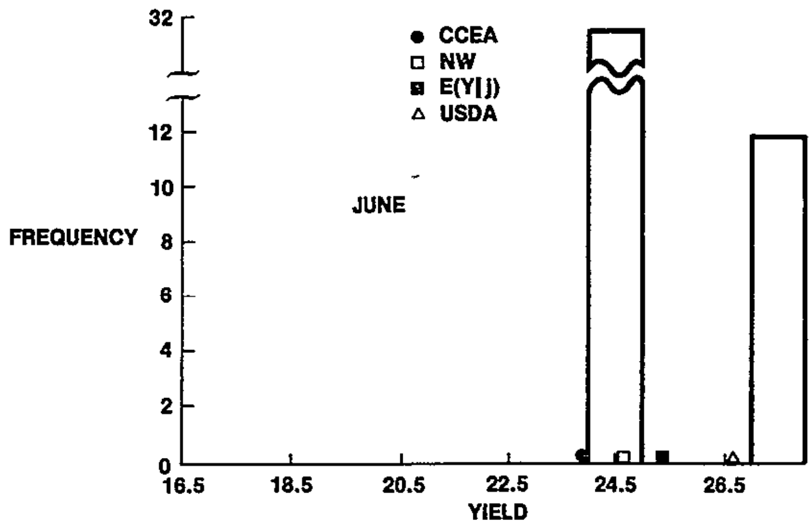
COMPARISON OF THREE METHODS FOR EARLY-SEASON ESTIMATION OF WHEAT YIELDS (CONT)



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CLASSIFICATION AND MENSURATION APPROACH

R. Heydorn, JSC

NASA-S-78-16867

CLASSIFICATION AND MENSURATION OF LACIE SEGMENTS

NASA-S-78-16868

3-YEAR CLASSIFICATION AND MENSURATION EXPERIMENT DESIGN - OVERVIEW

- THE FUNDAMENTAL APPROACH TO ESTIMATE THE ACREAGE OF WHEAT IN A 5-BY 6-N MI AREA
  - MACHINE CLASSIFICATION METHODS TO IDENTIFY ALL WHEAT PIXELS IN THE SEGMENT
  - MANUAL INTERPRETATION METHODS TO PROVIDE SPECTRAL EXAMPLES OF WHEAT AND NONWHEAT WITH WHICH TO "TRAIN" THE CLASSIFIER AND TO ADJUST FOR CLASSIFICATION-ERROR-RELATED BIAS
- USES NO GROUND ENUMERATIVE DATA EXCEPT AFTER-THE-FACT TO EVALUATE RESULTS

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3-YEAR CLASSIFICATION AND MENSURATION EXPERIMENT DESIGN - OVERVIEW (CONT)

- TWO DESIGNS WERE TESTED. THE SECOND DESIGN WAS MOTIVATED BY CLASSIFICATION AND MANUAL INTERPRETATION PROBLEMS ENCOUNTERED IN THE FIRST 2 YEARS
- IN THE FIRST DESIGN, AN ANALYST TRAINS THE CLASSIFIER TO MENSURATE A SEGMENT
  - ANALYST DOES NOT PERFORM AN INVENTORY FUNCTION
- IN THE SECOND DESIGN (P-1), BOTH THE ANALYST AND THE MACHINE PERFORM AN INVENTORY FUNCTION
  - ANALYST TRAINS THE CLASSIFIER
  - CLASSIFICATION TREATED AS A SMALL-GRAINS/NON-SMALL-GRAINS STRATIFICATION
  - ANALYST PERFORMS A STRATIFIED AREAL ESTIMATE
  - CONSISTENCY CHECKS ARE MADE BETWEEN ANALYST LABELING RESULTS AND MACHINE CLASSIFICATION RESULTS

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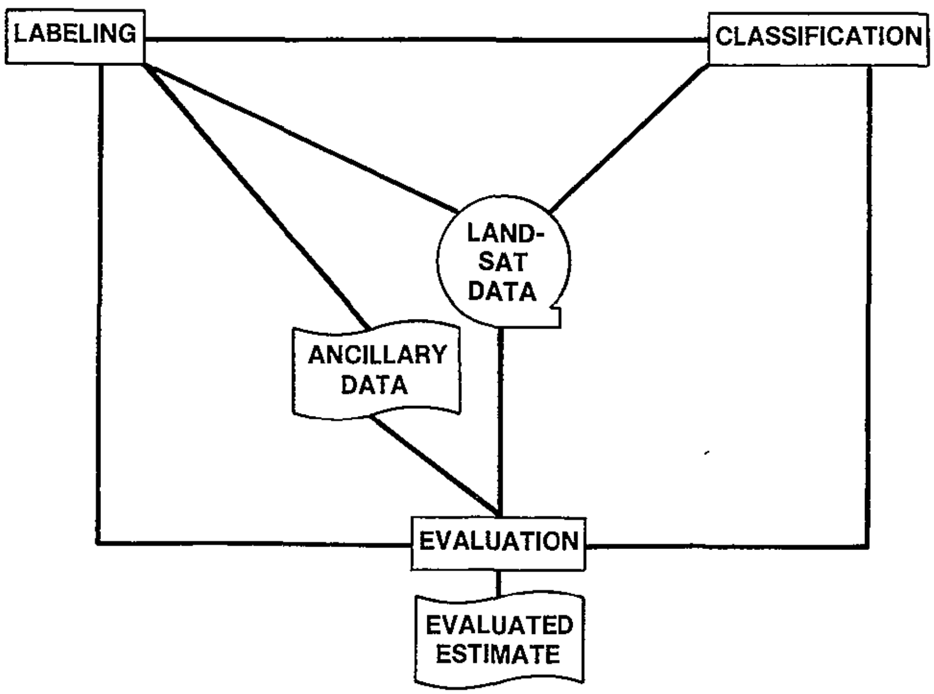
PROCESSING FLOW IN CAMS



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CLASSIFICATION MODEL

- EACH PIXEL OF SPECTRAL MEASUREMENTS, x, IS CLASSIFIED AS BELONGING TO A SMALL-GRAINS OR TO A NON-SMALL-GRAINS CLASS USING AN APPROXIMATION TO A BAYES APPROACH
- LET $f_1(\cdot)$ = LIKELIHOOD THAT A PIXEL IS SMALL GRAINS
  $f_0(\cdot)$ = LIKELIHOOD THAT A PIXEL IS NON-SMALL-GRAINS
  π = PRIOR PROBABILITY THAT A PIXEL IS SMALL GRAINS

  BASIC MODEL:

  "DECIDE PIXEL x BELONGS TO THE CLASS OF ALL SMALL GRAINS IF

  $$\pi f_1(x) > (1-\pi) f_0(x)$$

  AND x BELONGS TO THE CLASS OF ALL NON-SMALL-GRAINS OTHERWISE"
- EACH LIKELIHOOD IS APPROXIMATED BY A SUM OF NORMAL DISTRIBUTIONS

NASA-S-78-16872

MANUAL FIELD SELECTION AND LABELING

- THROUGH THE USE OF MANUAL INTERPRETATION METHODS, FIELDS OF SMALL GRAINS AND NON-SMALL-GRAINS ARE SELECTED AND LABELED. THESE FIELDS ARE USED TO TRAIN THE CLASSIFIER
- FIELDS ARE ENCLOSED IN POLYGONS AND THE VERTICES OF THOSE POLYGONS USED AS THE FIELD LOCATION INDEXES IN THE MACHINE PROCESSING
- AREAS THAT ARE DEFINITELY NON-SMALL-GRAINS AND LIKELY TO BE MISCLASSIFIED ARE ALSO ENCLOSED IN POLYGONS AND LABELED "DESIGNATED OTHER" (DO)
- AREAS COVERED BY CLOUDS ARE ALSO ENCLOSED IN POLYGONS AND LABELED "DESIGNATED UNIDENTIFIABLE" (DU). THESE AREAS ARE DISCARDED FROM THE SEGMENT ESTIMATE

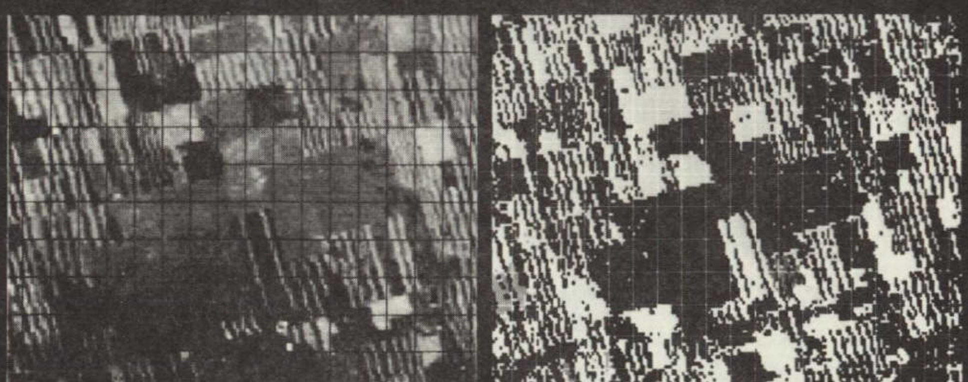
NASA-S-78-16873

ESTIMATE EVALUATION

- ANALYST COMPARES THE CLASSIFICATION MAP WITH THE MSS IMAGE
  - ERROR IN CLASSIFICATION CAN BE A RESULT OF
    - MISLABELING
    - NOT SELECTING A "REPRESENTATIVE" SAMPLE FROM EACH SUBCLASS
    - AREA CANNOT BE RESOLVED BY THE BAYES RULE IN AN ERROR-FREE WAY
- CORRECTIONS TO THE LABELING OR FIELD SELECTION PROCESS ARE MADE AND THE SEGMENT IS RECLASSIFIED

NASA-S-78-16493

CLASS MAP - CIR IMAGE COMPARISON



CIR IMAGE
CHOUTEAU, MONTANA
JULY 3, 1977
(BIOWINDOW 4)

CLASS MAP

NASA-S-78-16874

PROBLEMS WITH THE PHASE I AND II DESIGN

SELECTING AND LABELING FIELDS

- BASICALLY, THE ANALYST WAS REQUIRED TO INTERPRET COLOR IMAGERY TO ANSWER QUESTIONS SUCH AS
  - "HOW MANY NORMAL DISTRIBUTIONS WILL FIT THE DATA?"
  - "HOW MANY FIELDS SHOULD BE SAMPLED?"
- ANALYST MUST SAMPLE AND LABEL FIELDS AS BELONGING TO ONE CLASS WHEN, IN FACT, BASED ON SPECTRAL MEASUREMENTS ALONE, THE FIELDS ARE "MORE LIKELY" TO BELONG TO ANOTHER CLASS
  - IN STATISTICAL TERMS, THE ANALYST MUST SAMPLE AND LABEL OBSERVATION FROM THE "TAILS OF DISTRIBUTIONS"
  - THERE IS A TENDENCY TO SAMPLE ONLY FROM THE HIGH-DENSITY OR MORE LIKELY PORTION OF A CROP SPECTRAL DISTRIBUTION

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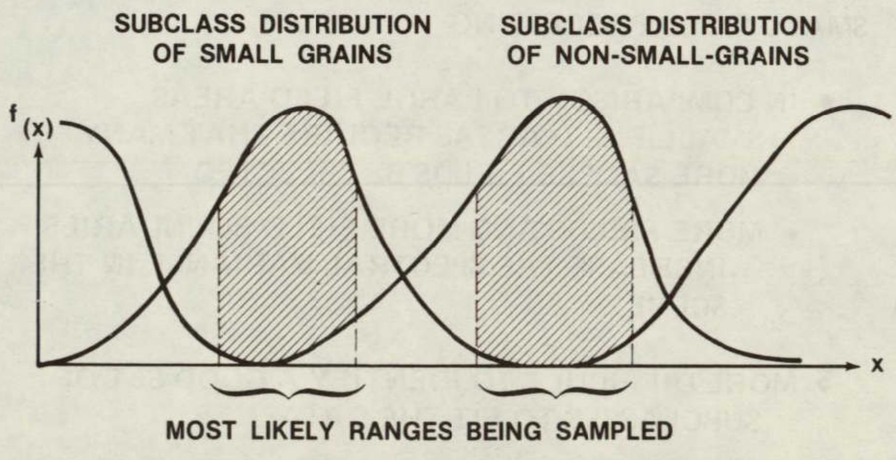
DIAGRAMMATIC EXPLANATION OF "SAMPLE FROM ONLY THE CENTRAL PART OF THE DISTRIBUTION"



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PROBLEMS WITH THE PHASE I AND II DESIGN (CONT)

EFFICIENCY

- THE DESIGN WAS NOT EFFICIENT FOR A LARGE-SCALE BATCH-PROCESSING OPERATION
  - THE ONLY WAY A SEGMENT ESTIMATE COULD BE MODIFIED WAS TO RECLASSIFY IT. SINCE MANY SEGMENTS REQUIRED REWORK, PROCESSING DELAYS WERE EXPERIENCED
  - ACCURATELY DETERMINING POLOYGONAL FIELD VERTICES AND PUNCHING THEM ONTO CARDS WAS SLOW
  - BY THE END OF PHASE II, THE AVERAGE TIME REQUIRED TO PROCESS A SEGMENT WAS 7 HOURS

NASA-S-78-16877

PROBLEMS WITH THE PHASE I AND II DESIGN (CONT)

SMALL-FIELD PROCESSING

- IN COMPARISON TO LARGE-FIELD AREAS, SMALL-FIELD AREAS REQUIRE THAT MANY MORE SAMPLE FIELDS BE SELECTED
  - MORE FIELDS AND MORE FIELD BOUNDARIES INCREASE THE SPECTRAL VARIANCE IN THE SCENE
- MORE DIFFICULT TO IDENTIFY A GOOD SET OF SUBCLASSES TO FIT THE DATA

NASA-S-78-16878

PROBLEMS WITH THE PHASE I AND II DESIGN (CONT)

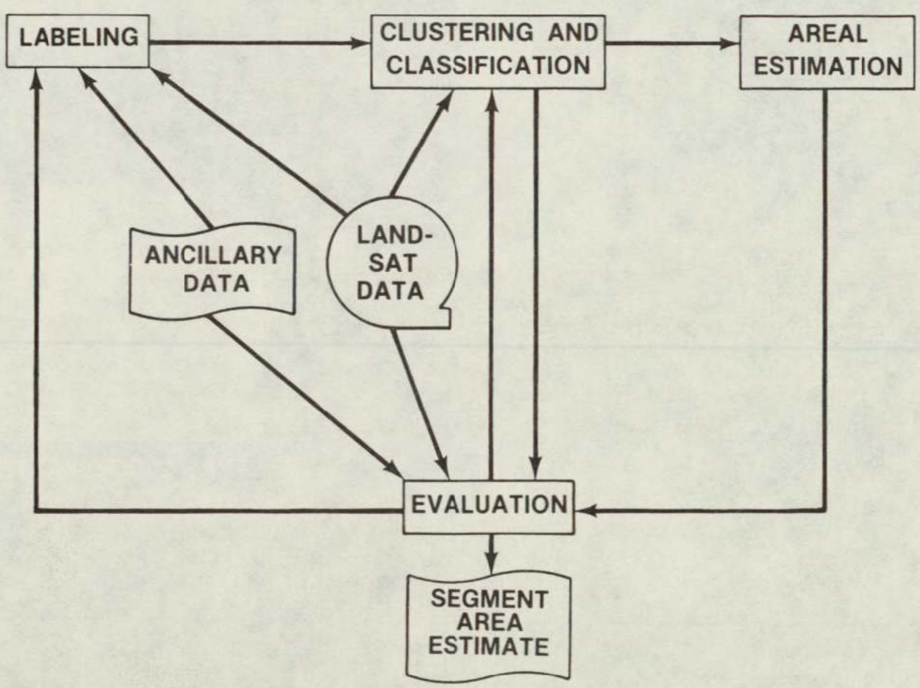
MULTITEMPORAL PROCESSING

- BELIEF IS THAT TO DISCRIMINATE WELL BETWEEN CROP TYPES, MSS MEASUREMENTS AT SEVERAL STAGES OF CROP GROWTH MUST BE SIMULTANEOUSLY CONSIDERED – THAT IS – MULTITEMPORALLY PROCESSED

- ATTEMPTS TO OBTAIN MULTITEMPORAL CLASSIFICATION WERE LARGELY UNSUCCESSFUL
  - ANALYST MUST NOW ACCOUNT FOR MORE SUBCLASSES DUE TO THE MORE COMPLEX DIMENSIONAL DATA
  - COVARIANCES IN THE DATA INCREASE THE REQUIREMENT FOR A LARGER SAMPLE OF FIELDS

NASA-S-78-16879

PROCESSING FLOW IN PROCEDURE 1



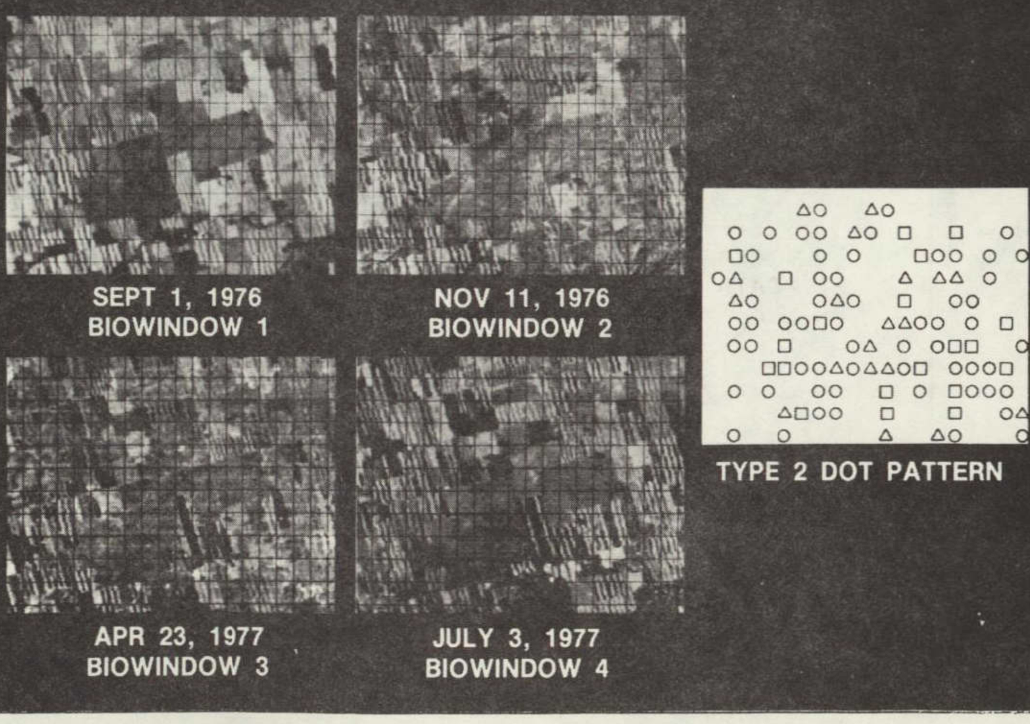
NASA-S-78-16880

LABELING REQUIREMENTS

- THE PURPOSE OF LABELING IS TO
  - OBTAIN TRAINING SAMPLES
  - OBTAIN A STRATIFIED AREAL ESTIMATE (SAE)
  - EVALUATE THE CLASSIFIER
- OF THE 22 932 PIXELS IN THE LACIE SEGMENT, 209 ARE SELECTED AS CANDIDATE LABELING "DOTS"
  - THE 209 DOTS ARE THOSE PIXELS COINCIDING WITH A GRID SPACING OF EVERY 10TH ROW AND EVERY 10TH COLUMN OF A LACIE SEGMENT
- TWO SETS OF DOTS ARE LABELED – TYPE 1 AND TYPE 2
  - TYPE 1 DOTS ARE USED FOR TRAINING. APPROXIMATELY 40 ARE SELECTED AT RANDOM FROM THE 209
  - TYPE 2 DOTS ARE USED FOR THE SAE AND FOR EVALUATION. APPROXIMATELY 60 ARE SELECTED AT RANDOM FROM THE 209

NASA-S-78-12540

CHOUTEAU, MONTANA
LABELING EXAMPLE



TYPE 2 DOT PATTERN

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NASA-S-78-16881

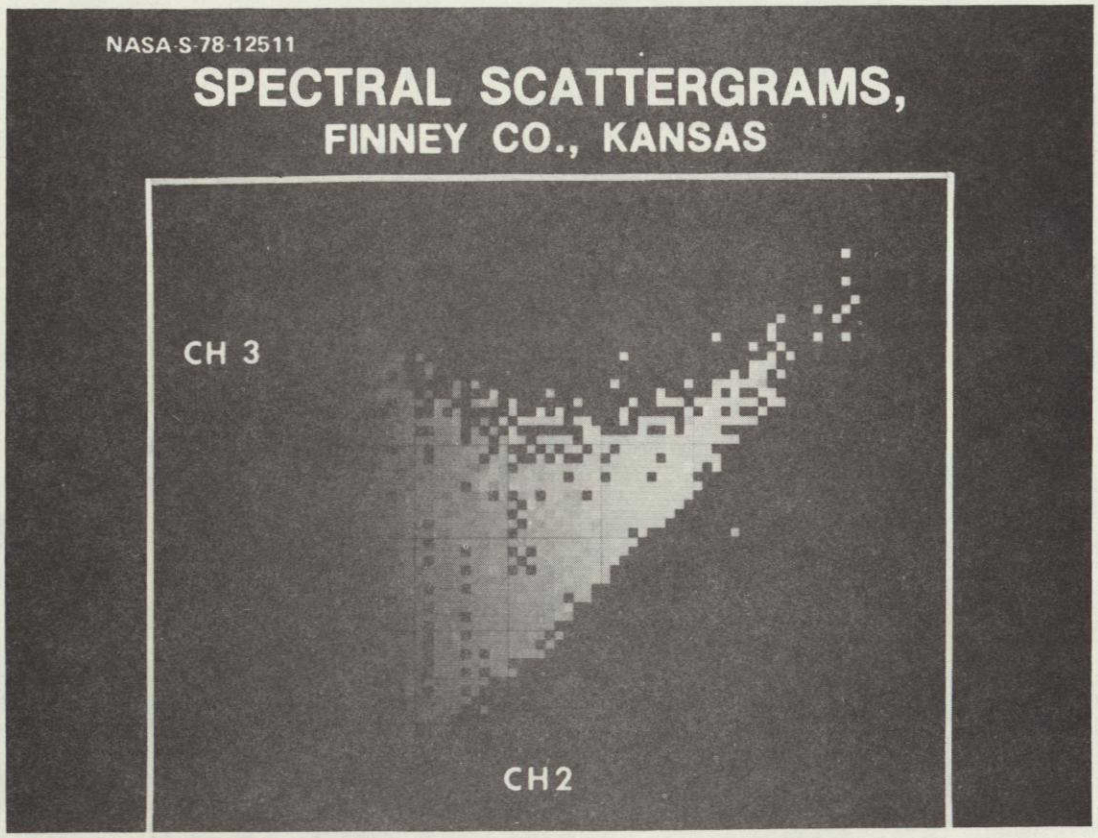
PRODUCTS USED IN LABELING

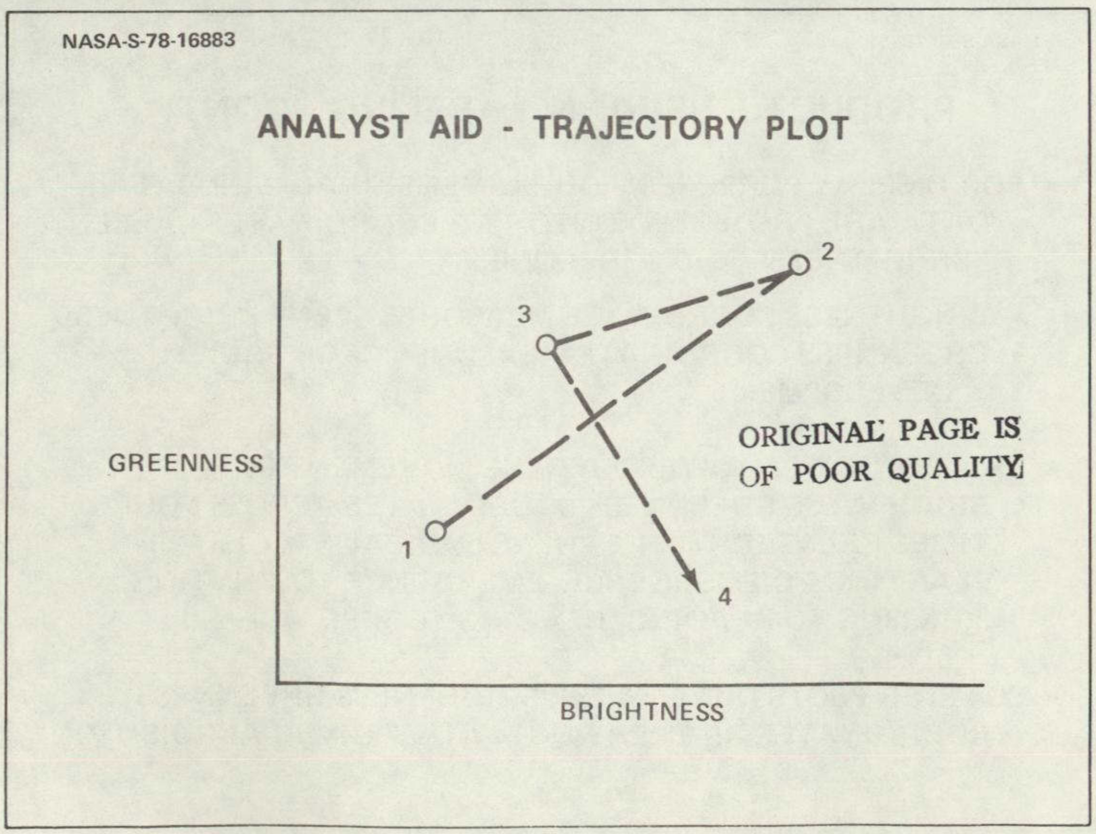
- DOTS ARE LABELED BY THE ANALYST USING
  - CIR IMAGERY
  - TRAJECTORY PLOTS
  - SCATTER PLOTS
  - ANCILLARY DATA
    - CROP CALENDARS
    - WEATHER SUMMARIES
    - CROPPING PRACTICES
    - OTHER

NASA-S-78-16882

PRODUCTS USED IN LABELING (CONT)

- FOR DISPLAY PURPOSES, FOUR-DIMENSIONAL LANDSAT DATA ARE PROJECTED ONTO TWO COORDINATES CALLED "BRIGHTNESS" AND "GREENNESS"
  - BRIGHTNESS COORDINATE MEASURES SCENE BRIGHTNESS
  - GREENNESS COORDINATE MEASURES CROP GROWTH DEVELOPMENT
- TRAJECTORY PLOTS DISPLAY THE MOVEMENT OF BRIGHTNESS-GREENNESS COORDINATES ACROSS FOUR TIMES RELATED TO THE PHENOLOGICAL STAGES – PLANTING TO EMERGENCE, EMERGENCE TO JOINTING, JOINTING TO HEADING, HEADING TO RIPE
- SCATTER PLOTS DISPLAY THE BRIGHTNESS-GREENNESS COORDINATES OF EVERY DOT WITH A GIVEN ACQUISITION


NASA-S-78-12511
SPECTRAL SCATTERGRAMS,
FINNEY CO., KANSAS
CH 3
CH2


NASA-S-78-16883
ANALYST AID - TRAJECTORY PLOT
GREENNESS
BRIGHTNESS
1
2
3
4
ORIGINAL PAGE IS
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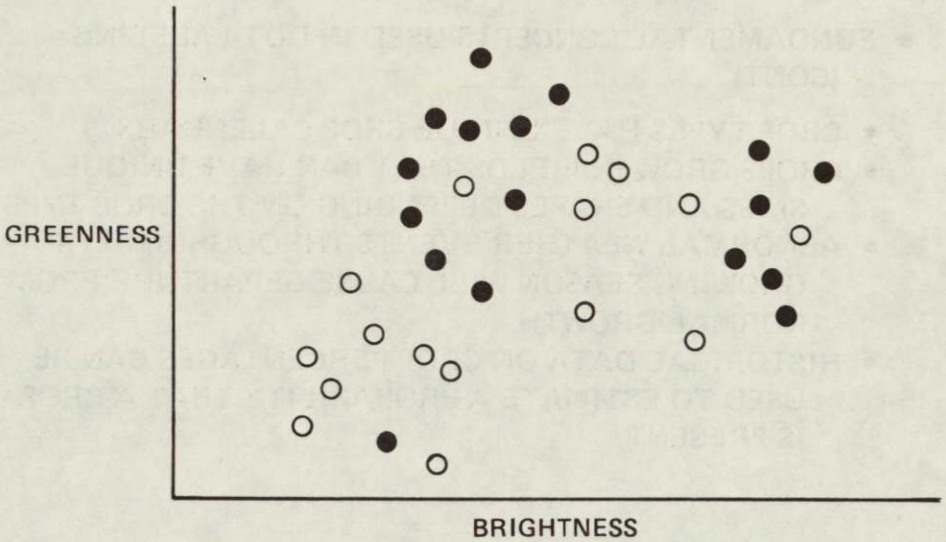
NASA-S-78-16884

ANALYST AID - SCATTER PLOT



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LABELING APPROACH

- FUNDAMENTAL CONCEPTS USED IN DOT LABELING
  - THE SEQUENCE OF FILM COLORS, OR THE NUMERICAL LANDSAT VALUES, (PHOTOPHENOLOGY) OVER TIME IS RELATED TO TRANSITIONS OF CROP GROWTH STAGES (PHENOLOGY)

PHENOLOGY		PHOTOPHENOLOGY*
• EMERGENCE	→ LANDSAT →	• MEDIUM GREEN
• TILLERING		• LIGHT PINK/GREEN
• BOOTING		• ORANGE
• HEADING		• ORANGE
• RIPE		• RED
• POSTHARVEST		• GREEN

* COLORS DEPEND ON ENVIRONMENTAL (SOILS), ATMOSPHERIC, AND FILM-GENERATION FACTORS

NASA-S-78-16886

LABELING APPROACH (CONT)

- FUNDAMENTAL CONCEPTS USED IN DOT LABELING (CONT).
  - CROP TYPES HAVE UNIQUE CROP CALENDARS
  - CROPS GROW IN FIELDS THAT CAN HAVE UNIQUE SIZES AND SHAPES DEPENDING ON THE CROP TYPE
  - ABNORMAL WEATHER EVENTS THROUGHOUT THE GROWING SEASON WILL CAUSE DEPARTURE FROM NORMAL GROWTH
  - HISTORICAL DATA ON CROP PERCENTAGES CAN BE USED TO ESTIMATE A PROBABILITY THAT A CROP IS PRESENT

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LABELING APPROACH (CONT)

- GENERAL STEPS IN DOT LABELING
  - HISTORICAL INFORMATION SUCH AS PERCENTAGE OF A GIVEN CROP GROWN IN THE AREA, CROPPING PRACTICES, ETC, IS REVIEWED
  - WHEAT CROP CALENDAR MODEL PREDICTIONS AND WEATHER SUMMARIES ARE CONSULTED TO ADJUST NOMINAL CROP CALENDARS FOR WHEAT AND CONFUSION CROPS
  - DETERMINATION IS MADE WHETHER OR NOT A DOT IS IN A FIELD
  - TEMPORAL COLOR SEQUENCE AND THE TRAJECTORY PLOT OF A DOT IS CORRELATED WITH ADJUSTED CROP CALENDARS TO MAKE A SMALL-GRAINS OR NON-SMALL-GRAINS DETERMINATION
  - SCATTER PLOTS AND CLASSIFICATION PRODUCTS ARE CONSULTED TO EVALUATE LABELING DECISIONS

NASA-S-78-16888

LABELING APPROACH (CONT)

- IN ANY GIVEN APPLICATION, THE SPECIFIC DECISION-MAKING STRATEGY IS HIGHLY PROBLEM DEPENDENT
- IN GENERAL, DOTS ARE LABELED ACCORDING TO THE FIELD THAT CONTAINS THE DOT
  - TYPE 1 DOTS IN UNREPRESENTATIVE PORTIONS OF A FIELD OF ONE CROP TYPE MAY BE ASSIGNED A LABEL DIFFERENT FROM THE FIELD LABEL
  - TYPE 1 BOUNDARY DOTS ARE NOT LABELED
  - ALL TYPE 2 DOTS ARE LABELED

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CLUSTERING

- LABELED TYPE 1 DOTS ARE USED TO START CLUSTERING AND TO LABEL THE RESULTING CLUSTERS AS BEING SMALL-GRAINS OR NON-SMALL-GRAINS CLUSTERS
- ALL THE PIXELS IN A GIVEN CLUSTER ARE TREATED AS OBSERVATIONS FROM ONE SUBCLASS AND ARE USED TO ESTIMATE THE MEAN AND COVARIANCE MATRIX OF THAT SUBCLASS
- CLUSTER AND CONDITIONAL CLUSTER MAPS ARE PROVIDED TO EVALUATE THE RESULTS
  - CLUSTER MAP IS A SPATIAL MAP (SIMILAR TO THE CIR IMAGE) WITH ALL AREAS IN A GIVEN CLUSTER ASSIGNED ONE COLOR; ALL CLUSTERS HAVE SEPARATE COLORS
  - CONDITIONAL CLUSTER MAP IS THE SAME AS A CLASS MAP EXCEPT THAT AREAS WITHIN THRESHOLD DISTANCE FROM ANY LABELING DOT ARE ASSIGNED A SEPARATE COLOR

NASA S 78-12583

EVALUATION AIDS, CHOUTEAU, MONTANA

MULTITEMPORAL
CLUSTER MAP

MULTITEMPORAL
CONDITIONAL CLUSTER MAP

NASA-S-78-16890

STRATIFIED AREAL ESTIMATION

- THE SMALL-GRAINS AREAL ESTIMATE IS OBTAINED BY COMBINING THE RESULTS OF TYPE 2 DOT LABELING WITH THE MACHINE CLASSIFICATION RESULT USING THE FOLLOWING FORMULA:

$$P = \alpha_1 \frac{N_1}{N} + \alpha_2 \frac{N_2}{N}$$

NASA-S-78-16893

EVALUATION

- EACH SEGMENT ESTIMATE IS EVALUATED BY CHECKING FOR INCONSISTENCY BETWEEN ANALYST LABELS AND MACHINE CLASSIFICATION
  - QUANTITATIVE AND QUALITATIVE CHECKS USED
- QUANTITATIVE CHECKS
  - PROBABILITY OF MISCLASSIFICATION AS DETERMINED FROM TYPE 2 LABELED DOTS
  - COMPARISON OF SAE WITH THE MACHINE ESTIMATE
    - MACHINE ESTIMATE COMPARED WITH CONFIDENCE INTERVAL ABOUT THE SAE
- QUALITATIVE CHECKS
  - COMPARISONS ARE MADE AMONG
    - CIR IMAGERY
    - CLASS MAP
    - CONDITIONAL CLUSTER MAP

NASA-S-78-16894

TEST AND EVALUATION OF PROCEDURE 1

TESTS PERFORMED

- EVALUATIONS WERE DONE USING GROUND TRUTH FOR LABELING DOTS TO
  - ESTIMATE PARAMETER VALUES
  - EVALUATE CLUSTERING AND CLASSIFICATION PERFORMANCE
  - DETERMINE BIAS AND EFFICIENCY OF THE SAE
- ANALYST INTERPRETATION THEN USED FOR ALL DOT LABELING TO STUDY THE EFFECTS OF LABELING ERROR ON PERFORMANCE
- COMPARISON OF P-1 CLASSIFICATION PERFORMANCE WITH CLASSIFICATION PERFORMANCE OF THE PHASE I & II DESIGN WAS ALSO DONE

NASA-S-78-16895

TEST AND EVALUATION OF PROCEDURE 1 (CONT)

SUMMARY OF RESULTS

- AVERAGE CLASSIFICATION ERROR (G T. LABELING)
  - ON LARGE-FIELD SEGMENTS ~85 PERCENT
  - ON SMALL-FIELD SEGMENTS ~70 PERCENT
  - AVERAGED ACROSS FIELDS ~80 PERCENT
- NO DETECTABLE DIFFERENCE BETWEEN USING AI OR GT LABELED DOTS
- NO DETECTABLE DIFFERENCE BETWEEN AI AND GT SAE'S NOR WAS ANY BIAS DETECTED IN THOSE ESTIMATES (STUDY BASED ON 25 SEGMENTS)
- EFFICIENCY $\left(1 - \frac{\text{VARIANCE OF SAE}}{\text{VARIANCE OF SIMPLE RANDOM-SAMPLE ESTIMATE}}\right)$ IS LOW (~0.25) WHEN AVERAGED ACROSS ALL SEGMENTS
- IMPROVEMENT IN MULTITEMPORAL CLASSIFICATION PERFORMANCE OF P-1 WHEN COMPARED WITH THE PHASE I & II DESIGN

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CONCLUSIONS

- MULTITEMPORAL MACHINE CLASSIFICATION IS ROUTINELY DONE WITH P-1, WHEREAS IN THE FIRST DESIGN MOST ATTEMPTS FAILED
- P-1 PROVIDED AN OVERALL ACCURACY IMPROVEMENT OVER THE FIRST DESIGN
- ANALYST SEGMENT CONTACT TIME CUT IN HALF

NASA-S-78-16897

CONCLUSIONS (CONT)

- THE SAE WILL BE MORE EFFICIENT (SMALLER VARIANCE) THAN AN ESTIMATE THAT CAN BE OBTAINED DIRECTLY (NO MACHINE CLASSIFICATION) FROM TYPE 2 DOT LABELING, BUT
  - MAY NOT ALWAYS BE MORE EFFICIENT THAN THE ESTIMATE THAT COULD BE OBTAINED FROM THE COMBINED TYPE 1 AND TYPE 2 DOT SAMPLES (ASSUMING THAT THE ANALYST WOULD LABEL TYPE 1 BOUNDARY DOTS)
    - EFFICIENCY DEPENDS ON OMISSION AND COMMISSION ERROR RATES IN THE CLASSIFIER
      - THIS MAY DEPEND ON FACTORS SUCH AS FIELD SIZE, AMOUNT OF SMALL GRAINS IN THE SEGMENT, ETC
  - MORE EFFICIENCY CAN PROBABLY BE OBTAINED BY TRAINING ONLY A SUBSET OF SEGMENTS TO BE CLASSIFIED , i.e., A SIGNATURE EXTENSION APPROACH

N79-14464

ACCURACY ASSESSMENT – THE STATISTICAL APPROACH TO PERFORMANCE EVALUATION

G. Houston, JSC

NASA-S-78-16898

ACCURACY ASSESSMENT
THE STATISTICAL APPROACH TO PERFORMANCE EVALUATION IN LACIE

NASA-S-78-16899

OUTLINE

- ACCURACY ASSESSMENT OBJECTIVES
- 90/90 CRITERION AND EVALUATION
- PRODUCTION ERROR COMPONENTS AND ANALYSES

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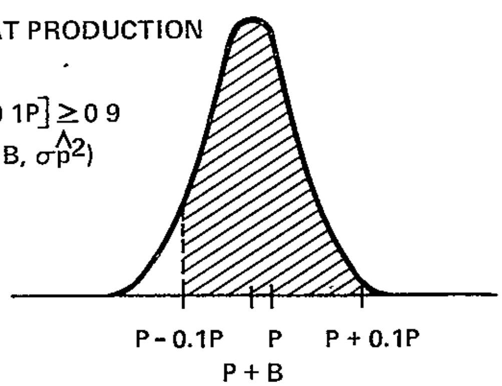
NASA-S-78-16900

ACCURACY ASSESSMENT

- NEED
  - TIMELY IDENTIFICATION OF MAJOR PROBLEM AREAS AND RECOMMENDATIONS FOR IMPROVEMENTS
- OBJECTIVES
  - TO DETERMINE THE ACCURACY AND RELIABILITY OF LACIE ESTIMATES OF PRODUCTION, AREA, AND YIELD MADE AT REGULAR INTERVALS THROUGHOUT A CROP SEASON
  - TO DETERMINE WHETHER OR NOT THESE ESTIMATES SUPPORT THE 90/90 ACCURACY GOAL
  - TO INVESTIGATE THE VARIOUS ERROR SOURCES OF THESE ESTIMATES, QUANTIFY AND RELATE THESE ERROR SOURCES TO CAUSAL ELEMENTS IN LACIE ESTIMATION PROCESS

NASA-S-78-16901

- 90/90 CRITERION
  - LET $\hat{P}$ = LACIE ESTIMATE OF WHEAT PRODUCTION
    P = TRUE WHEAT PRODUCTION
  - ACCURACY GOAL
    PROB $[|\hat{P} - P| \leq 0.1P] \geq 0.9$
    – ASSUME $\hat{P} \sim N(P + B, \sigma_{\hat{P}}^2)$



– SHADED AREA MUST BE GREATER THAN OR EQUAL TO 0.9

– WHETHER OR NOT IT IS SATISFIED IS A FUNCTION OF WHAT B AND $\sigma_{\hat{P}}^2$ ARE

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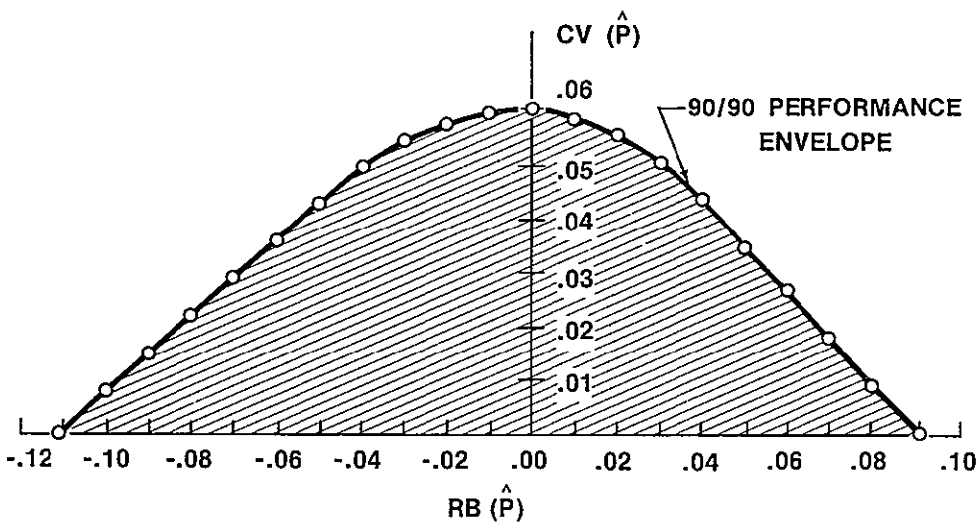
VALUES OF RELATIVE BIAS (RB) AND COEFFICIENT OF VARIATION (CV) THAT SUPPORT 90/90



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EXAMPLE

- PHASE III TOTAL WHEAT PRODUCTION FOR USGP
  - OBSERVED CV = 4.8 PERCENT
  - TOLERABLE RANGE FOR RELATIVE BIAS (-4.2 PERCENT, +3.4 PERCENT)
  - OBSERVED RELATIVE DIFFERENCE AS COMPARED TO ESCS

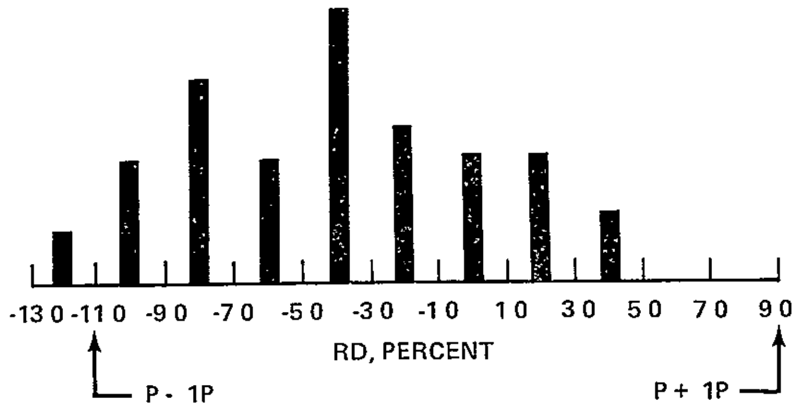
    RD = -10.0 PERCENT

    – MOST LIKELY 90/90 ESTIMATOR HAS

    CV = 4.8 PERCENT
    RB = -4.2 PERCENT
  - QUESTION: WHAT IS PROBABILITY OF 90/90 ESTIMATOR HAVING A RELATIVE DIFFERENCE LESS THAN OR EQUAL TO -10.0 PERCENT?

NASA-S-78-16904

- FOLLOWING IS A HISTOGRAM OF 50 RELATIVE DIFFERENCES FROM SUCH A 90/90 ESTIMATOR



- 5 OBSERVATIONS (10 PERCENT) WERE LESS THAN -10 0 PERCENT
  - THEORETICALLY, ANSWER IS 13.7 PERCENT
  - CONCLUSION INSUFFICIENT EVIDENCE TO REJECT 90/90

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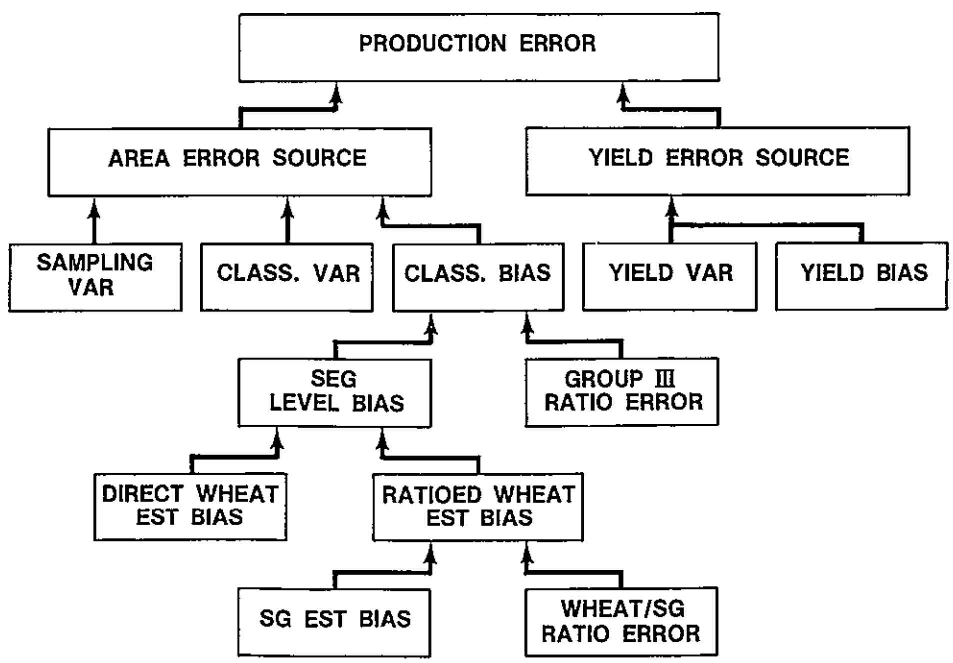
FIRST-ORDER ERROR COMPONENTS



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COMPARISONS WITH REFERENCE STANDARD

- COMPARE LACIE ESTIMATES (P, A, Y) WITH REFERENCE STANDARD AT COUNTRY AND REGION LEVELS
  - ASSUME LACIE $\dot{\sim}$ N (μ, σ^2), μ UNKNOWN
    - TEST H_O: μ = STANDARD

      VS

      H_A: $\mu \neq$ STANDARD
    - TEST STATISTIC

$$Z = \frac{\text{LACIE} - \text{STANDARD}}{\hat{\sigma}} \dot{\sim} N(0,1)$$

  - REPORT RESULTS BY
    - RELATIVE DIFFERENCE $= \frac{\text{LACIE} - \text{STANDARD}}{\text{LACIE}} \times 100$ PERCENT
    - COEFFICIENT OF VARIATION $= \frac{\hat{\sigma}}{\text{LACIE}} \times 100$ PERCENT

NASA-S-78-16907

AREA ERROR SOURCES

- BIAS ESTIMATION (WEIGHTED ANALYSIS)
  - LACIE ACREAGE ESTIMATE FOR A LARGE AREA MAY BE EXPRESSED AS

$$A = \sum_{I=1}^{N} W_I \hat{P}_I$$

WHERE $\hat{P}_I$ = SEGMENT WHEAT PROPORTION ESTIMATE

W_I = WEIGHT WHICH DEPENDS ON SIZE OF CORRESPONDING STRATUM, NO SEGMENTS IN STRATUM, GROUP III RATIO, ETC

N = NUMBER OF ACQUIRED SEGMENTS

  - TRUE ACREAGE ESTIMATE FOR LARGE AREA MAY BE EXPRESSED AS

$$A = \sum_{I=1}^{N} W_I^* C_I$$

WHERE C_I = TRUE STRATUM WHEAT PROPORTION

W_I^* = IDEAL WEIGHTS FOR THE N ACQUIRED SEGMENTS

NASA-S-78-16908

AREA ERROR SOURCES (CONT)

- BIAS ESTIMATION (CONT)
  - $\hat{A} - A = \sum_{I=1}^{N} W_I \hat{P}_I - \sum_{I=1}^{N} W_I^* C_I$

$$= \sum_{I=1}^{N} W_I (\hat{P}_I - P_I) + \sum_{I=1}^{N} W_I (P_I - C_I) + \sum_{I=1}^{N} C_I (W_I - W_I^*)$$

$$= B_C + B_S + B_{III}$$

WHERE B_C = ERROR DUE TO CLASSIFICATION

B_S = ERROR DUE TO SAMPLING

B_{III} = ERROR DUE TO GROUP III RATIO

- $(\hat{P}_I - P_I) \equiv \theta_I$, θ_I UNKNOWN

ASSUME B_S NEGLIGIBLE, SINCE SEGMENTS ARE RANDOMLY LOCATED IN STRATA

NASA-S-78-16909

AREA ERROR SOURCES (CONT)

- BIAS ESTIMATION (CONT)
  - ESTIMATION OF $B_C = \sum_{I=1}^{N} W_I \theta_I$
    - LET n = NUMBER OF BLIND SITES IN THE AREA
    - FOR EACH BLIND SITE, θ_I IS KNOWN SO LET

$$\hat{B}_C = \frac{N}{n} \sum_{I=1}^{n} W_I \theta_I$$

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AREA ERROR SOURCES (CONT)

- BIAS ESTIMATION (CONT)
  - ESTIMATION OF $B_{III} = \sum_{I=1}^{N} C_I (W_I - W_I^*)$
    - FOR A PREVIOUS YEAR FOR WHICH STRATUM-LEVEL SRS ESTIMATES ARE AVAILABLE, REPLACE C_I BY CORRESPONDING SRS STRATUM WHEAT PROPORTION ESTIMATE
    - THEN $\hat{B}_{III} = \sum_{I=1}^{N} W_I C_I - A_{SRS}$

    WHERE A_{SRS} = SRS WHEAT ESTIMATE FOR THE LARGE AREA

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AREA ERROR SOURCES (CONT)

- BIAS ESTIMATION (UNWEIGHTED ANALYSIS)
  - LET N BE THE NUMBER OF SEGMENTS ACQUIRED IN A REGION (STATE OR HIGHER) AND LET n BE THE NUMBER OF BLIND SITES IN THE REGION
  - FOR I = 1, ,N LET

    $\hat{X}_I$ = WHEAT PROPORTION ESTIMATE FOR I^{th} SEGMENT

    AND

    X_I = GROUND-TRUTH WHEAT PROPORTION FOR I^{th} SEGMENT
  - THE AVERAGE ERROR B IS GIVEN BY

$$B = \frac{1}{N} \sum_{I=1}^{N} (\hat{X}_I - X_I)$$

  - ESTIMATE B BY

$$\hat{B} = \bar{D} = \frac{1}{n} \sum_{I=1}^{n} D_I = \frac{1}{n} \sum_{I=1}^{n} (\hat{X}_I - X_I)$$

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AREA ERROR SOURCES (CONT)

- IF B SIGNIFICANTLY DIFFERENT FROM ZERO, DETERMINE CONTRIBUTIONS OF SMALL-GRAINS CLASSIFICATION ERROR AND WHEAT-TO-SMALL-GRAINS RATIO ERROR IF APPROPRIATE
  - $\hat{X}_I = \hat{R}_I \hat{G}_I$ WHERE $\hat{R}_I$ = ESTIMATE OF RATIO

    $\hat{G}_I$ = SMALL-GRAINS ESTIMATE
  - AVERAGE ERROR B AND MEAN SQUARED ERROR MSE OF WHEAT PROPORTION ARE ESTIMATED BY

$$\hat{B} = \frac{1}{n} \sum_{I=1}^{n} (\hat{R}_I \hat{G}_I - R_I G_I)$$

$$\hat{MSE} = \frac{1}{n} \sum_{I=1}^{n} (\hat{R}_I \hat{G}_I - R_I G_I)^2$$

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AREA ERROR SOURCES (CONT)

- CONTRIBUTION OF A PARTICULAR ERROR IS MEASURED BY THE REDUCTION IN THE AVERAGE ERROR OR THE MEAN SQUARED ERROR THAT IS ACHIEVED WHEN THAT ERROR FACTOR IS ELIMINATED
- AVERAGE ERROR AND MEAN SQUARED ERROR ESTIMATES WITH NO RATIO ERROR

$$\hat{B}_1 = \frac{1}{n} \sum_{I=1}^{n} (R_I \hat{G}_I - R_I G_I)$$

$$\hat{MSE}_1 = \frac{1}{n} \sum_{I=1}^{n} (R_I \hat{G}_I - R_I G_I)^2$$

- ACREAGE ERROR AND MEAN SQUARED ERROR ESTIMATES WITH NO CLASSIFICATION ERROR

$$\hat{B}_2 = \frac{1}{n} \sum_{I=1}^{n} (\hat{R}_I G_I - R_I G_I)$$

$$\hat{MSE}_2 = \frac{1}{n} \sum_{I=1}^{n} (\hat{R}_I G_I - R_I G_I)^2$$

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AREA ERROR SOURCES (CONT)

- CONTRIBUTIONS OF SAMPLING AND CLASSIFICATION ERRORS TO VARIANCE OF ACREAGE ESTIMATE
  - VARIANCE OF ACREAGE ESTIMATE FOR LARGE AREA MAY BE EXPRESSED AS:

$$\text{VAR}(\hat{A}) = \sum_{I} V_I \sigma_I^2$$

WHERE σ_I^2 = VARIANCE OF ACREAGE ESTIMATE FOR I^{th} STRATUM

V_I = WEIGHT WHICH DEPENDS ON SIZE, NUMBER OF SEGMENTS, ETC

NASA-S-78-16915

AREA ERROR SOURCES (CONC)

- ASSUME $\sigma_I^2 = \sigma_C^2 + \lambda^2\sigma_S^2$

  WHERE σ_C^2 = CONTRIBUTION DUE TO CLASSIFICATION

  $\lambda^2\sigma_S^2$ = CONTRIBUTION DUE TO SAMPLING
- PROPORTION OF LARGE-AREA ACREAGE ESTIMATE VARIABILITY DUE TO

  SAMPLING $R = \dfrac{\lambda^2\sigma_S^2}{\sigma_C^2 + \lambda^2\sigma_S^2}$

  CLASSIFICATION 1 - R
- MAXIMUM LIKELIHOOD APPROACH AND REGRESSION TECHNIQUES USED TO ESTIMATE σ_S^2, σ_C^2, AND λ

NASA-S-78-16916

YIELD ERROR SOURCES

- YIELD PREDICTIONS ARE PROVIDED BY THE CCEA OF NOAA
  - PREDICTIONS ARE PRODUCED AT THE ZONE LEVEL FROM MULTIPLE LINEAR REGRESSION MODELS DEVELOPED FROM HISTORICAL YIELD AND WEATHER DATA
  - ESTIMATES OF THE YIELD PREDICTION ERROR AT THE ZONE LEVEL ARE ALSO PROVIDED BY CCEA

NASA-S-78-16917

- TEN-YEAR TESTS
  - BOOTSTRAP PROCEDURE USED TO GET 10 YEARS OF YIELD PREDICTIONS AND CORRESPONDING PREDICTION ERROR ESTIMATES
    - DETERMINE IF BIASES ARE INDICATED
    - EVALUATE ESTIMATED PREDICTION ERRORS BY COMPARISON WITH OBSERVED MEAN SQUARED ERROR OVER THE TEST SET
    - 90/90 EVALUATION MADE INDEPENDENT OF ACREAGE ESTIMATION ERRORS (SRS AREA ESTIMATES ARE USED TO FORM A PRODUCTION ESTIMATOR WITH NO ACREAGE ESTIMATION ERROR)

NASA-S-78-16918

SECOND-ORDER ERROR SOURCE INVESTIGATIONS

- METHODOLOGY USED IS GENERALLY RESTRICTED TO·
  - PLOTTING AND TABULATION OF DATA
  - FITTING DATA BY REGRESSION TO EXAMINE RELATIONSHIPS
  - TESTS OF SIGNIFICANCE FOR COMPARATIVE ANALYSES

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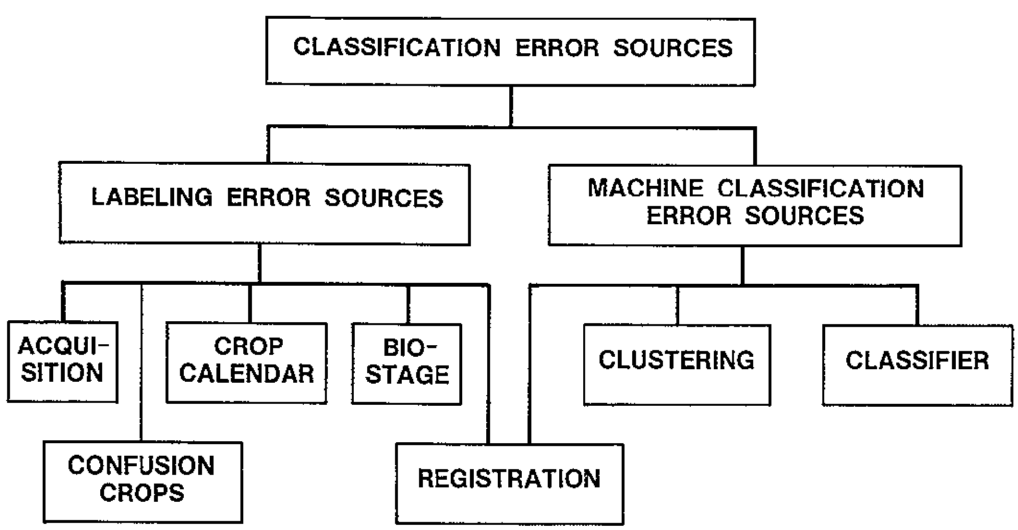

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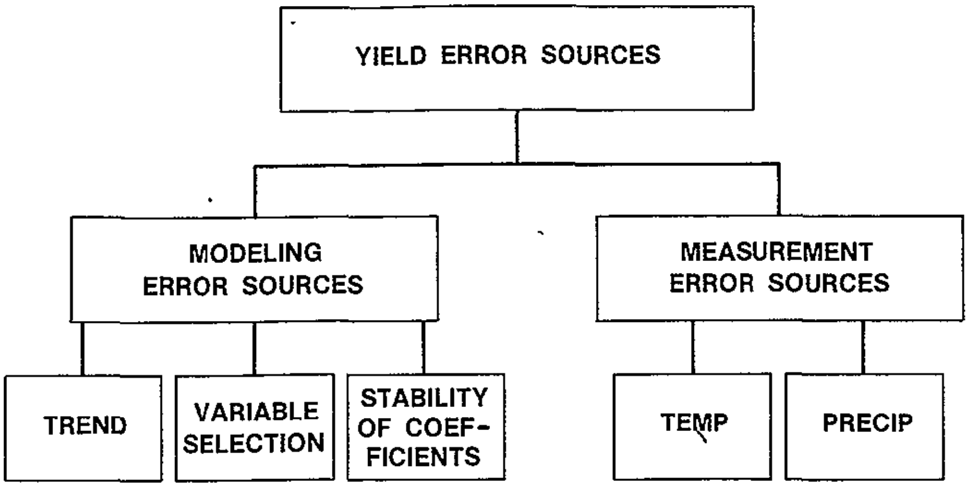


N79-14465

SYSTEM IMPLEMENTATION AND OPERATIONS SESSION

THE LACIE APPLICATION EVALUATION SYSTEM (AES) – A DESIGN OVERVIEW

R. Hill, JSC

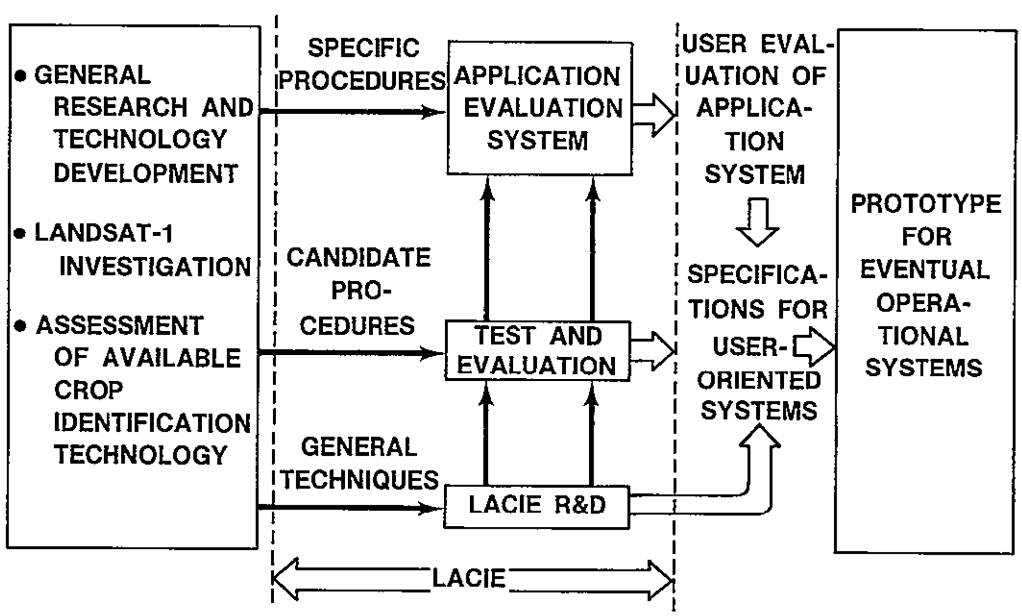
NASA-S-78-16500

THE LACIE APPLICATIONS EVALUATION SYSTEM (AES)

A DESIGN OVERVIEW

NASA-S-78-16501

LACIE PROJECT ELEMENTS



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OUTLINE OF PRESENTATION

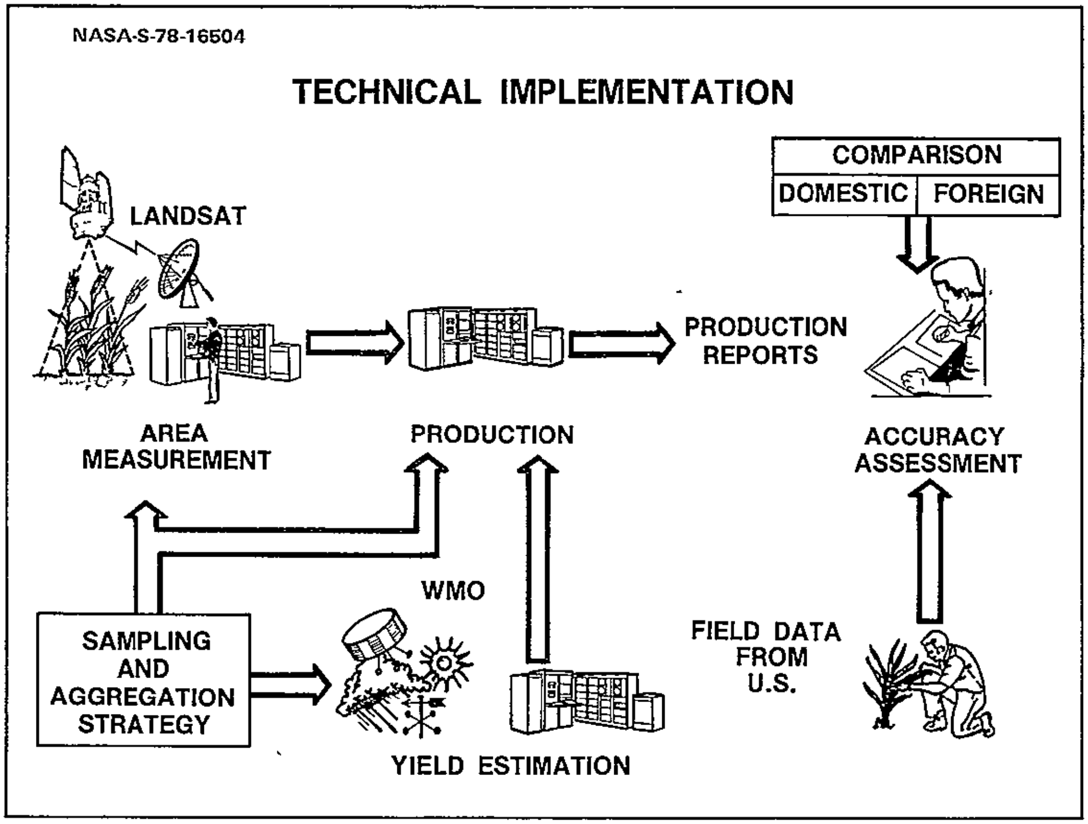
- OBJECTIVES
- TECHNICAL APPROACH
- IMPLEMENTATION AND DATA FLOW
- ORGANIZATION, INTEGRATION, AND CONTROL
- CHRONOLOGY
- DATA LOAD AND OPERATIONS
- MAJOR ACCOMPLISHMENTS

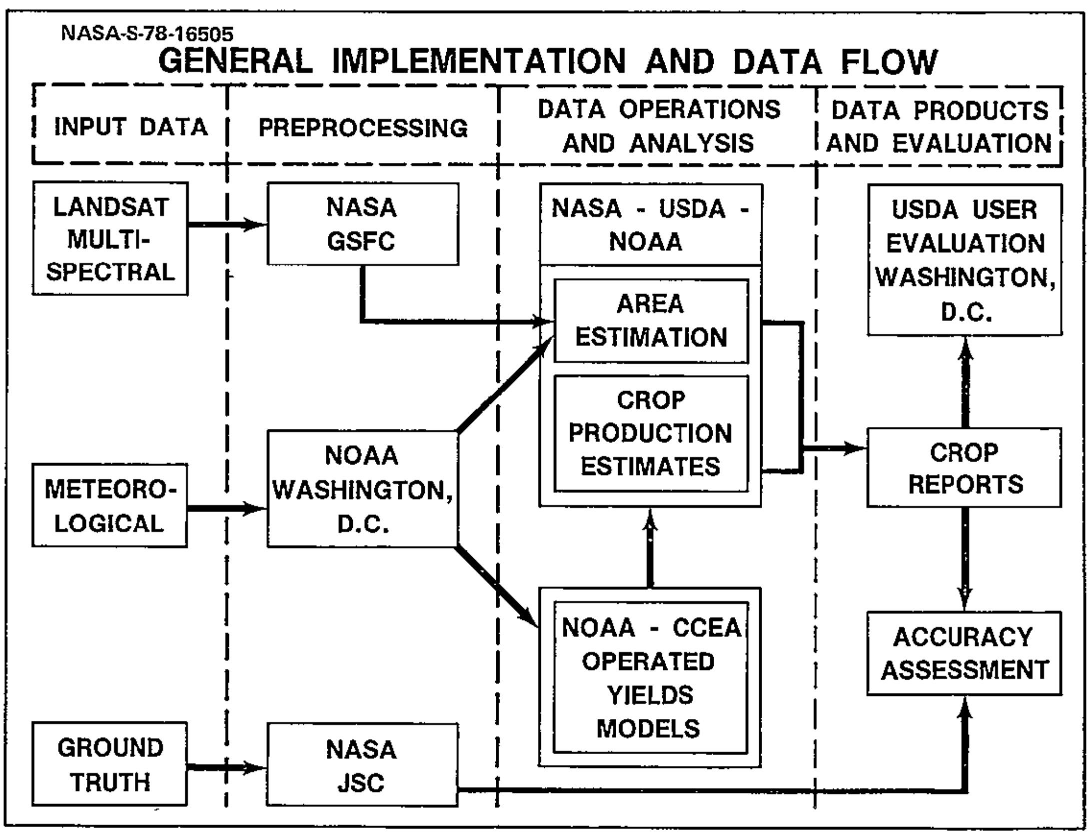
NASA-S-78-16503

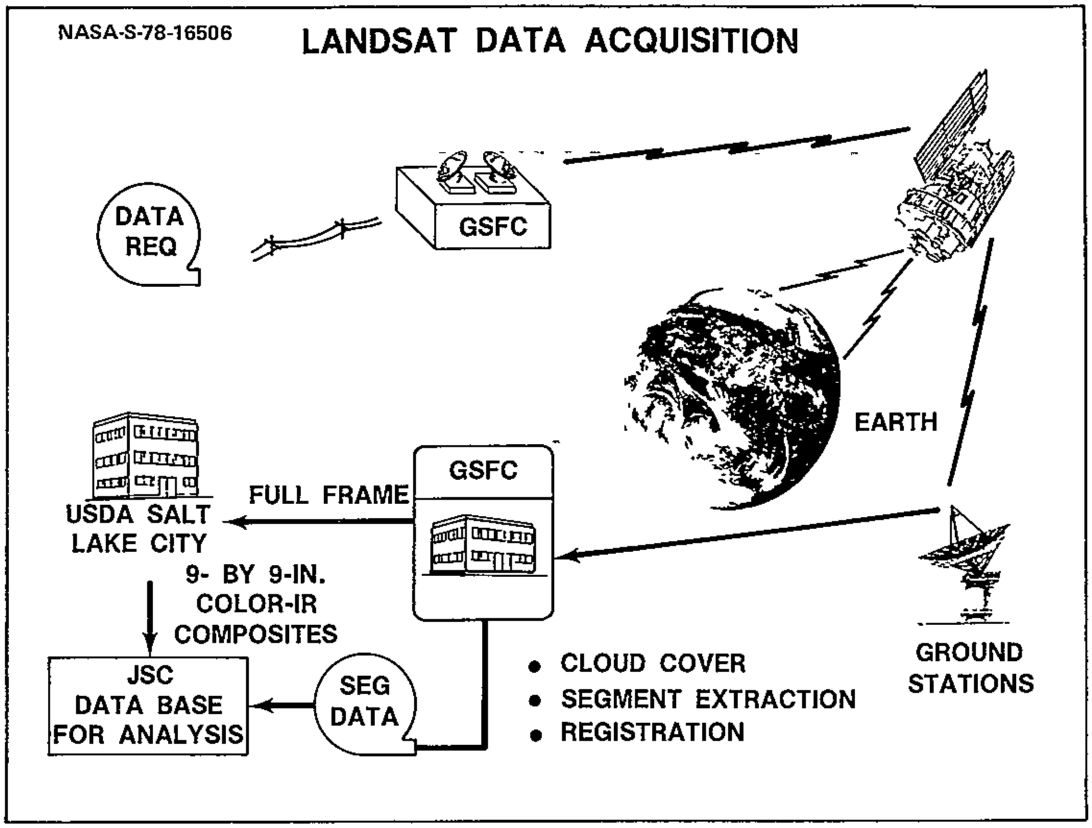
LACIE APPLICATIONS EVALUATION SYSTEM

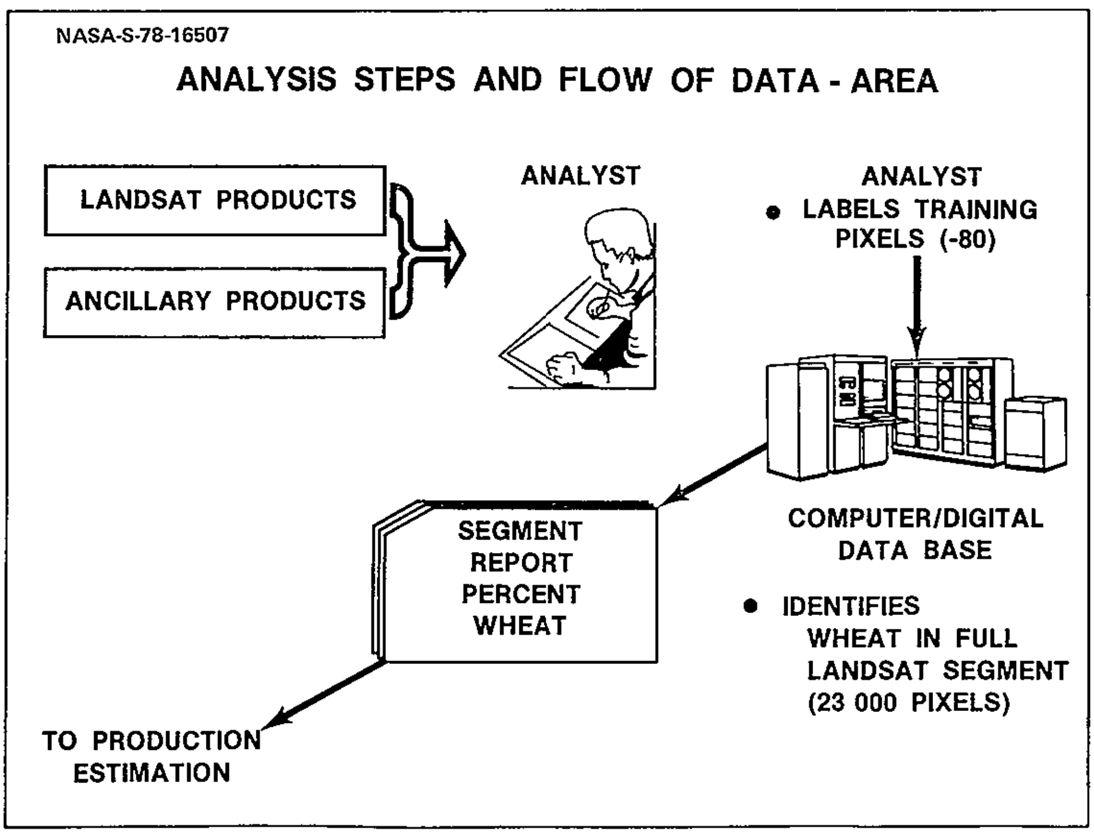
OBJECTIVES

- PROVIDE FROM AN ANALYSIS OF LANDSAT AND METEOROLOGICAL DATA, EXPERIMENTAL ESTIMATES OF WHEAT PRODUCTION, AREA, AND YIELD
  - 90/90 AT HARVEST (PRODUCTION AT COUNTRY LEVEL)
  - EVALUATE ACCURACY ATTAINED EARLIER IN THE SEASON
  - OBJECTIVE
  - TIMELY
  - CONFIDENCE ESTIMATES
- DEVELOP OPERATIONAL AND DATA FLOW CONCEPTS AND PROCEDURES
- IDENTIFY KEY TECHNICAL ISSUES


NASA-S-78-16504
TECHNICAL IMPLEMENTATION
COMPARISON
DOMESTIC
FOREIGN
LANDSAT
PRODUCTION
REPORTS
AREA
MEASUREMENT
PRODUCTION
ACCURACY
ASSESSMENT
WMO
SAMPLING
AND
AGGREGATION
STRATEGY
FIELD DATA
FROM
U.S.
YIELD ESTIMATION

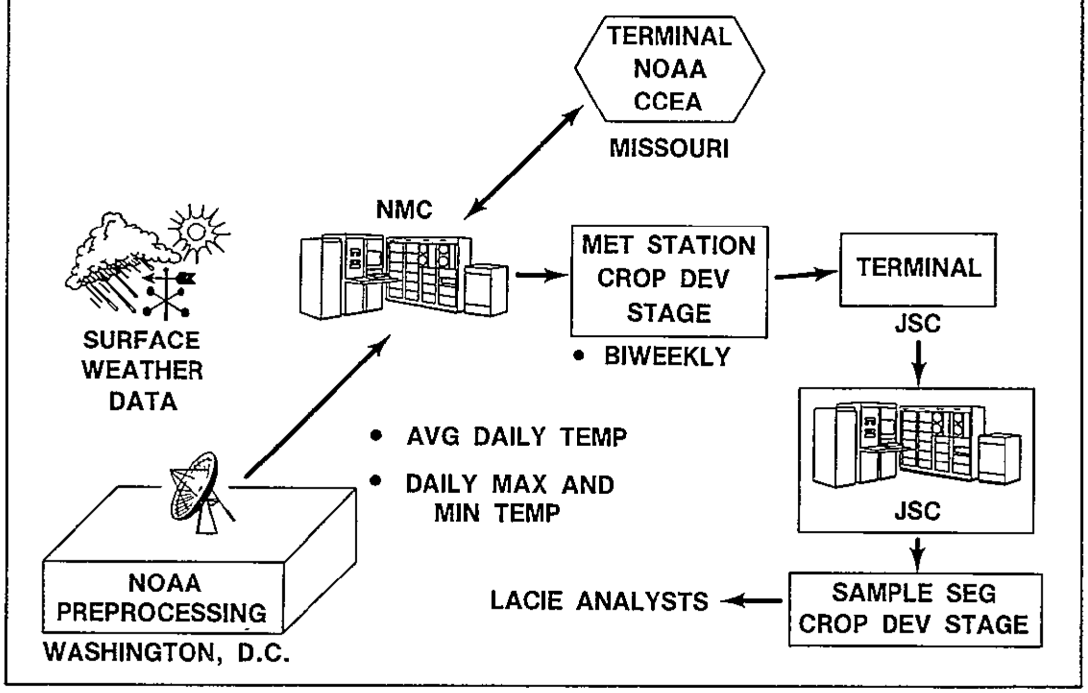

NASA-S-78-16505
GENERAL IMPLEMENTATION AND DATA FLOW
INPUT DATA
PREPROCESSING
DATA OPERATIONS
AND ANALYSIS
DATA PRODUCTS
AND EVALUATION
LANDSAT
MULTI-
SPECTRAL
NASA
GSFC
NASA - USDA -
NOAA
USDA USER
EVALUATION
WASHINGTON,
D.C.
AREA
ESTIMATION
CROP
PRODUCTION
ESTIMATES
NOAA
WASHINGTON,
D.C.
METEORO-
LOGICAL
CROP
REPORTS
NOAA - CCEA
OPERATED
YIELDS
MODELS
ACCURACY
ASSESSMENT
GROUND
TRUTH
NASA
JSC


NASA-S-78-16506
LANDSAT DATA ACQUISITION
DATA REQ
GSFC
EARTH
GSFC
FULL FRAME
USDA SALT LAKE CITY
9- BY 9-IN. COLOR-IR COMPOSITES
JSC DATA BASE FOR ANALYSIS
SEG DATA
• CLOUD COVER
• SEGMENT EXTRACTION
• REGISTRATION
GROUND STATIONS


NASA-S-78-16507
ANALYSIS STEPS AND FLOW OF DATA - AREA
LANDSAT PRODUCTS
ANCILLARY PRODUCTS
ANALYST
ANALYST
• LABELS TRAINING PIXELS (-80)
COMPUTER/DIGITAL DATA BASE
• IDENTIFIES WHEAT IN FULL LANDSAT SEGMENT (23 000 PIXELS)
SEGMENT REPORT PERCENT WHEAT
TO PRODUCTION ESTIMATION

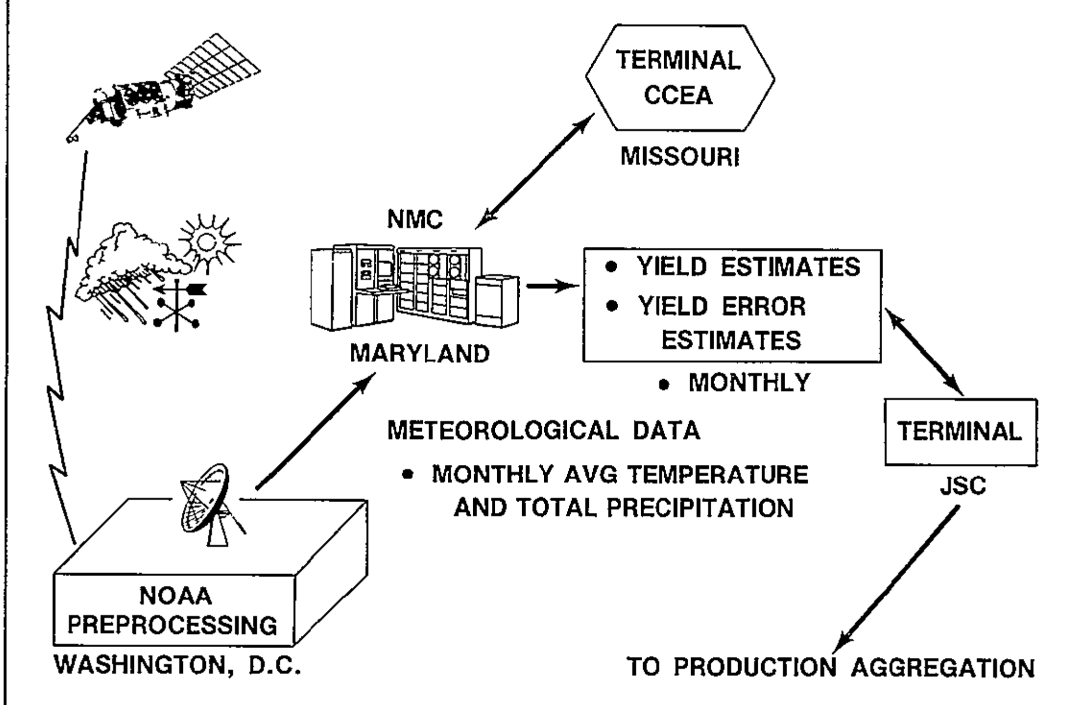
NASA-S-78-16508

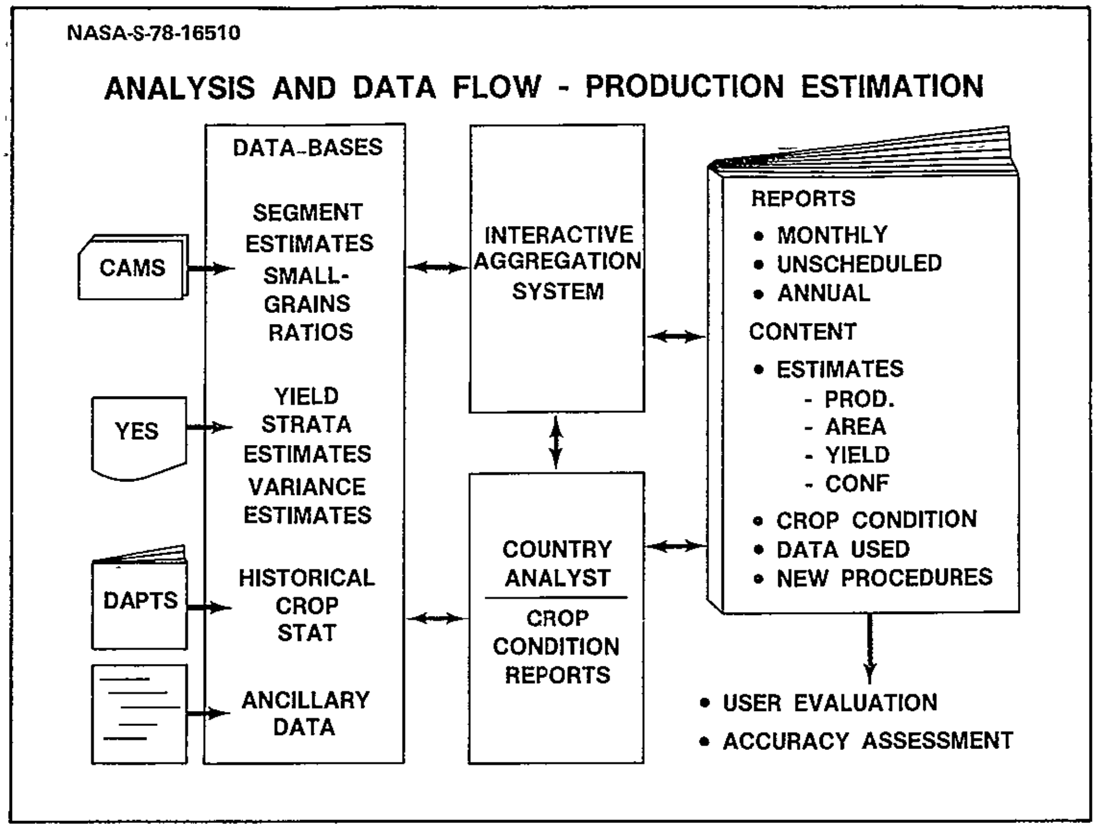
ANALYSIS STEPS AND FLOW OF DATA - CROP CALENDAR MODELS

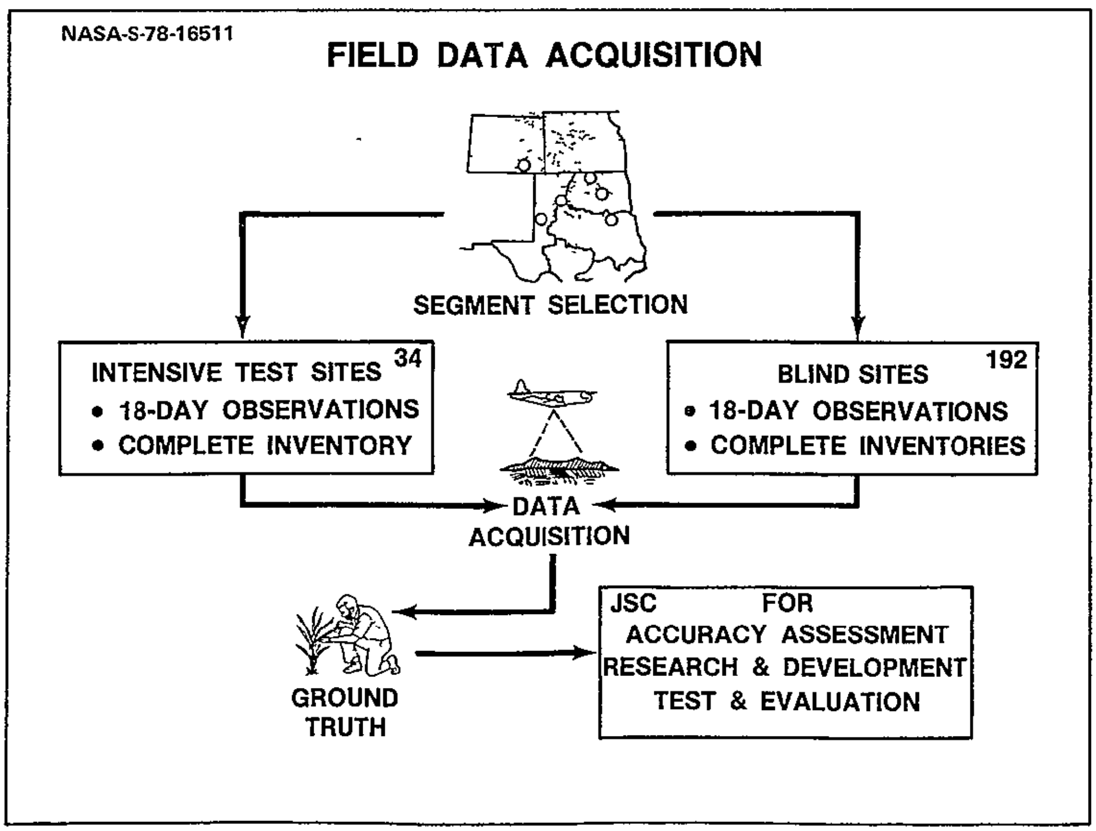


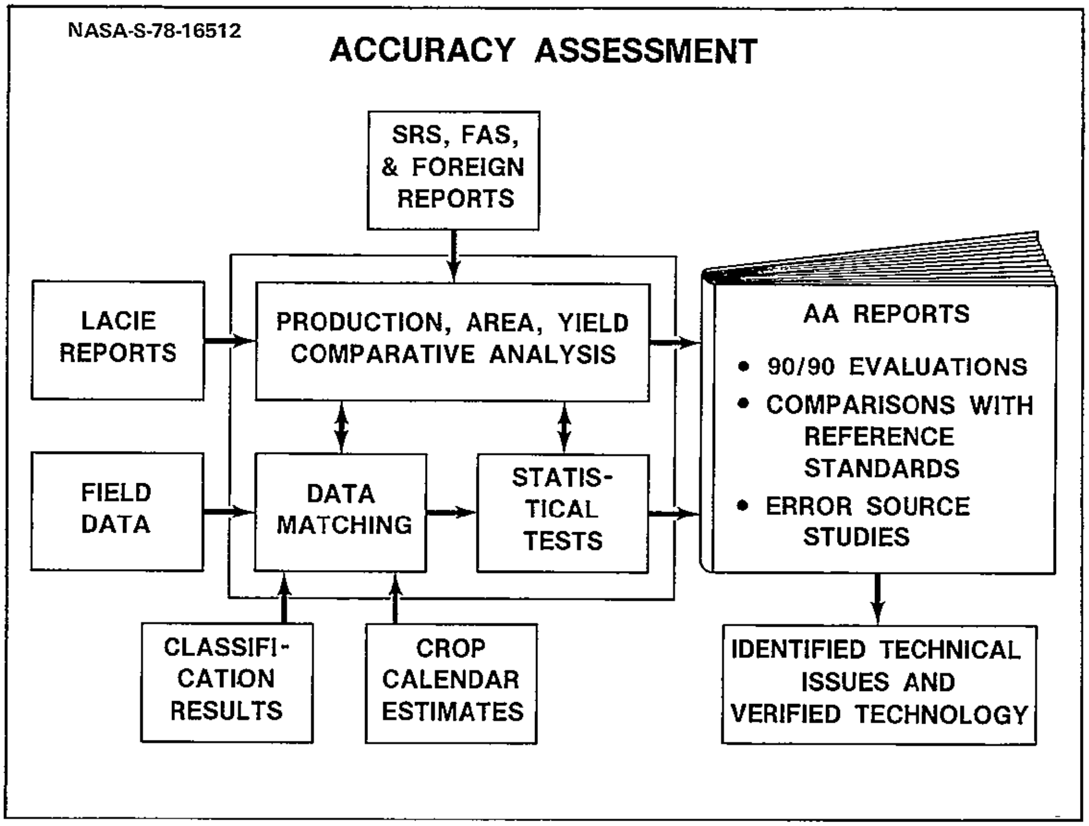
NASA-S-78-16509

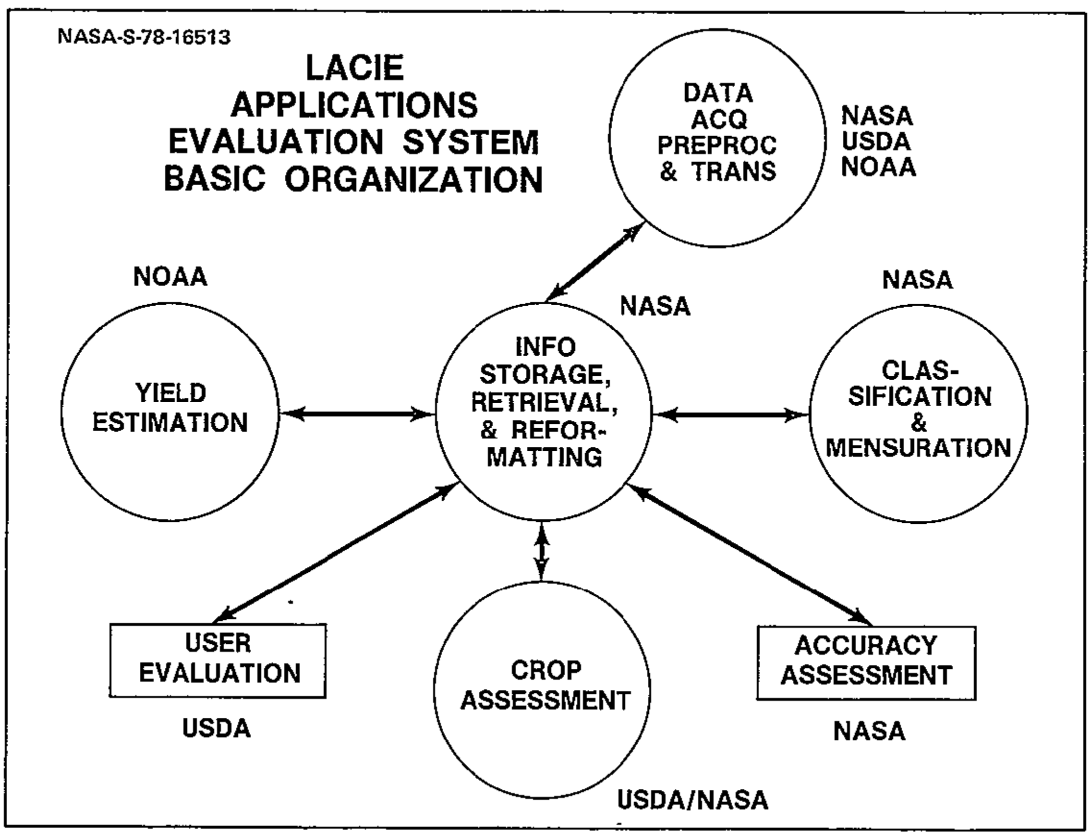
ANALYSIS STEPS AND FLOW OF DATA-YIELD




NASA-S-78-16510
ANALYSIS AND DATA FLOW - PRODUCTION ESTIMATION
DATA-BASES
SEGMENT ESTIMATES
SMALL-GRAINS RATIOS
YIELD STRATA ESTIMATES
VARIANCE ESTIMATES
HISTORICAL CROP STAT
ANCILLARY DATA
CAMS
YES
DAPTS
INTERACTIVE AGGREGATION SYSTEM
COUNTRY ANALYST
CROP CONDITION REPORTS
REPORTS
• MONTHLY
• UNSCHEDULED
• ANNUAL
CONTENT
• ESTIMATES
- PROD.
- AREA
- YIELD
- CONF
• CROP CONDITION
• DATA USED
• NEW PROCEDURES
• USER EVALUATION
• ACCURACY ASSESSMENT


NASA-S-78-16511
FIELD DATA ACQUISITION
SEGMENT SELECTION
INTENSIVE TEST SITES 34
• 18-DAY OBSERVATIONS
• COMPLETE INVENTORY
BLIND SITES 192
• 18-DAY OBSERVATIONS
• COMPLETE INVENTORIES
DATA ACQUISITION
GROUND TRUTH
JSC FOR
ACCURACY ASSESSMENT
RESEARCH & DEVELOPMENT
TEST & EVALUATION


NASA-S-78-16512
ACCURACY ASSESSMENT
SRS, FAS, & FOREIGN REPORTS
LACIE REPORTS
PRODUCTION, AREA, YIELD COMPARATIVE ANALYSIS
FIELD DATA
DATA MATCHING
STATISTICAL TESTS
CLASSIFICATION RESULTS
CROP CALENDAR ESTIMATES
AA REPORTS
• 90/90 EVALUATIONS
• COMPARISONS WITH REFERENCE STANDARDS
• ERROR SOURCE STUDIES
IDENTIFIED TECHNICAL ISSUES AND VERIFIED TECHNOLOGY


NASA-S-78-16513
LACIE APPLICATIONS EVALUATION SYSTEM BASIC ORGANIZATION
DATA ACQ PREPROC & TRANS
NASA
USDA
NOAA
NOAA
YIELD ESTIMATION
NASA
INFO STORAGE, RETRIEVAL, & REFORMATTING
NASA
CLASSIFICATION & MENSURATION
USER EVALUATION
USDA
CROP ASSESSMENT
USDA/NASA
ACCURACY ASSESSMENT
NASA

NASA-S-78-16514

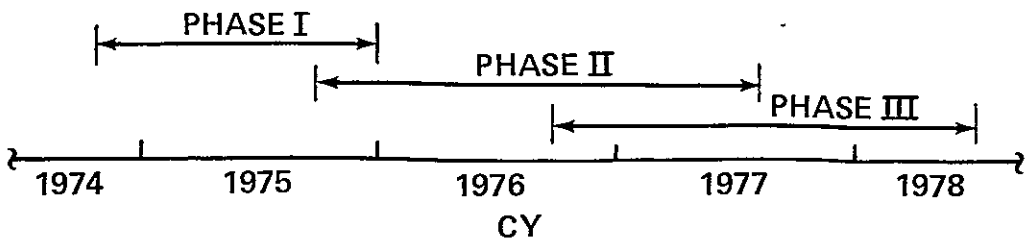
INTEGRATION AND CONTROL

- SOURCES OF DESIGN INPUTS
  - USER REQUIREMENTS
  - R&D AND T&E
  - PEER REVIEWS
- PROCEDURE CHANGES
  - SYSTEMS ENGINEERING
  - CONFIGURATION CONTROL BOARDS
  - VERIFICATION TESTS
  - QUALITY ASSURANCE
- OPERATIONS
  - OPERATIONS PLANNING
  - READINESS REVIEWS
  - PAPER SIMULATIONS
  - QUALITY ASSURANCE
  - OPERATIONS CONTROL CENTER

NASA-S-78-16515

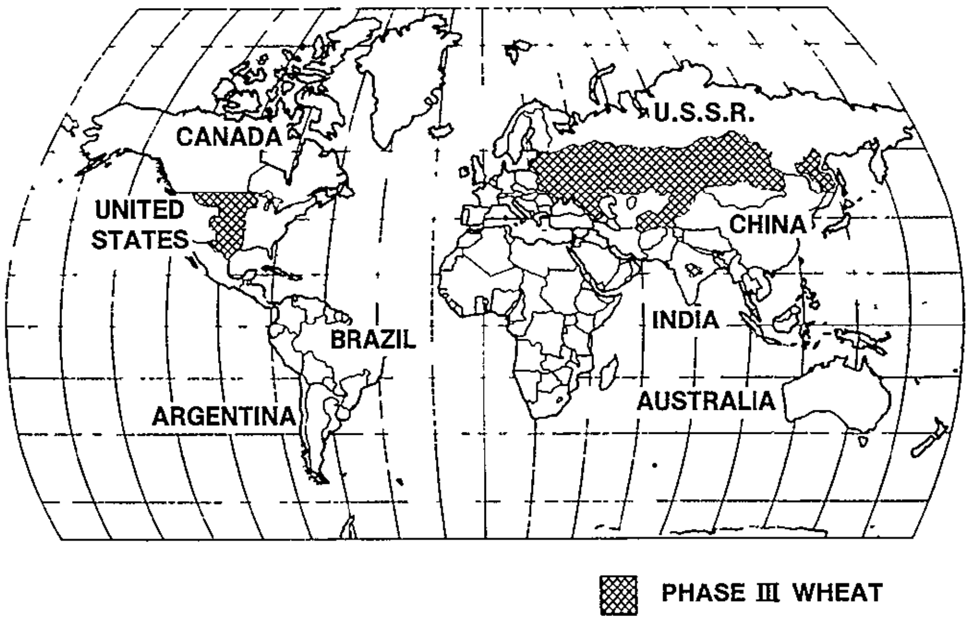
DESIGN CHRONOLOGY

- PHASE I
  - BRING INITIAL COMPONENTS ON-LINE
  - IDENTIFY PRESSING ISSUES
  - MAKE NEAR-TERM IMPROVEMENTS
- PHASE II
  - EXPAND TO ADDITIONAL REGIONS
  - AREA, YIELD, PRODUCTION ESTIMATES
  - EVALUATE NEAR-TERM IMPROVEMENTS
- PHASE III
  - FULL-COUNTRY U.S.S.R. AND USGP
  - SPRING WHEAT
  - SECOND-GENERATION TECHNOLOGY



NASA-S-78-16518

PHASE III STUDY AREAS



NASA-S-78-16519

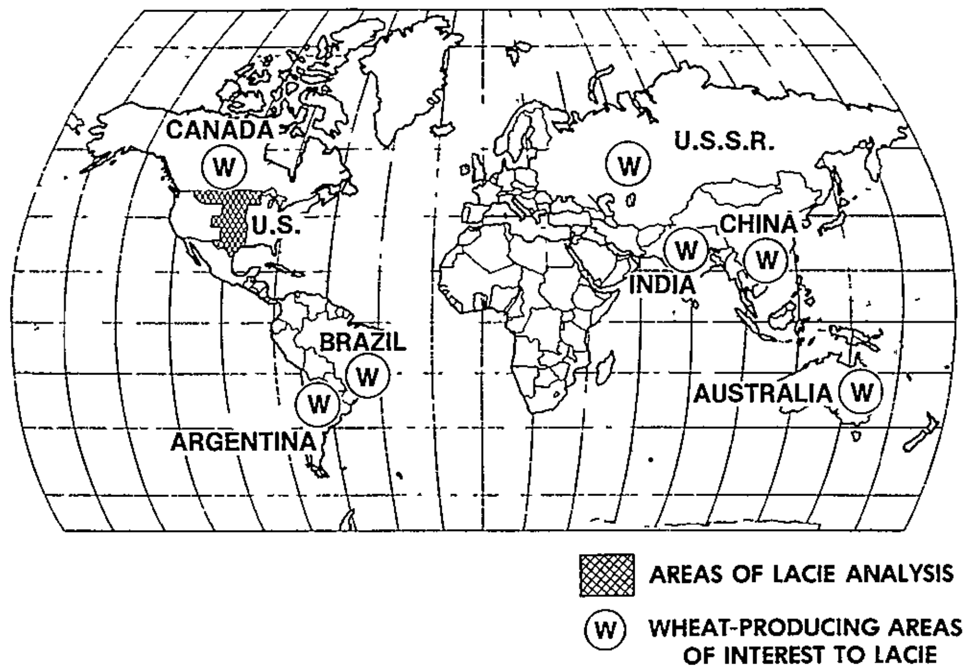
TYPICAL LACIE LANDSAT DATA LOAD - MID-PHASE III

SUMMARY

- 3000 DIGITAL SEGMENT ACQUISITION
  - 300/DAY INTO GSFC
  - 110/DAY PREPROCESSED THROUGH GSFC
  - 330 IMAGES/DAY PROCESSED PHOTOGRAPHICALLY
- 18 000 DIGITAL ACQUISITIONS IN DATA BASE
  - 3000 SEGMENT DATA PACKAGES
  - 700 SEGMENTS IN WORK (AVERAGE)
- 1000 NEW DATA PRODUCTS GENERATED PER DAY

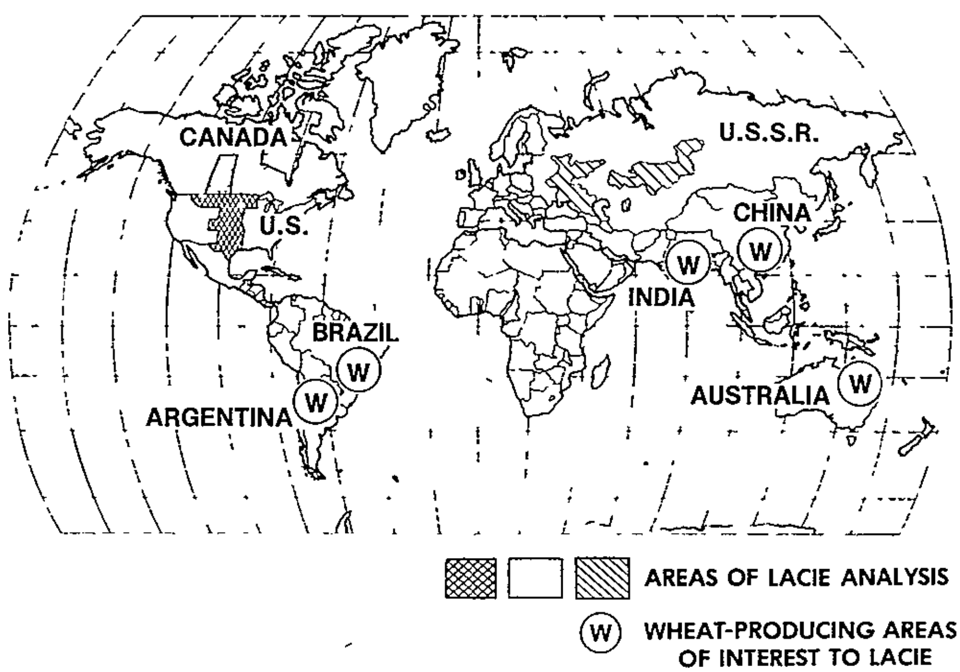
NASA-S-78-16516

PHASE I STUDY AREAS

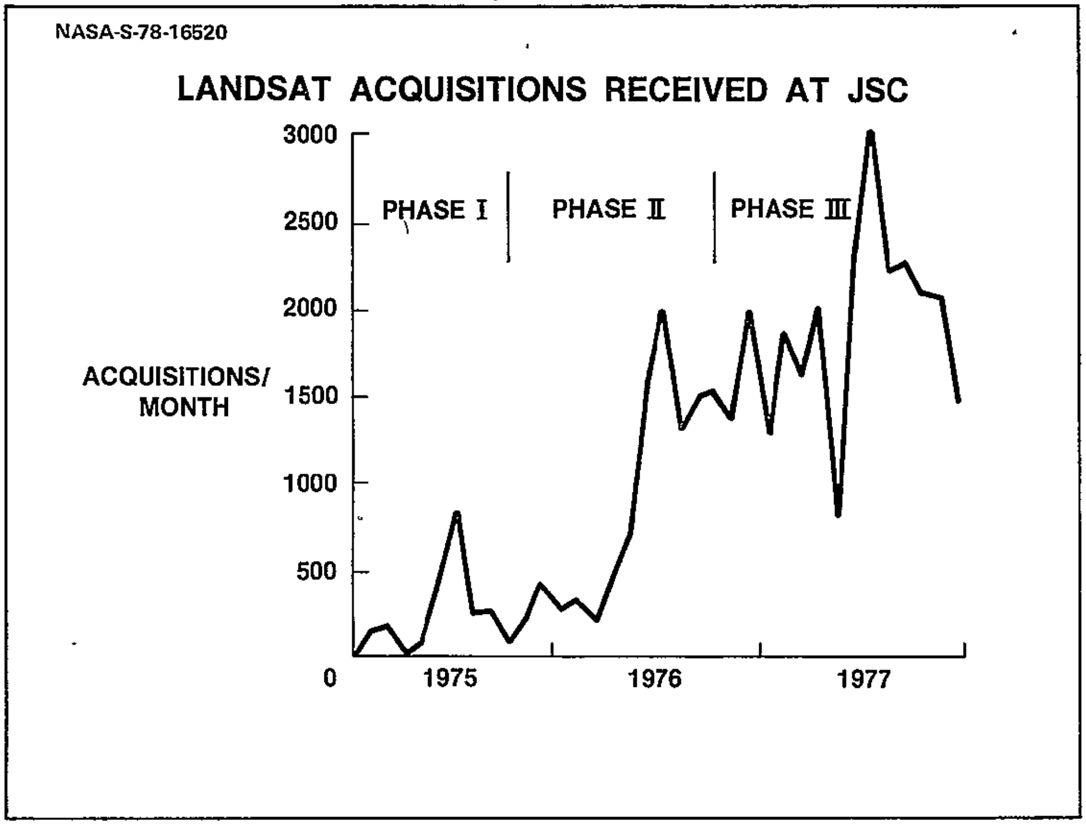


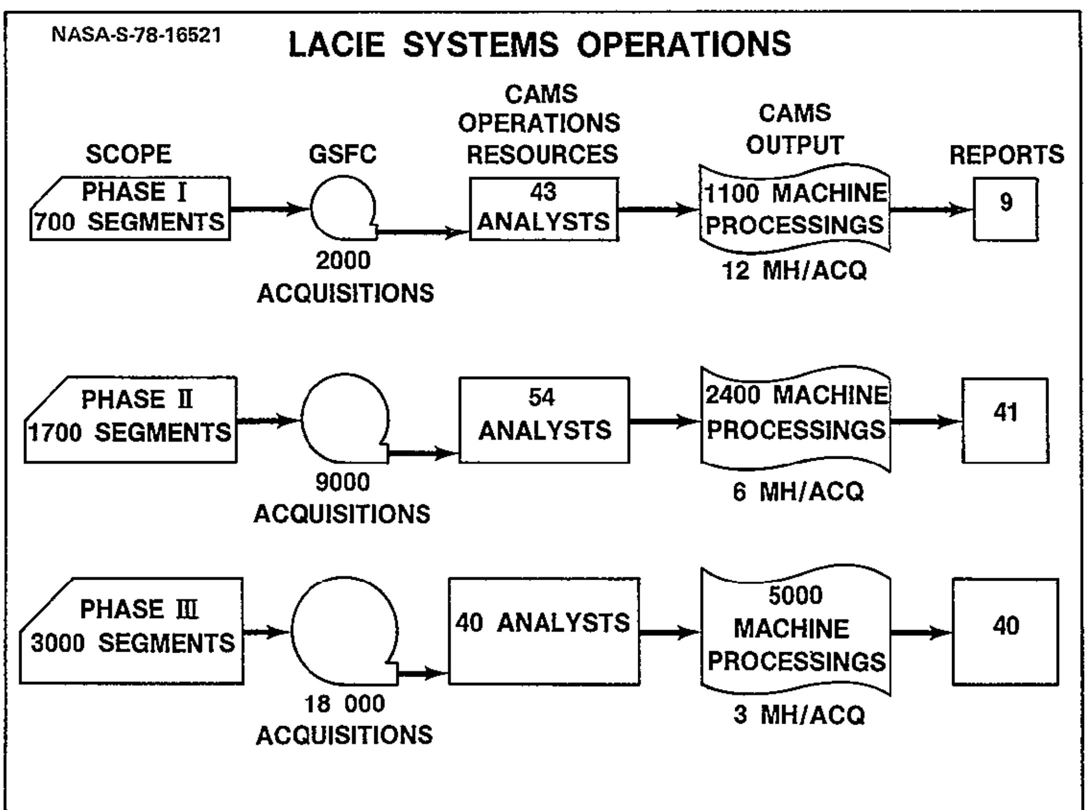
NASA-S-78-16517

PHASE II STUDY AREAS



C-2


NASA-S-78-16520
LANDSAT ACQUISITIONS RECEIVED AT JSC
ACQUISITIONS/ MONTH
3000
2500
2000
1500
1000
500
0
PHASE I
PHASE II
PHASE III
1975
1976
1977


NASA-S-78-16521
LACIE SYSTEMS OPERATIONS
SCOPE
GSFC
CAMS OPERATIONS RESOURCES
CAMS OUTPUT
REPORTS
PHASE I 700 SEGMENTS
2000 ACQUISITIONS
43 ANALYSTS
1100 MACHINE PROCESSINGS
12 MH/ACQ
9
PHASE II 1700 SEGMENTS
9000 ACQUISITIONS
54 ANALYSTS
2400 MACHINE PROCESSINGS
6 MH/ACQ
41
PHASE III 3000 SEGMENTS
18 000 ACQUISITIONS
40 ANALYSTS
5000 MACHINE PROCESSINGS
3 MH/ACQ
40

NASA-S-78-16522

MAJOR ACCOMPLISHMENTS

- FIRST REMOTE-SENSING/DATA-PROCESSING CROP INVENTORY SYSTEM
- FIRST-TIME TEST OF TECHNOLOGY OVER REPRESENTATIVE RANGE OF AGRONOMIC/CLIMATOLOGIC CONDITIONS
- FIRST-TIME EVALUATION OF TECHNOLOGY UNDER REALISTIC FOREIGN SITUATIONS
- DEMONSTRATED TIMELY AND ACCURATE PRODUCTION ESTIMATES FOR MAJOR WHEAT-GROWING REGIONS
- FOCUSED KEY TECHNICAL ISSUES FOR REMOTE-SENSING CROP INVENTORY IN WHEAT (APPLICABLE TO OTHER CROPS)
- OBTAINED EXPERIENCE TO SUPPORT DESIGN OF FUTURE OPERATIONAL SYSTEMS
- ESTABLISHED A BASE OF INTERAGENCY, MULTIDISCIPLINARY, EXPERIENCED PERSONNEL FOR ADDITIONAL REMOTE-SENSING AGRICULTURAL APPLICATIONS RESEARCH AND DEVELOPMENT

N79-14466

SYSTEM IMPLEMENTATION AND OPERATIONS SESSION

ACQUISITION AND PREPROCESSING OF LANDSAT DATA

L. Brown, GSFC

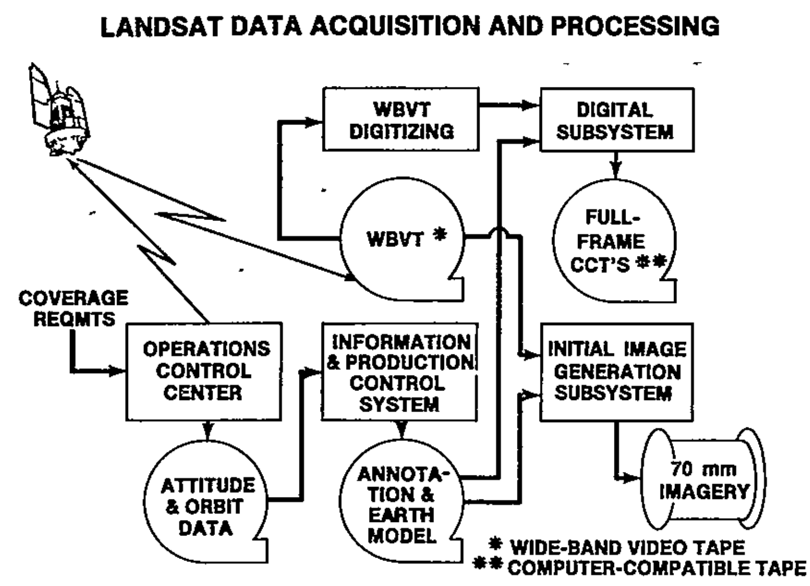
NASA-S-78-16598

ACQUISITION AND PREPROCESSING OF LANDSAT DATA

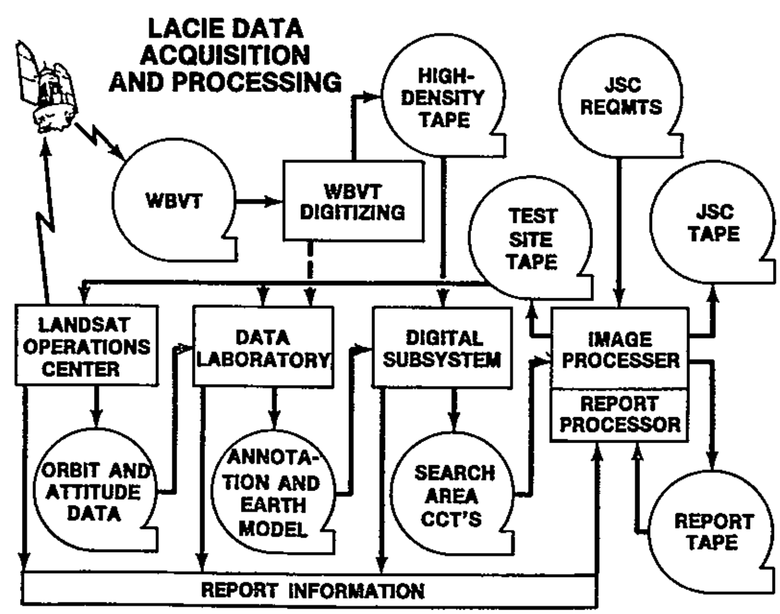
NASA-S-78-16599

DAPTS/LACIE AT GSFC

NASA-S-78-16600



NASA-S-78-16601



NASA-S-78-16602

INCREASED THROUGHPUT ENHANCEMENTS

- OPERATIONS CONTROL CENTER
  - VIDEO TAPE DIRECTORY IDENTIFYING ONLY LACIE INTERVALS
- DATA SERVICES LABORATORY
  - ELIMINATION OF IN-TRACK OVERLAP AREAS
- DIGITAL SUBSYSTEM
  - AUTOMATIC CLOUD SCREENING
  - MULTIPLE PASSES OF INPUT DATA TO PERMIT OVERLAPPING OF AREAS
- GENERAL-PURPOSE IMAGE PROCESSOR
  - IMPROVED CORRELATION AND STATISTICAL EVALUATION
  - ELIMINATION OF VISUAL SCREENING
  - CLOUD EDGE AND SHADOW DETECTION

NASA-S-78-16603

OPERATIONAL EFFICIENCY ENHANCEMENTS

- GENERATION OF USDA FILM WORK ORDERS
- REMOVAL OF VISUAL SCREENING
- QUALITY ASSURANCE FILM LIBRARY AND PROCESSING PROCEDURES ESTABLISHED
- ADDITIONAL DISK RESOURCES IN DATA SERVICES LABORATORY
- TRANSMISSION TO JSC VIA LAND LINES
- STREAMLINING INTERFACE OF ATTITUDE AND ORBIT DATA

NASA-S-78-16604

GSFC PERFORMANCE SUMMARY

	JAN-SEPT '75 PHASE I	OCT '75-SEPT '76 PHASE II	OCT '76-SEPT '77 PHASE III
ACQUISITIONS	7380	31 296	63 568
SEARCH AREAS EXTRACTED	3979	15 676	30 438
SAMPLE SEGMENTS TRANSMITTED TO JSC	2602	10 645	22 718
CLOUD/SNOW REJECTIONS	39%	52%	49%
CORRELATION REJECTIONS	14%	9%	4%
MISCELLANEOUS REJECTIONS	12%	5%	11%

N79-14467

SYSTEM IMPLEMENTATION AND OPERATIONS SESSION

CLASSIFICATION AND MENSURATION – AN APPROACH TO LANDSAT DATA ANALYSIS FOR CROP IDENTIFICATION

R. Bizzell, JSC

NASA-S-78-16921

CLASSIFICATION AND MENSURATION - AN APPROACH TO LANDSAT DATA ANALYSIS FOR CROP IDENTIFICATION

NASA-S-78-16922

CLASSIFICATION AND MENSURATION SUBSYSTEM

- AREA ESTIMATION
- CLASSICAL CLASSIFICATION
- LACIE RULES
  - NO GROUND TRUTH
  - INTERPRETATION OF LANDSAT IMAGERY
  - OPERATIONAL ENVIRONMENT

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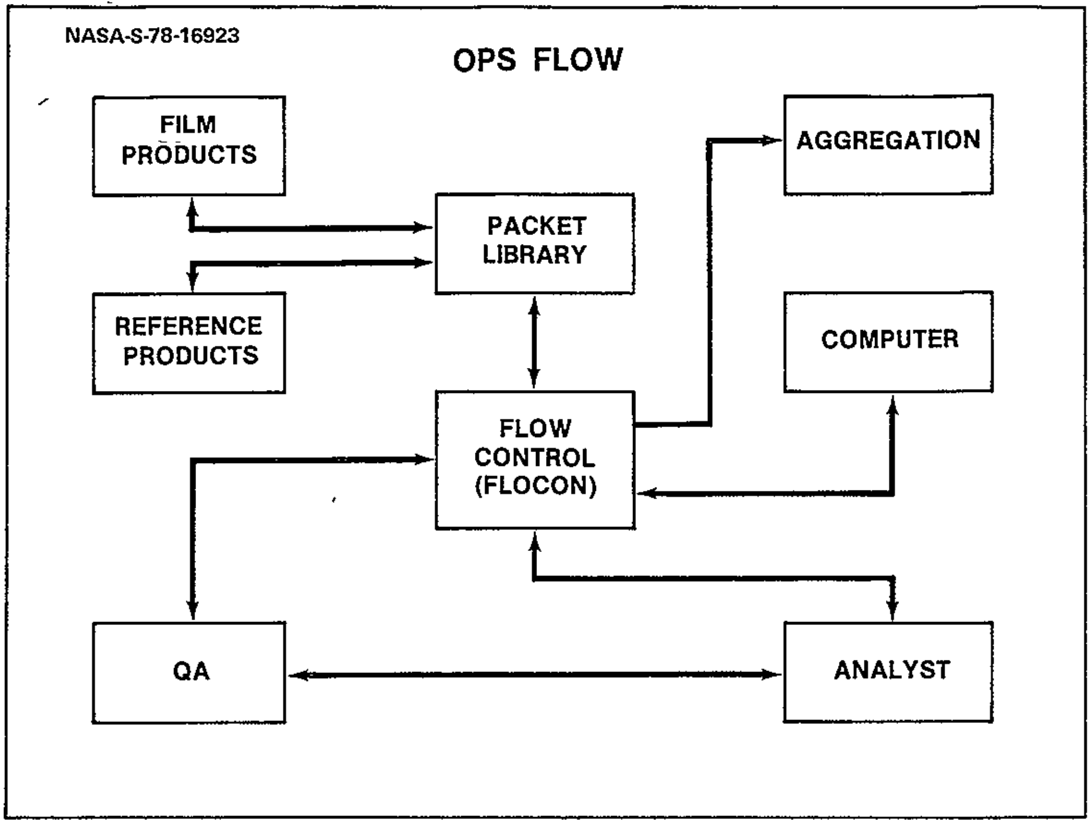
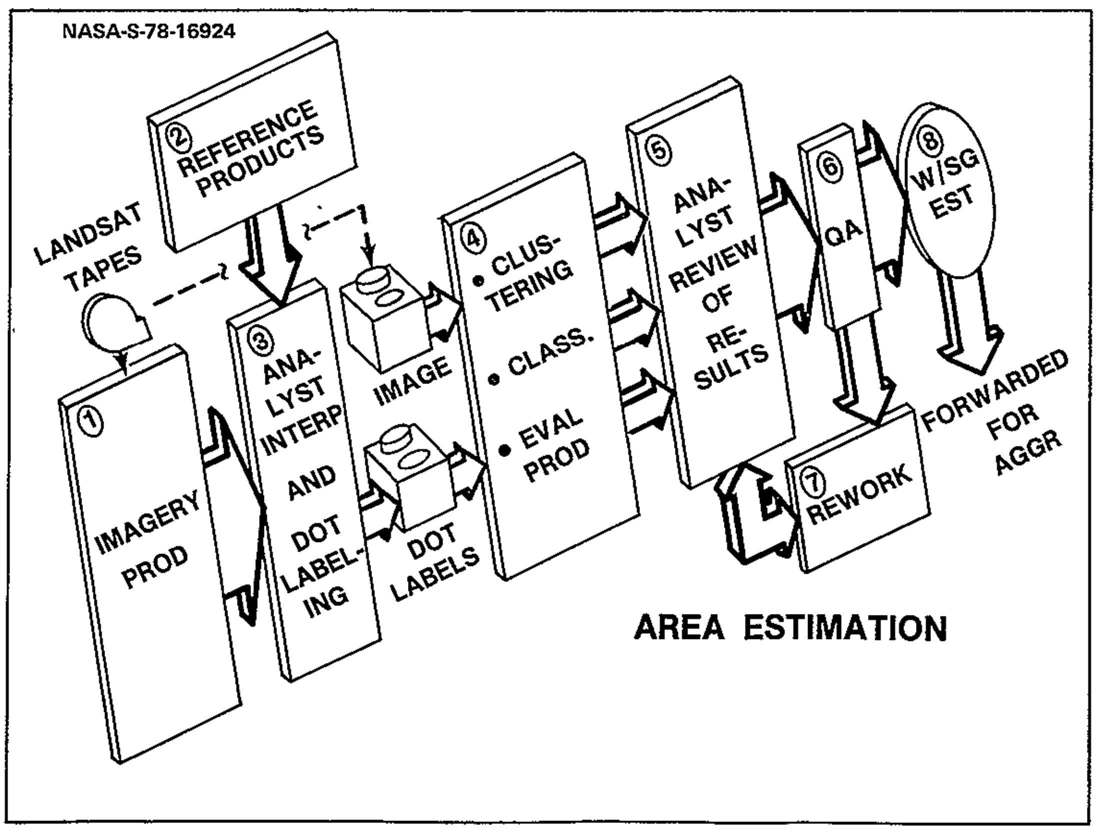
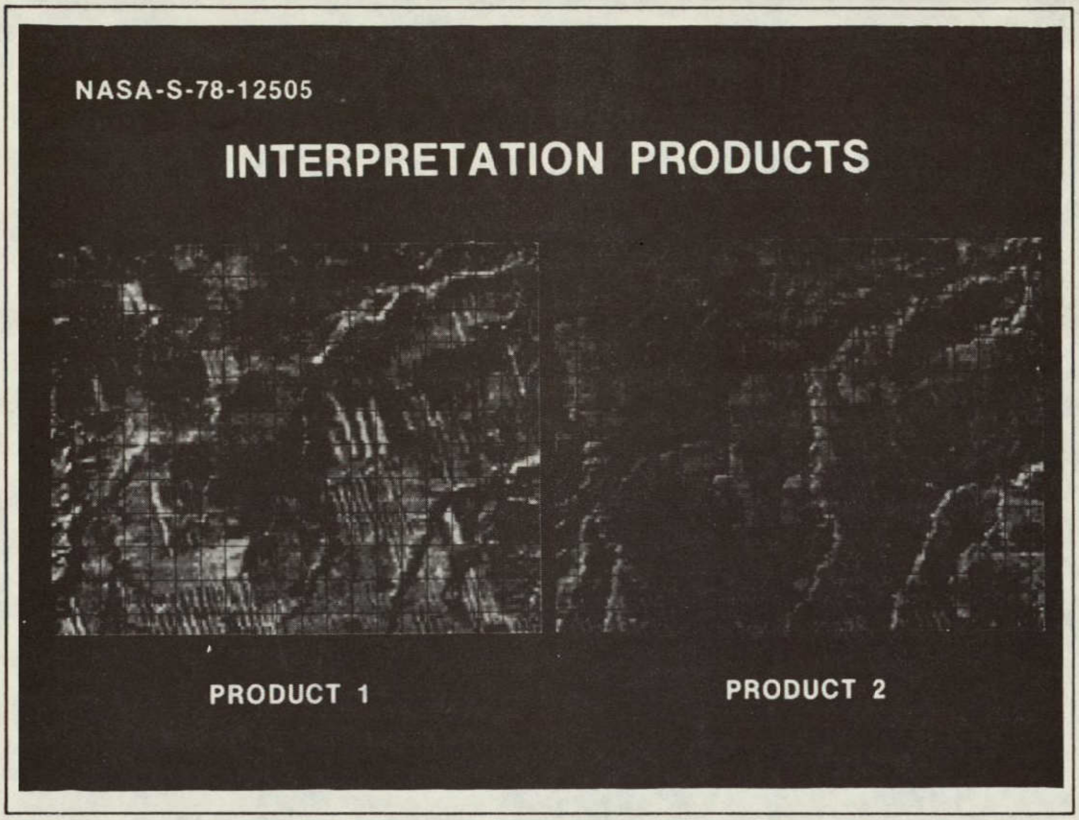
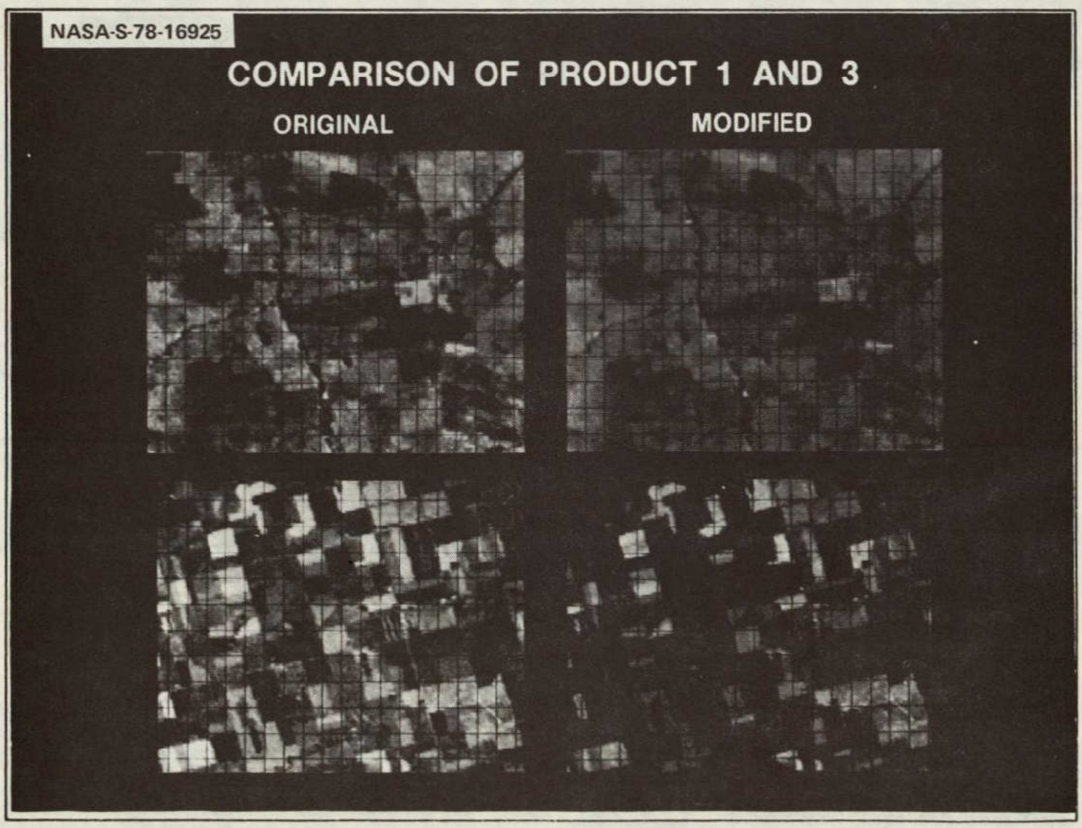

NASA-S-78-16923
OPS FLOW
FILM PRODUCTS
REFERENCE PRODUCTS
PACKET LIBRARY
AGGREGATION
COMPUTER
FLOW CONTROL (FLOCON)
QA
ANALYST


NASA-S-78-16924
② REFERENCE PRODUCTS
LANDSAT TAPES
① IMAGERY PROD
③ ANA-LYST INTERP AND DOT LABEL-ING
IMAGE
DOT LABELS
④ • CLUS-TERING • CLASS. • EVAL PROD
⑤ ANA-LYST REVIEW OF RE-SULTS
⑥ QA
⑦ REWORK
⑧ W/SG EST
FORWARDED FOR AGGR
AREA ESTIMATION


NASA-S-78-12505
INTERPRETATION PRODUCTS
PRODUCT 1
PRODUCT 2


NASA-S-78-16925
COMPARISON OF PRODUCT 1 AND 3
ORIGINAL
MODIFIED

NASA-S-78-16926

REFERENCE PRODUCTS

- DETAILED ANALYSIS PROCEDURES
- CROP CALENDAR
- METEOROLOGICAL SUMMARIES
- AGRICULTURAL STATISTICS
- FULL-FRAME IMAGERY
- CROPPING PRACTICES
- MAPS
- ANALYST INTERPRETATION KEYS

NASA-S-78-12514

U.S. MIXED WHEAT

FULL LANDSAT FRAME JULY 3, 1977

LACIE SEGMENT 1528, BLAINE, MONTANA

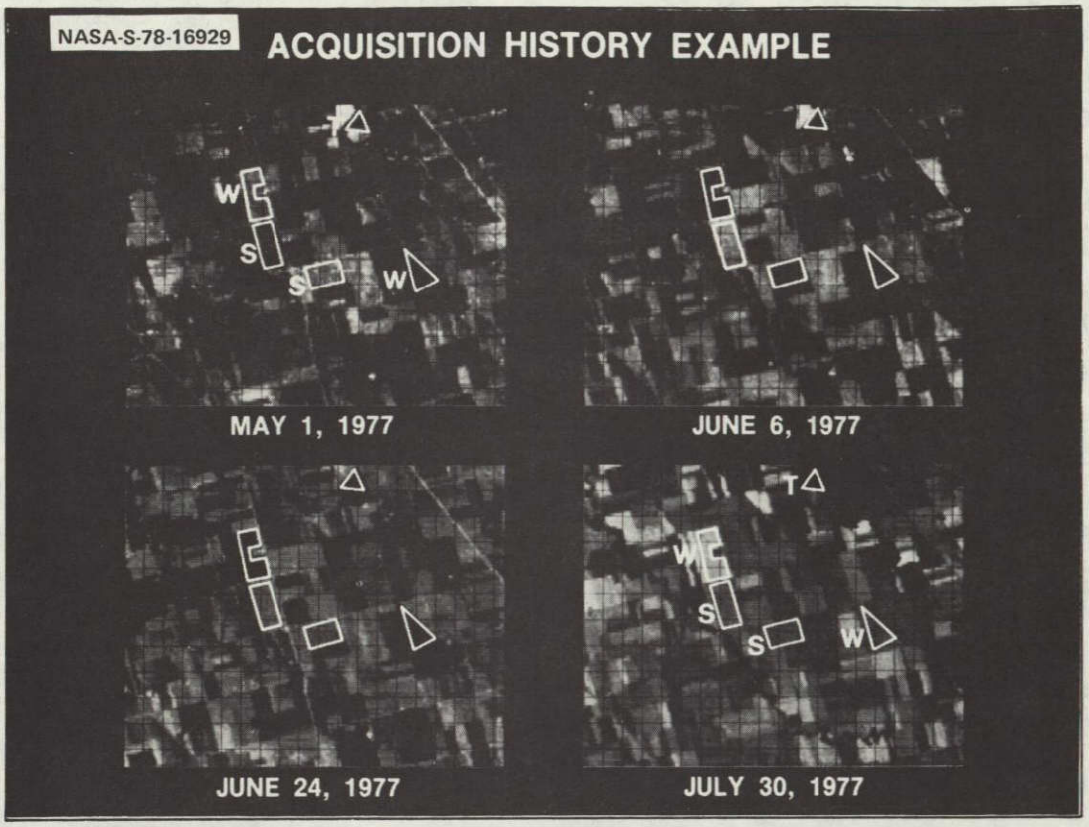
NASA-S-78-16927

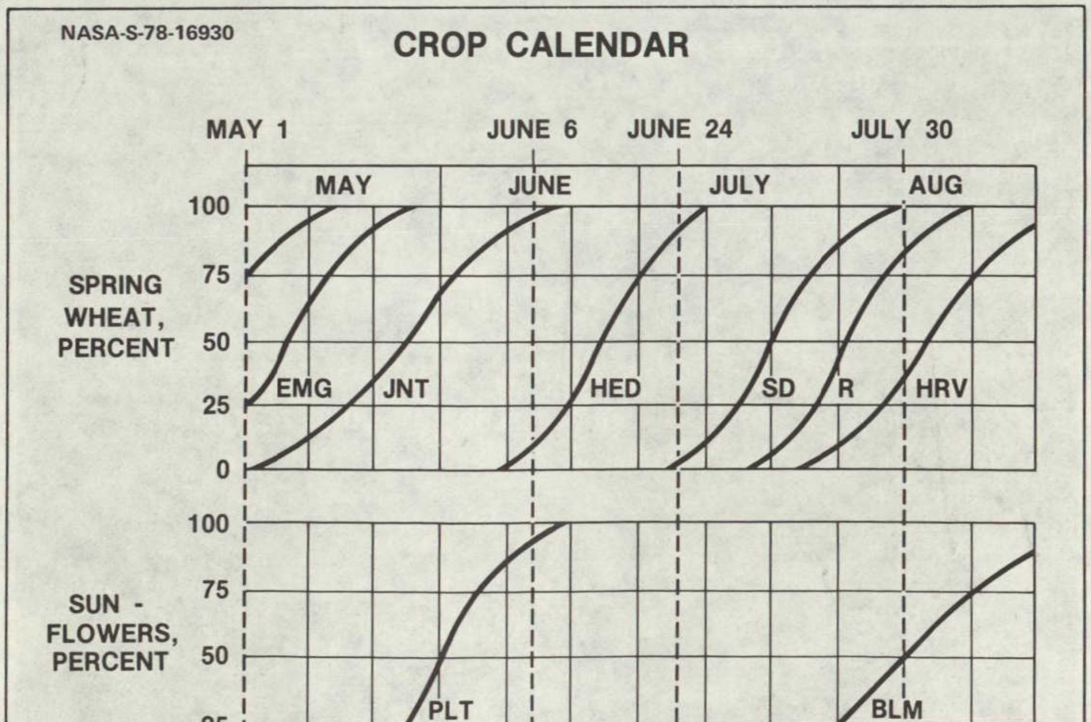
INTERPRETATION VARIABLES

- REGION
- FIELD SIZE
- ACQUISITION HISTORY
- SIGNATURES
- EPISODIC EVENTS
- CONFUSION CROPS
- REGISTRATION

NASA-S-78-16928

COMPARISON OF FIELD SIZES


NASA-S-78-16929
ACQUISITION HISTORY EXAMPLE
T
W
S
S
W
MAY 1, 1977
JUNE 6, 1977
JUNE 24, 1977
T
W
S
S
W
JULY 30, 1977


NASA-S-78-16930
CROP CALENDAR
MAY 1
JUNE 6
JUNE 24
JULY 30
MAY
JUNE
JULY
AUG
SPRING WHEAT, PERCENT
100
75
50
25
0
EMG
JNT
HED
SD
R
HRV
SUN - FLOWERS, PERCENT
100
75
50
25
0
PLT
BLM

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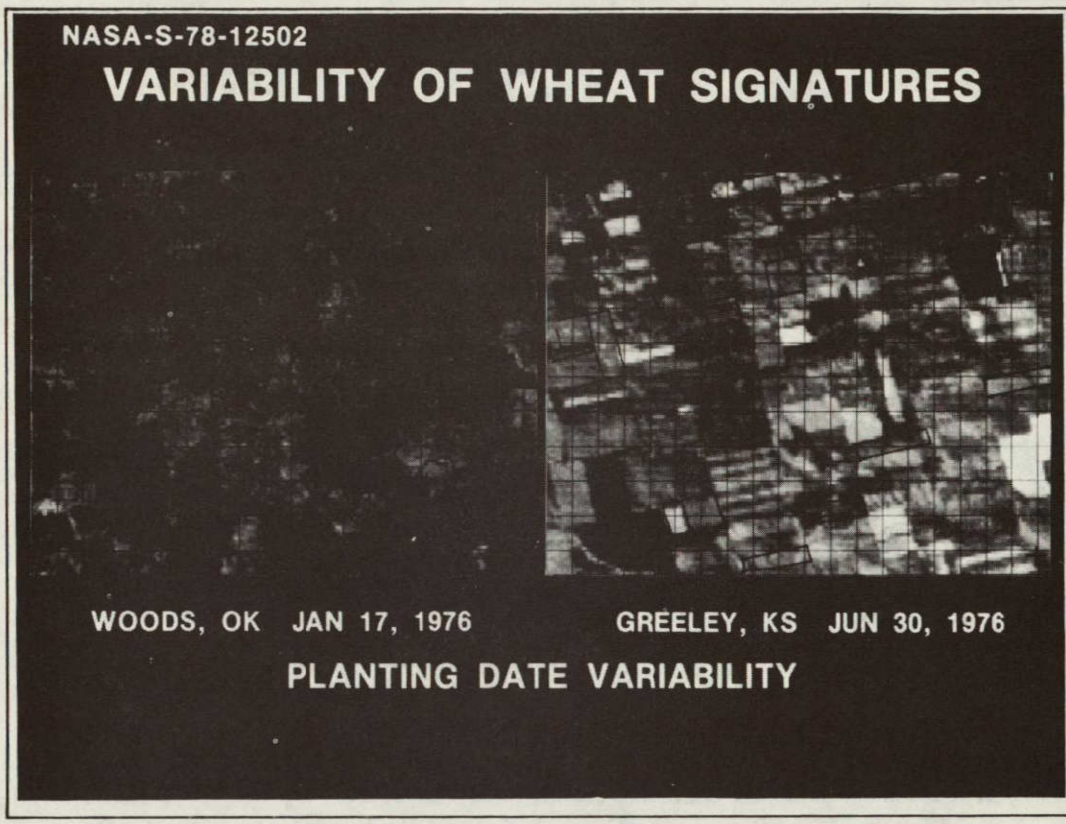
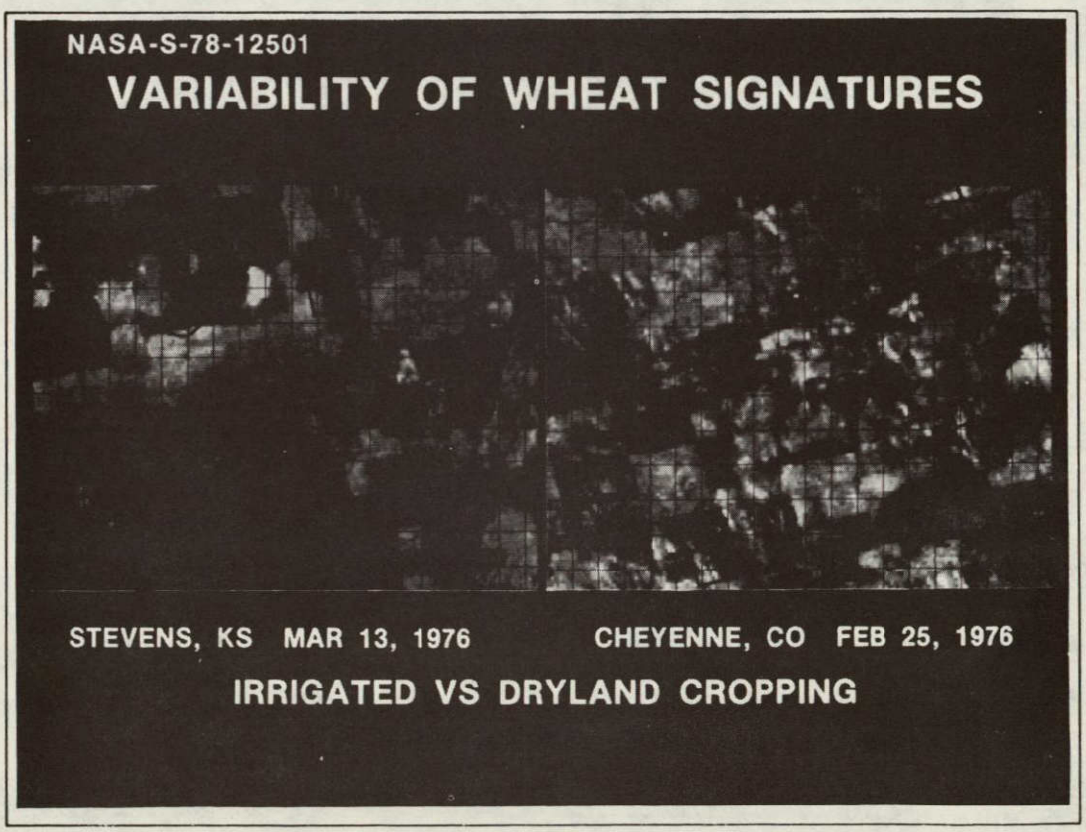
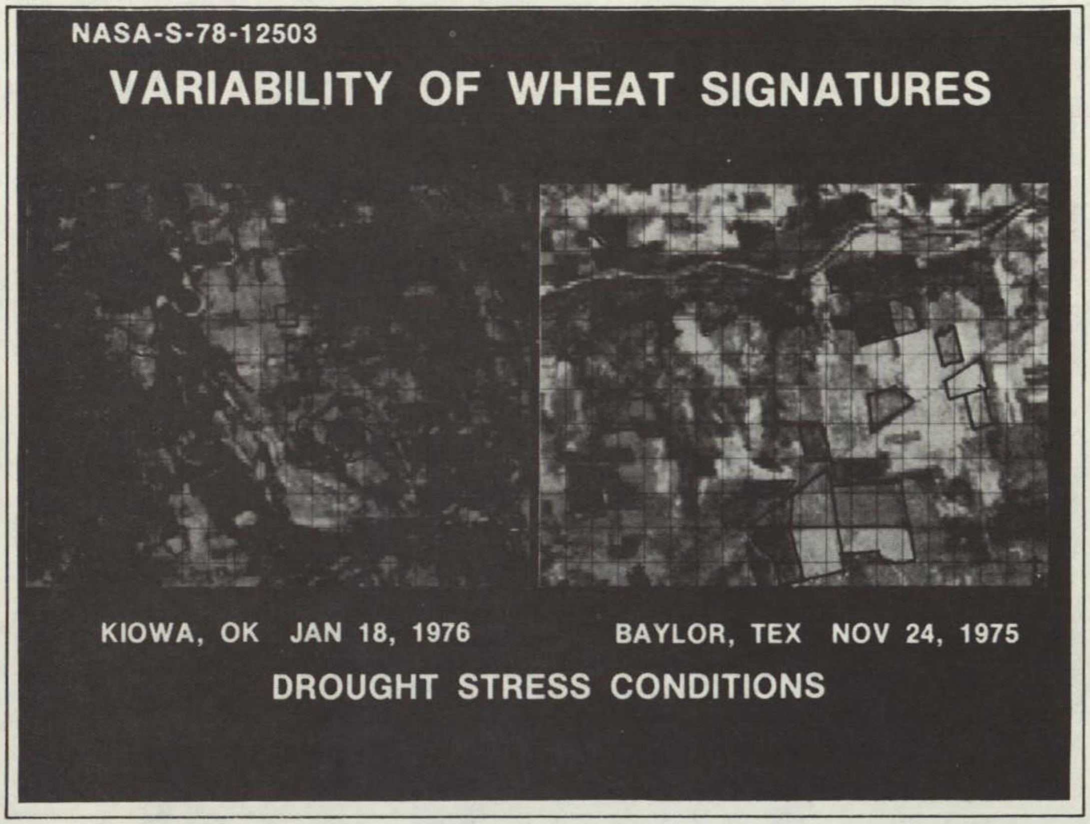
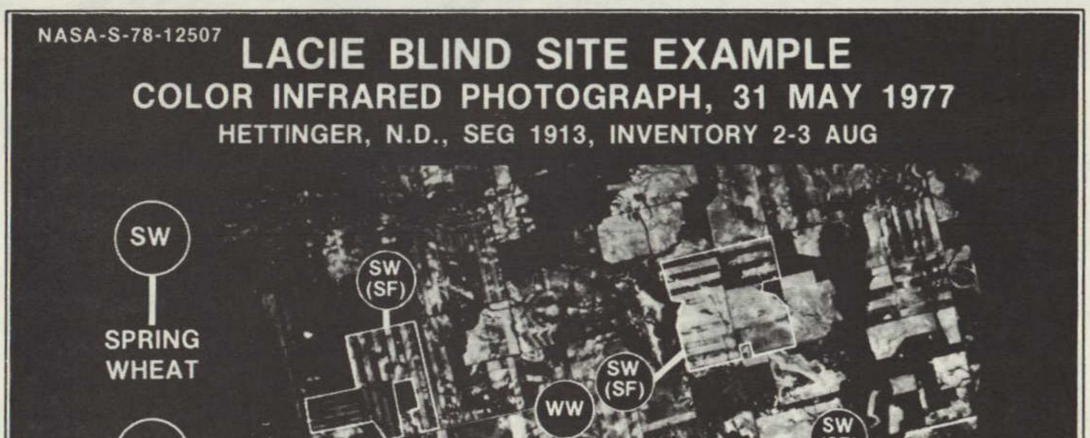
OF POOR QUALITY






NASA-S-78-12503
VARIABILITY OF WHEAT SIGNATURES
KIOWA, OK JAN 18, 1976
BAYLOR, TEX NOV 24, 1975
DROUGHT STRESS CONDITIONS


NASA-S-78-12507
LACIE BLIND SITE EXAMPLE
COLOR INFRARED PHOTOGRAPH, 31 MAY 1977
HETTINGER, N.D., SEG 1913, INVENTORY 2-3 AUG
SW
SPRING WHEAT
WW
WINTER WHEAT
'(SF)
STRIP FIELDS
SW (SF)
WW
SW (SF)
SW (SF)
SW (SF)
RYE (SF)
SW (SF)
SW
SW (SF)

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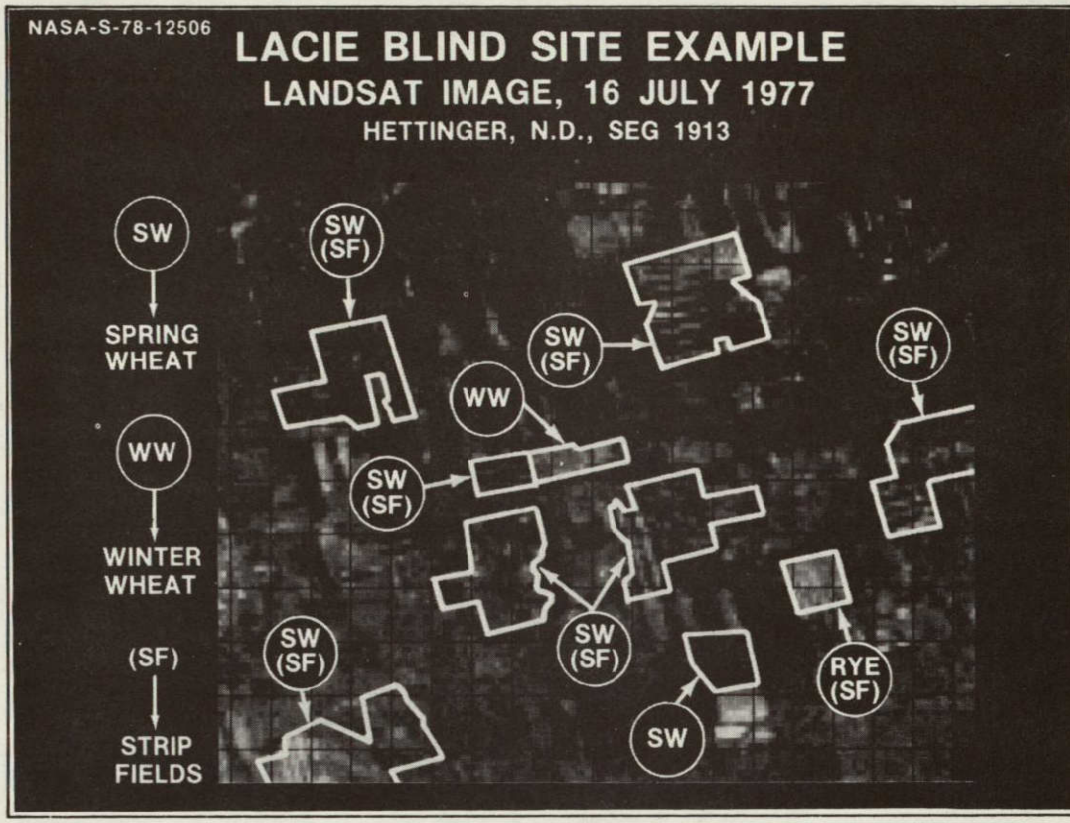
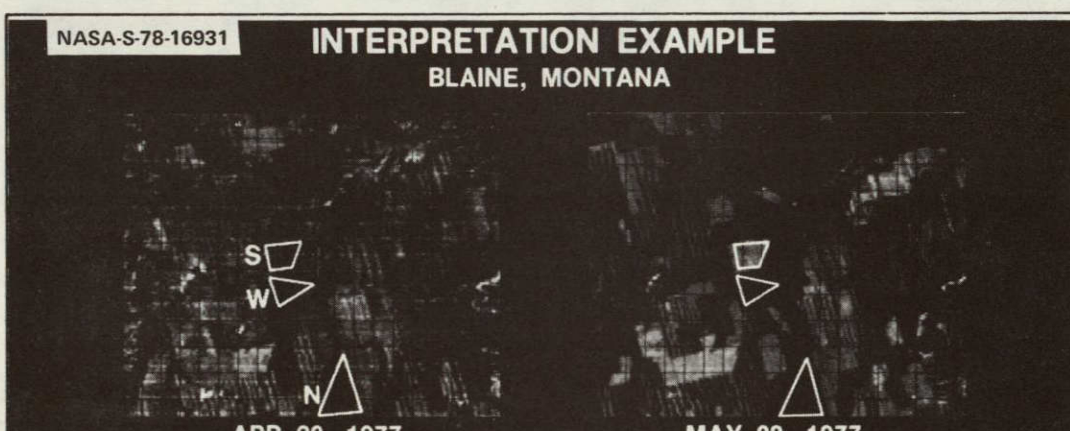
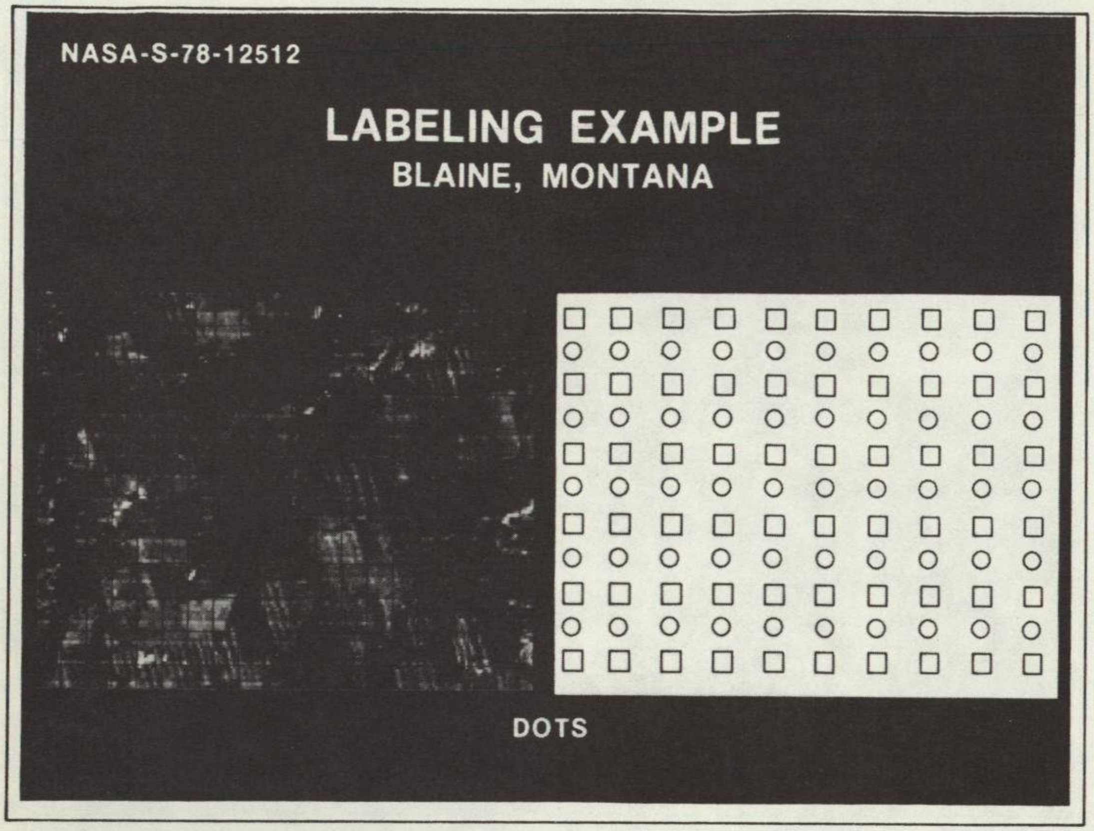
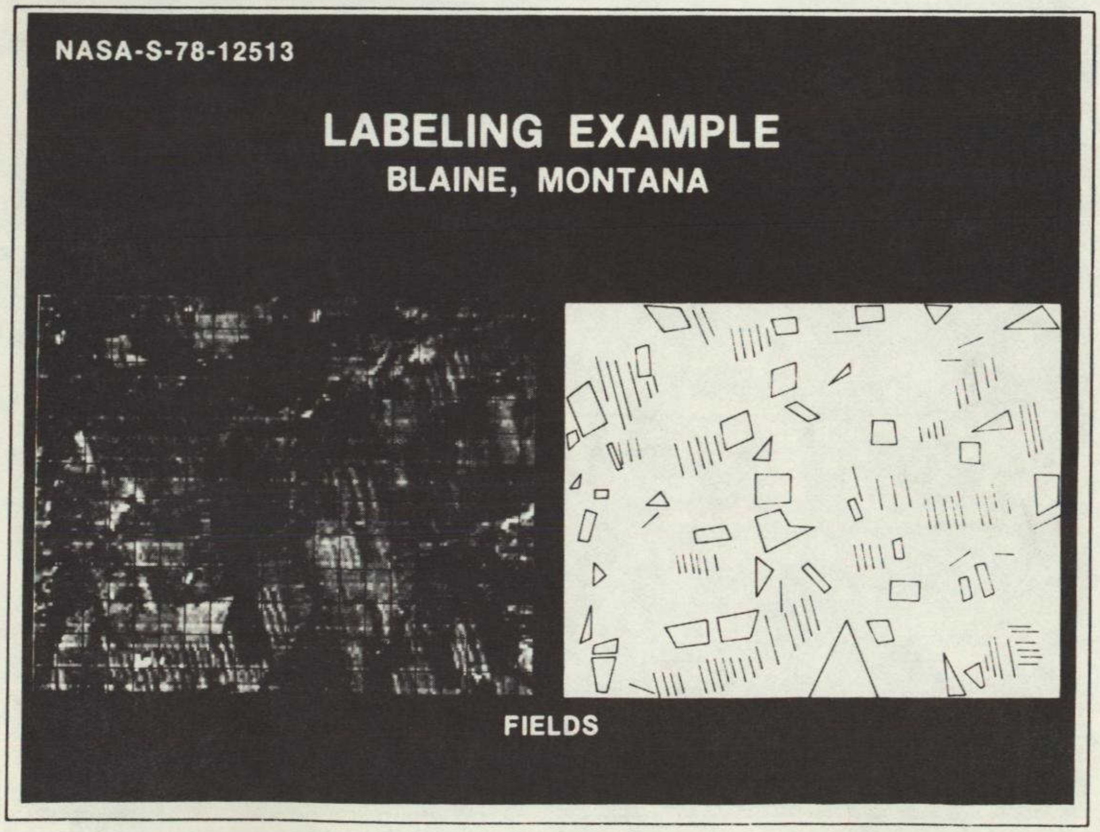





NASA-S-78-12512
LABELING EXAMPLE
BLAINE, MONTANA
DOTS


NASA-S-78-12513
LABELING EXAMPLE
BLAINE, MONTANA
FIELDS

NASA-S-78-16932

MACHINE PROCESSING

BATCH

- CLUSTERING
- AUTOMATIC CLUSTER LABELING
- CLASSIFYING
- PERFORMING STRATIFIED AREAL ESTIMATION
- GENERATING EVALUATION PRODUCTS
  - CLUSTER MAPS
  - CLASS MAP
  - CLASS SUMMARY
  - SPECTRAL AIDS

NASA-S-78-12510

LACIE 16 CHANNEL CLASSIFICATION PRODUCTS

BLAINE, MONTANA

PLAIN CLUSTER MAP

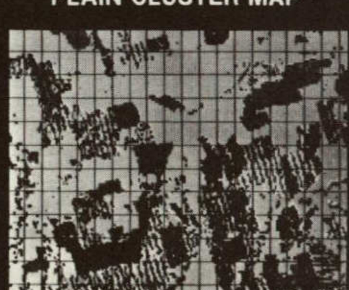
ACQUISITION DATES

APRIL 22, 1977

MAY 28, 1977

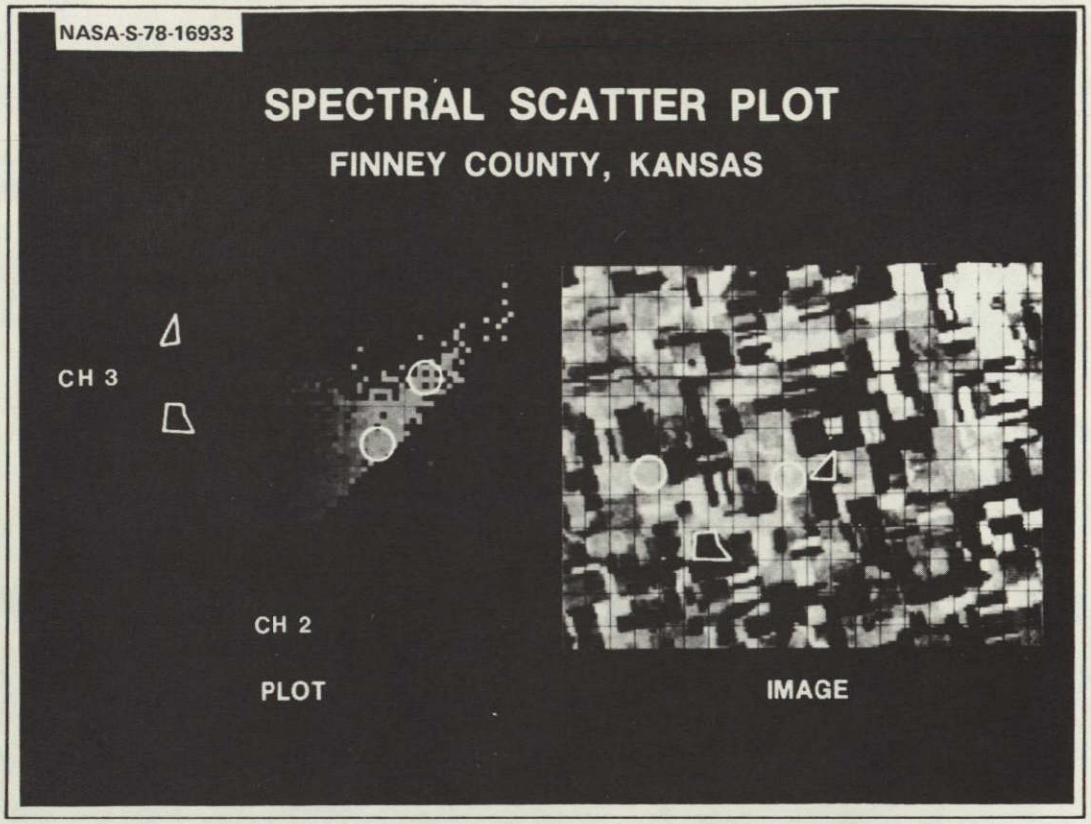
JULY 3, 1977

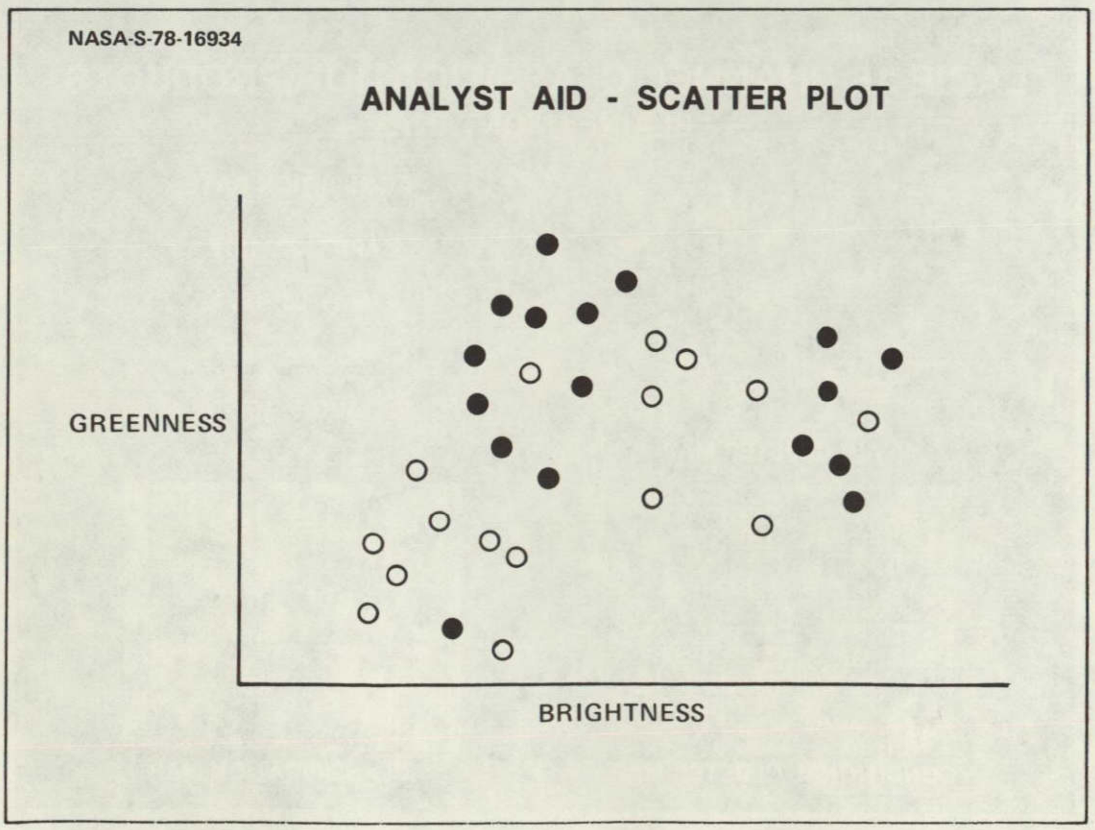
AUG 8, 1977



CONDITIONAL CLUSTER MAP

CLASSIFICATION MAP


NASA-S-78-16933
SPECTRAL SCATTER PLOT
FINNEY COUNTY, KANSAS
CH 3
CH 2
PLOT
IMAGE


NASA-S-78-16934
ANALYST AID - SCATTER PLOT
GREENNESS
BRIGHTNESS

NASA-S-78-16937

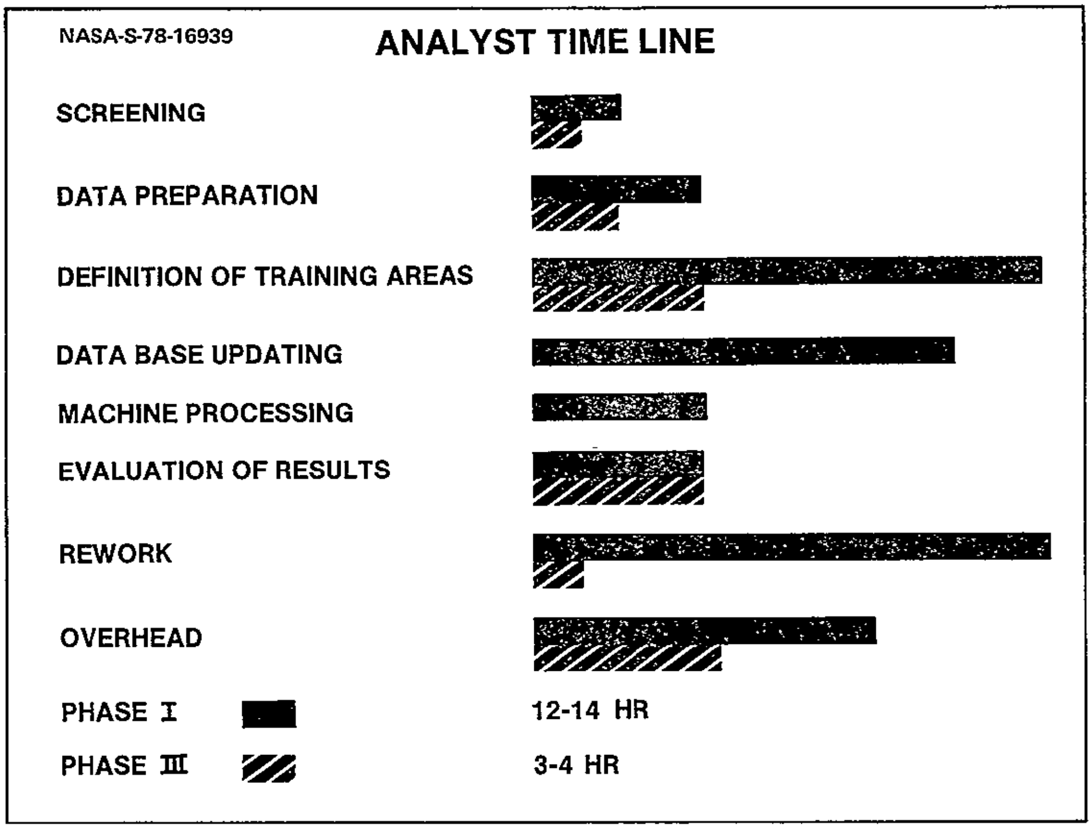
QUALITY ASSURANCE

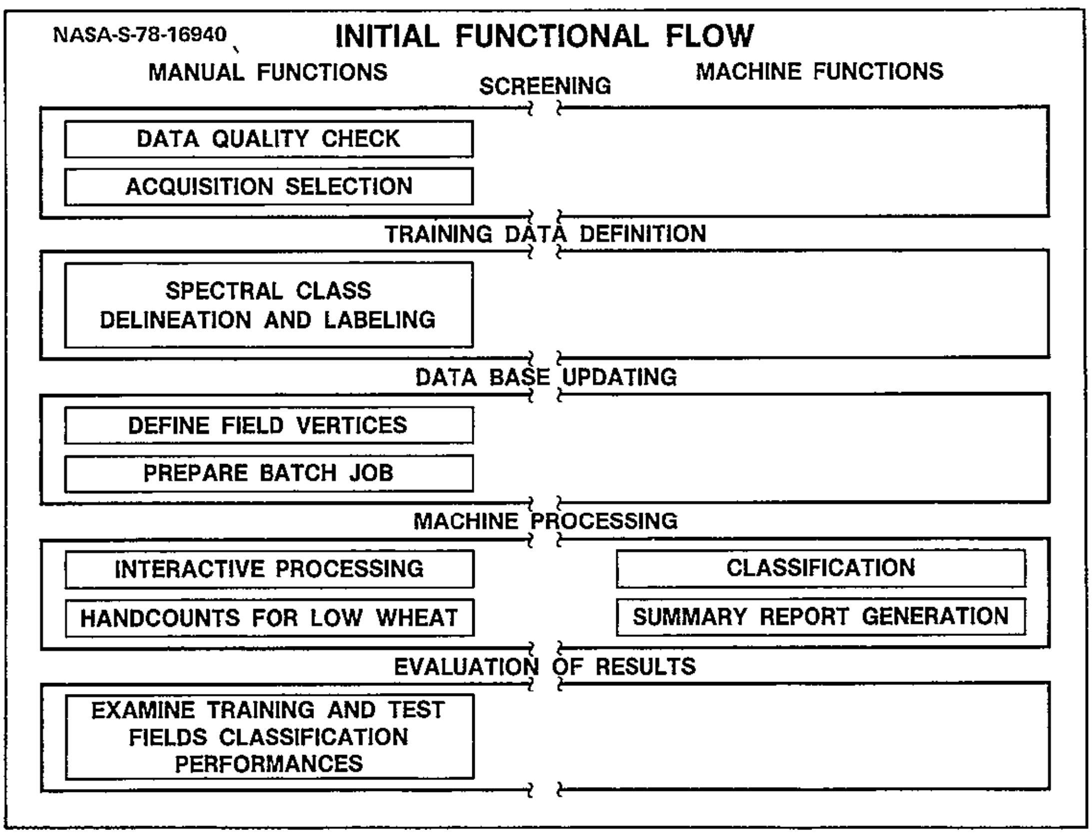
- PROCEDURES
- DOT LABELS
- WHEAT/SMALL GRAINS ESTIMATE

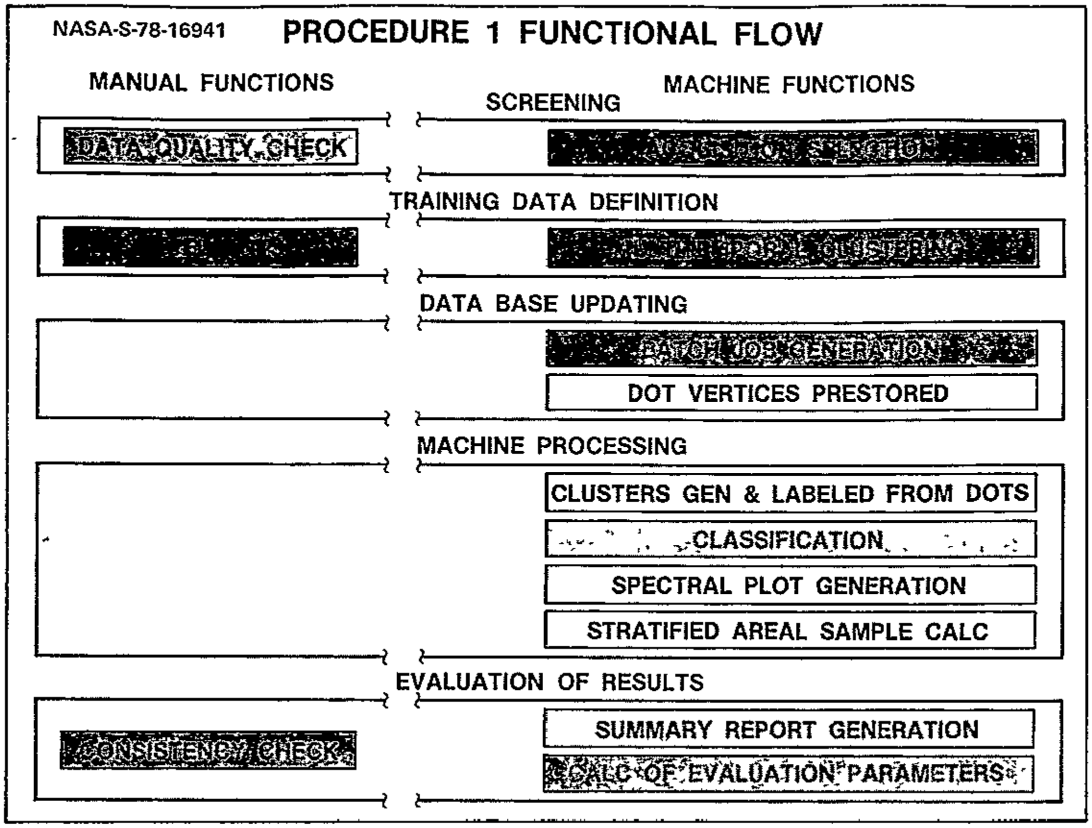
NASA-S-78-16938

ACCOMPLISHMENTS

- THROUGHPUT
- TECHNOLOGY
- VARIABILITY


NASA-S-78-16939
ANALYST TIME LINE
SCREENING
DATA PREPARATION
DEFINITION OF TRAINING AREAS
DATA BASE UPDATING
MACHINE PROCESSING
EVALUATION OF RESULTS
REWORK
OVERHEAD
PHASE I
12-14 HR
PHASE III
3-4 HR


NASA-S-78-16940
INITIAL FUNCTIONAL FLOW
MANUAL FUNCTIONS
SCREENING
MACHINE FUNCTIONS
DATA QUALITY CHECK
ACQUISITION SELECTION
TRAINING DATA DEFINITION
SPECTRAL CLASS DELINEATION AND LABELING
DATA BASE UPDATING
DEFINE FIELD VERTICES
PREPARE BATCH JOB
MACHINE PROCESSING
INTERACTIVE PROCESSING
HANDCOUNTS FOR LOW WHEAT
CLASSIFICATION
SUMMARY REPORT GENERATION
EVALUATION OF RESULTS
EXAMINE TRAINING AND TEST FIELDS CLASSIFICATION PERFORMANCES


NASA-S-78-16941
PROCEDURE 1 FUNCTIONAL FLOW
MANUAL FUNCTIONS
MACHINE FUNCTIONS
SCREENING
DATA QUALITY CHECK
TRAINING DATA DEFINITION
DATA BASE UPDATING
BATCH JOB GENERATION
DOT VERTICES PRESTORED
MACHINE PROCESSING
CLUSTERS GEN & LABELED FROM DOTS
CLASSIFICATION
SPECTRAL PLOT GENERATION
STRATIFIED AREAL SAMPLE CALC
EVALUATION OF RESULTS
CONSISTENCY CHECK
SUMMARY REPORT GENERATION
CALC OF EVALUATION PARAMETERS

N79-14468

SYSTEM IMPLEMENTATION AND OPERATIONS SESSION

IMPLEMENTATION AND OPERATION OF YIELD FORECASTING AND CROP GROWTH STAGE ESTIMATION

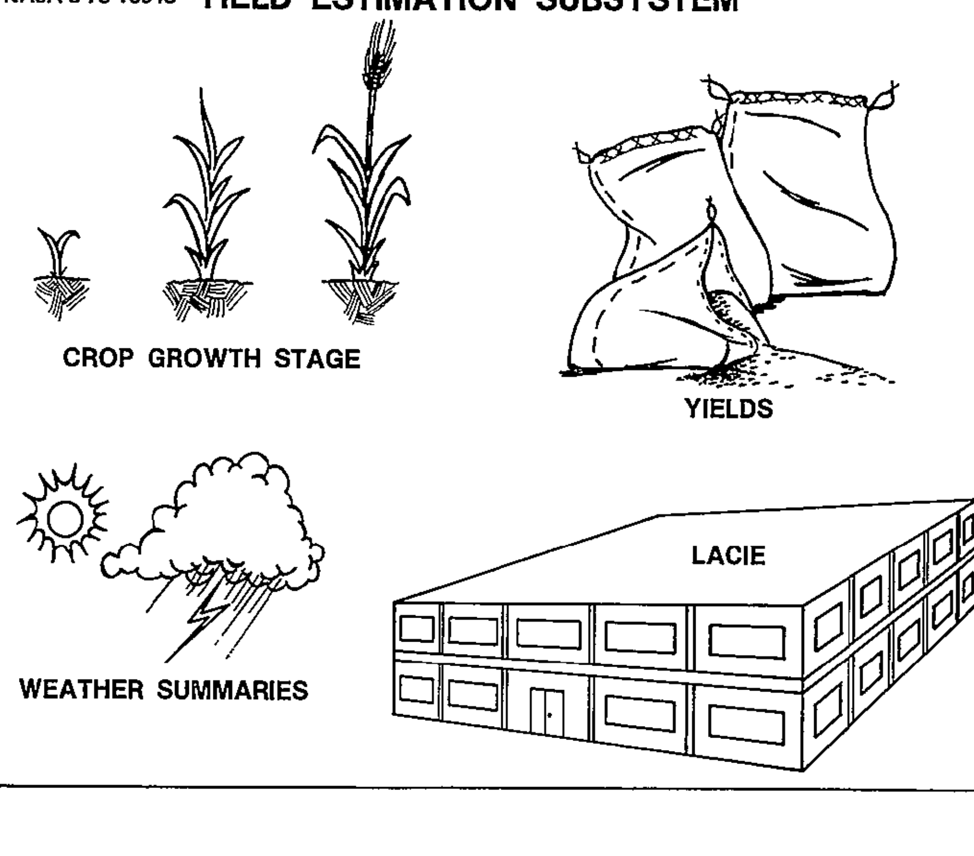
D McCrary, NOAA

NASA-S-78-16942

IMPLEMENTATION AND OPERATION OF YIELD FORECASTING AND CROP GROWTH STAGE ESTIMATION

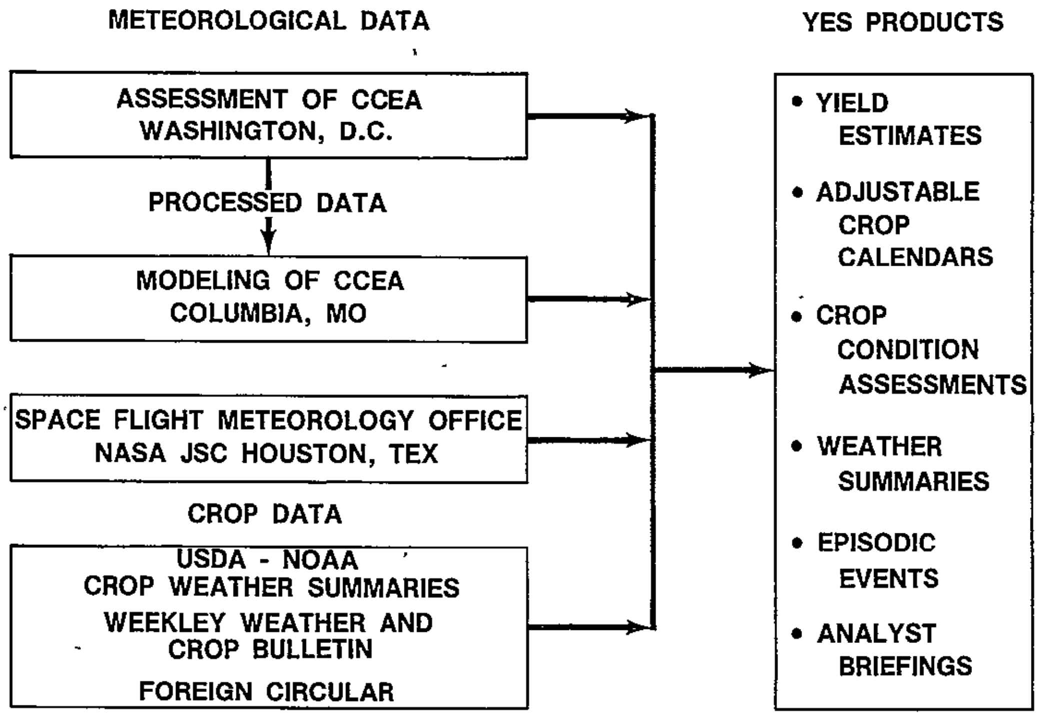
NASA-S-78-16943

YIELD ESTIMATION SUBSYSTEM



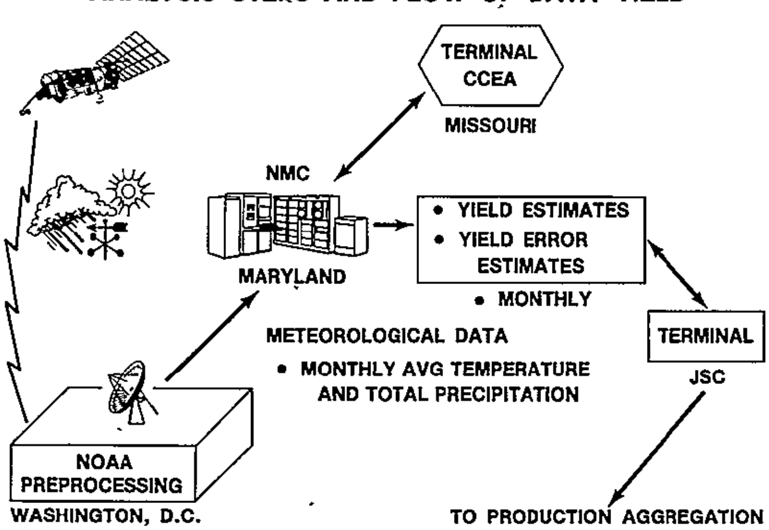
NASA-S-78-16944

YES OPERATIONS

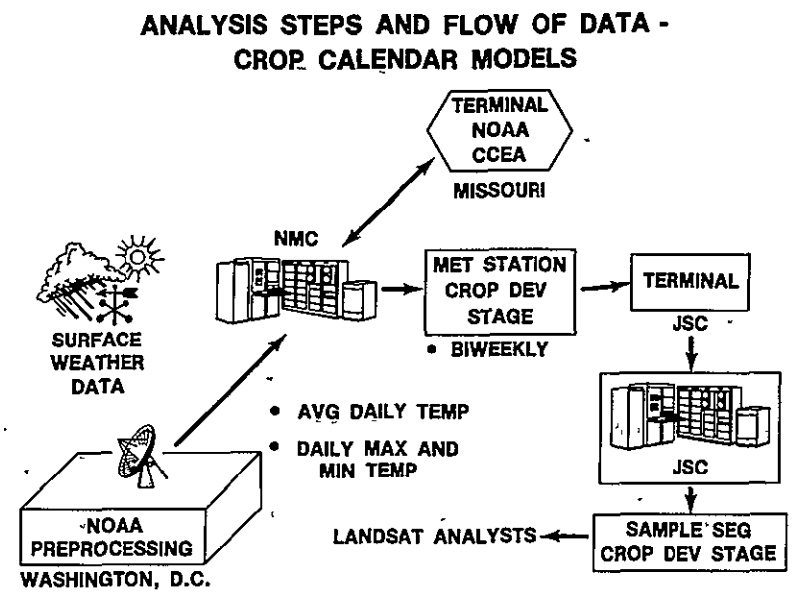


NASA-S-78-16945

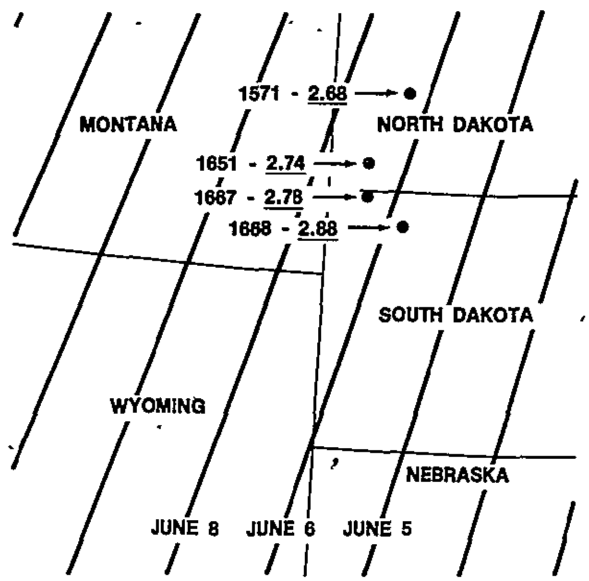
ANALYSIS STEPS AND FLOW OF DATA-YIELD



NASA-S-78-16946



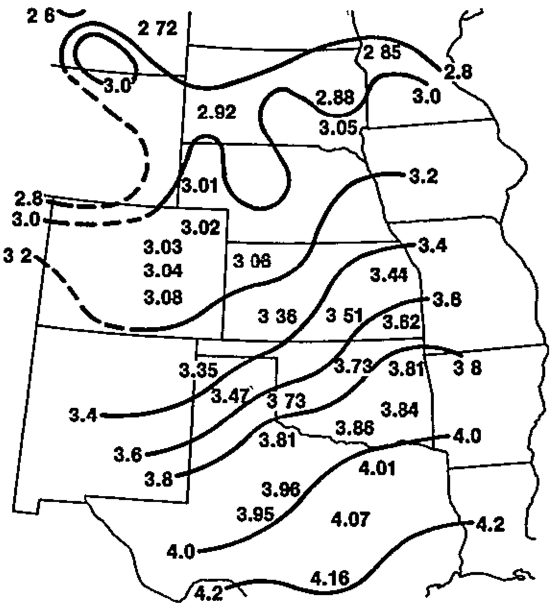
NASA-S-78-16947



NASA-S-78-16948

CROP CALENDAR ADJUSTMENT

MAY 2, 1976



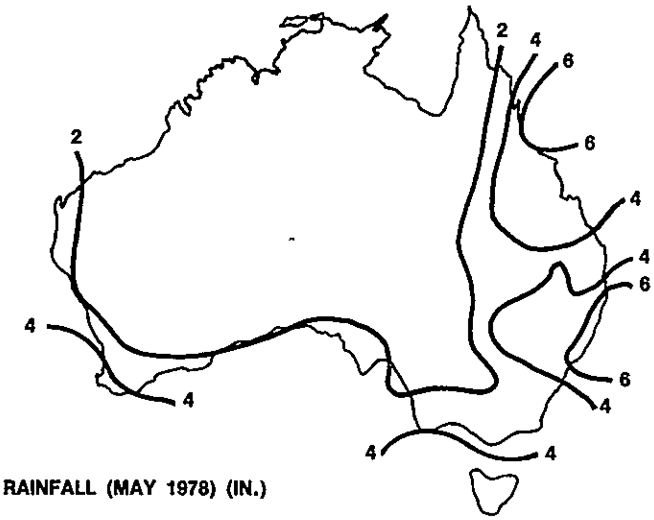
NASA-S-78-16949

WEEKLY METEOROLOGY SUMMARY

- TEMPERATURE AND PRECIPITATION MAPS
- TEMPERATURE AND PRECIPITATION DATA WITH DEPARTURES
- STATE WEATHER AND CROP ASSESSMENT
- CROP MOISTURE INDEX, MAY 27, 1978
- AVERAGE SOIL TEMPERATURE, MAY 22-28, 1978
- TOTAL GROWING DEGREE DAYS, MARCH 1 - MAY 28, 1978

NASA-S-78-16950

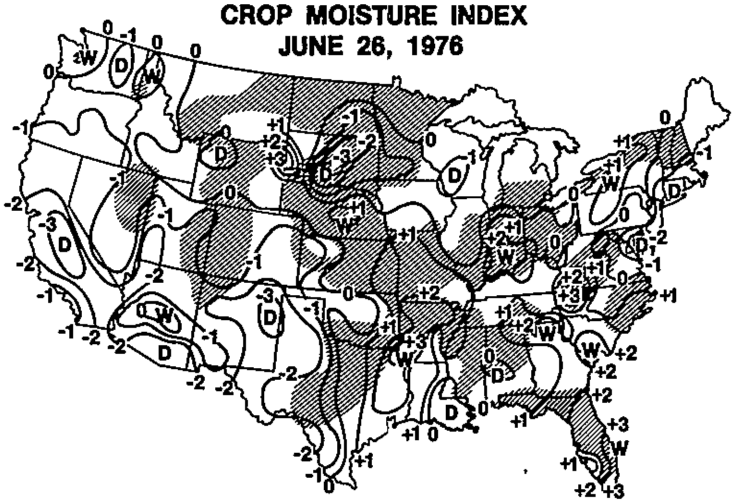
AUSTRALIAN METEOROLOGICAL DISTRICTS



RAINFALL (MAY 1978) (IN.)

NASA-S-78-16951

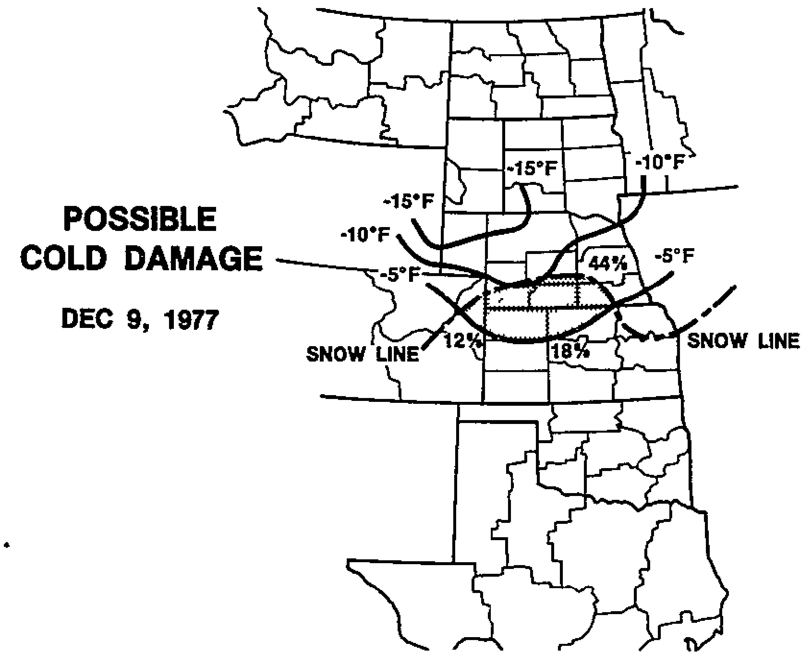
CROP MOISTURE INDEX
JUNE 26, 1976



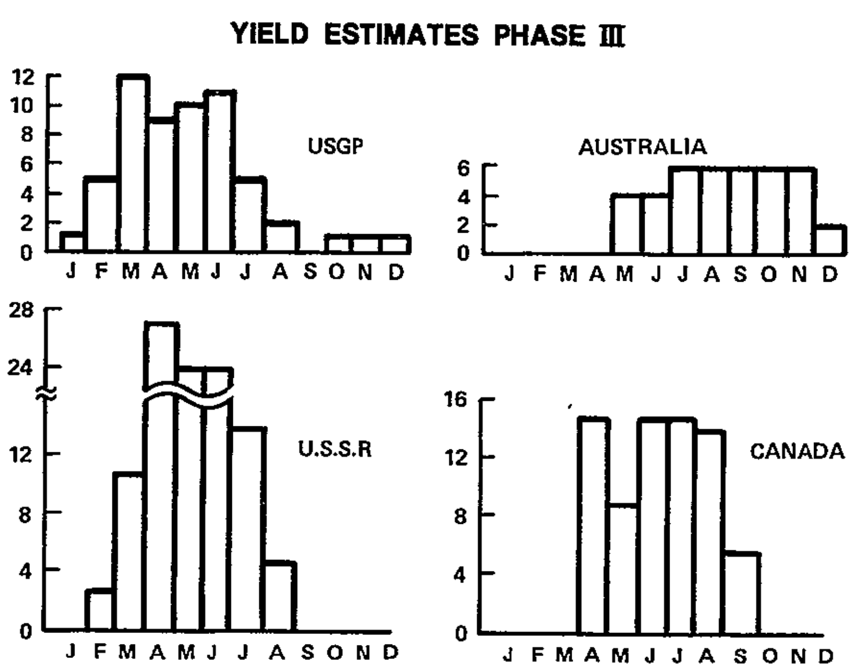
SHADED AREA INDICATES INCREASE OR NO CHANGE IN INDEX DURING WEEK

ORIGINAL PAGE IS
OF POOR QUALITY

NASA-S-78-16952



NASA-S-78-16953



NASA-S-78-16954

YIELD ESTIMATION SUBSYSTEM

ACCOMPLISHMENT

- OPERATION SYSTEM TO COLLECT AND PROCESS METEOROLOGICAL DATA FROM ALL LACIE COUNTRIES
- WEEKLY WEATHER SUMMARIES WERE PRODUCED FOR ALL LACIE COUNTRIES
- DAILY WEATHER REPORTS FROM 300 STATIONS IN 7 LACIE COUNTRIES WERE PROCESSED TO PROVIDE TEMPERATURE VALUES TO OPERATE THE CROP CALENDARS
- YIELD ESTIMATES IN LAST 12 MONTHS WERE PRODUCED FOR 306 AREAS IN 7 DIFFERENT COUNTRIES

SYSTEM IMPLEMENTATION AND OPERATIONS SESSION

SYSTEM IMPLEMENTATION AND APPROACHES USED FOR GENERATION OF CROP PRODUCTION REPORTS

R Hatch, USDA

NASA-S-78-16955

SYSTEM IMPLEMENTATION AND APPROACHES USED FOR GENERATION OF CROP PRODUCTION REPORTS

NASA-S-78-16956

THE CROP ASSESSMENT SUBSYSTEM - GENERATION OF CROP PRODUCTION REPORTS

- SUBSYSTEM FUNCTIONS
- SUBSYSTEM DESIGN CONSIDERATIONS
- REPORT CONTENT, SECURITY, AND DISTRIBUTION
- SYSTEM IMPLEMENTATION AND OPERATIONS
- MAJOR ACHIEVEMENTS

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NASA-S-78-16957

SUBSYSTEM FUNCTIONS

- OVERALL RESPONSIBILITY FOR SAMPLING STRATEGY
  - ALLOCATION OF SAMPLE SEGMENTS TO SAMPLING UNIT
  - LOCATION OF SAMPLE SEGMENTS WITHIN SAMPLING UNIT
- PRODUCE SCHEDULED CROP REPORTS (USUALLY MONTHLY) DURING THE CROP SEASON THAT INCLUDE:
  - ESTIMATES OF WHEAT AREA, YIELD, AND PRODUCTION
  - STATISTICAL DESCRIPTORS FOR EACH ESTIMATE

NASA-S-78-16958

SUBSYSTEM DESIGN

- SAMPLING STRATEGY SELECTED
  - DICTATES THE AGGREGATION METHODOLOGY
  - PROVIDES BASIS FOR FORMULATING STATISTICAL DESCRIPTORS TO EVALUATE THE ACCURACY AND RELIABILITY OF ESTIMATES
- AGGREGATION SYSTEM DESIGNED TO USE A STRATIFIED RANDOM SAMPLE FOR WHEAT AREA ESTIMATION AT THE STRATUM LEVEL
- AREA ESTIMATES COMBINED WITH INDEPENDENT YIELD ESTIMATE TO OBTAIN PRODUCTION
- INTERACTIVE SYSTEM DESIGN DEEMED NECESSARY TO
  - PROCESS ANTICIPATED DATA LOADS FOR EIGHT COUNTRIES
  - PROVIDE CHOICE OF OUTPUT PRODUCTS FOR USE IN ACCURACY ASSESSMENT AND EVALUATION
  - PROVIDE ADDITIONAL OPTIONS FOR USE IN EVALUATING THE IMPACT OF PROCEDURAL CHANGES

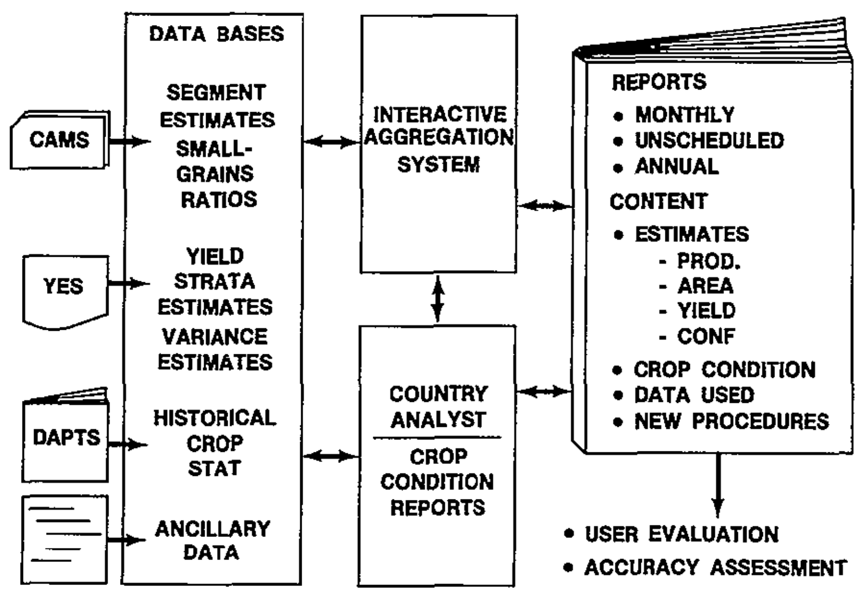
NASA-S-78-16959

BASIC INPUT DATA

- SAMPLE SEGMENT WHEAT PROPORTION ESTIMATES
- YIELD AND YIELD VARIANCE FOR STRATA
- HISTORICAL CROP STATISTICS
- DATA ARE STORED FOR USE BY AGGREGATION AND REPORTING MODULES
- PREPROCESSOR USED TO REFORMAT BEFORE STORAGE WHERE REQUIRED

NASA-S-78-16960

ANALYSIS AND DATA FLOW - PRODUCTION ESTIMATION



NASA-S-78-16961

SEGMENT DATA INPUT

- SAMPLE SEGMENT CLASSIFICATION RESULTS USED FOR AREA EXPANSION WERE SUPPLIED BY CAMS
- CLASSIFICATION RESULTS TRANSMITTED VIA COMPUTER CARDS WITH SPECIFIC FORMATS TO:
  - ACCOMMODATE LARGE DATA LOADS
  - MINIMIZE TRANSCRIPTION ERRORS
- DATA TRANSMITTED
  - FIVE POSSIBLE CLASSES – WINTER WHEAT, SPRING WHEAT, WINTER SMALL GRAINS, SPRING SMALL GRAINS, AND SMALL GRAINS
  - OTHER INFORMATION – DATE SEGMENT ACQUIRED, DATE SEGMENT CLASSIFIED, CROP DEVELOPMENT BIOSTAGE, CLASSIFICATION CODE
- SMALL-GRAINS RATIOS APPLIED TO CLASSIFICATION RESULTS BEFORE ENTRY INTO THE SEGMENT-LEVEL DATA BASE – CREATES TWO MORE CLASSES (RATIOED WINTER WHEAT AND RATIOED SPRING WHEAT)

NASA-S-78-16962

SEGMENT INPUT DATA (CONT)

- CLASSIFICATION RESULTS QUALITATIVELY EVALUATED AS UNSATISFACTORY, MARGINAL, OR SATISFACTORY STORED IN DATA BASE
- SEGMENTS NOT CLASSIFIED (PREEMERGENCE, CLOUD COVER, DORMANCY) WERE NOT STORED
- DATA EDITING PROCEDURES USED IN PHASE III (1976-77 CROP YEAR)
  - EARLY-SEASON ESTIMATES THAT DID NOT DETECT ALL PLANTED WHEAT WERE ELIMINATED FROM AGGREGATION
  - SEGMENT ESTIMATES THAT WERE OUTLIERS WERE ELIMINATED FROM AGGREGATION

NASA-S-78-16963

YIELD DATA INPUT

- YIELD AND YIELD VARIANCE WERE SUPPLIED FOR EACH STRATUM BY YES
- YIELDS WERE GENERALLY SUPPLIED MONTHLY DURING THE GROWING SEASON
  - U.S – FOURTH WORKING DAY
  - U.S.S R. AND CANADA – NINTH WORKING DAY
- INTERACTIVE SYSTEM ORIGINALLY DESIGNED FOR MAGNETIC-TAPE INPUT
  - UNAVAILABILITY OF DATA TERMINAL AT JSC REQUIRED ADDITIONAL INPUT CAPABILITY – COMPUTER CARD AND INTERACTIVE
  - DATA STORAGE KEYS – YIELD STRATUM AND MONTH RECEIVED
- YIELD AND AREA STRATA CORRELATED BY AGGREGATION SOFTWARE IN PRODUCTION ESTIMATION PROCESS

NASA-S-78-16964

HISTORICAL DATA INPUT

- HISTORICAL AGRICULTURAL STATISTICS FOR POLITICAL SUBDIVISIONS USED FOR AREA ESTIMATION AND STATISTICAL CALCULATIONS WERE SUPPLIED BY DAPTS
- INTERACTIVE SYSTEM DESIGNED FOR MAGNETIC-TAPE OR COMPUTER-CARD INPUT
- AGRICULTURAL STATISTICS NOT READILY AVAILABLE FOR ALL COUNTRIES AND MUST BE MADE COMPUTER COMPATIBLE
- THE FOLLOWING DATA ARE STORED (COMPLETE SET AVAILABLE FOR U S ONLY)
  - BASE YEAR FOR RATIO AREA ESTIMATION AND STATISTICAL CALCULATIONS (REQUIRED FOR AGGREGATION)
  - SECOND YEAR OF HISTORICAL DATA REQUIRED TO SUPPORT STATISTICAL CALCULATIONS
  - AREA, YIELD, AND PRODUCTION FOR 12 YEARS STORED FOR ALL HIERARCHICAL LEVELS IN A COUNTRY
- HISTORICAL DATA ACCESSED FOR REPORT GENERATION AND THE MAXIMUM, MINIMUM, AVERAGE, AND STANDARD DEVIATION OF AREA, YIELD, AND PRODUCTION AT EACH HIERARCHICAL LEVEL ARE REPORTED

NASA-S-78-16965

ANCILLARY DATA

- ANCILLARY DATA OBTAINED FROM NUMEROUS SOURCES
  - NEWSPAPERS
  - WEATHER AND CROP SUMMARIES
  - USDA REPORTS
- USED BY ANALYST TO
  - EVALUATE DATA INPUTS AND AGGREGATED RESULTS
  - IDENTIFY POTENTIAL PROBLEM AREAS
  - SUPPORT GENERAL CROP CONDITION ASSESSMENT

NASA-S-78-16966

SUBSYSTEM OUTPUTS

- PRIMARY PRODUCT WAS CROP REPORTS CONTAINING ESTIMATES OF WHEAT AREA, YIELD, AND PRODUCTION
- REPORT CONTENT AND FORMAT ESTABLISHED TO SATISFY USER REQUIREMENTS AND SUPPORT EVALUATION OF RESULTS
- CROP REPORTS WERE COMBINATION OF COMPUTER OUTPUT AND NARRATIVE ANALYTICAL SUMMARY
- COMPUTER OUTPUT TABLES
  - AREA, YIELD, AND PRODUCTION FOR ALL HIERARCHICAL LEVELS IN A COUNTRY
  - STANDARD STATISTICS FOR EACH ESTIMATE
  - MINIMUM, MAXIMUM, AVERAGE, AND STANDARD DEVIATION OF HISTORICAL DATA
- NARRATIVE
  - SUMMARY OF ESTIMATES
  - DISCUSSION OF SAMPLE SEGMENT DATA
  - YIELD TRACKING AND ANALYSIS
  - CROP CONDITION ASSESSMENT BASED ON ANALYSIS OF METEOROLOGICAL AND LANDSAT DATA

NASA-S-78-16967

REPORTS

- SCHEDULE
  - PHASE I REPORTS SCHEDULED FOR LAST WORKING DAY OF THE MONTH
  - PHASE II
    - – U.S. REPORTS RELEASED DAY BEFORE USDA RELEASE OF CROP PRODUCTION ESTIMATES
    - – FOREIGN REPORTS RELEASED 7 WORKING DAYS AFTER RECEIPT OF YIELD
  - PHASE III
    - – U.S. – SAME AS PHASE II
    - – U.S.S.R. – RELEASED TO SUPPORT U.S.S.R. GRAIN SITUATION TASK FORCE MEETING (NORMALLY FIRST WEEK OF MONTH)
- REPORTS TRANSMITTED DURING LACIE
  - 32 MONTHLY REPORTS
  - 7 UNSCHEDULED REPORTS
  - 6 ANNUAL REPORTS

NASA-S-78-16968

REPORTS (CONT)

- REPORTS WERE COUNTRY SPECIFIC
  - PHASE I
    - – U.S. GREAT PLAINS – 6 AREA REPORTS GENERATED; 5 NOT DISTRIBUTED
  - PHASE II
    - – U S GREAT PLAINS – 13 REPORTS
    - – U.S.S.R. INDICATOR REGIONS – 8 REPORTS
    - – CANADA – 4 REPORTS
  - PHASE III
    - – U.S. GREAT PLAINS – 10 REPORTS
    - – U.S.S.R. – 9 REPORTS

NASA-S-78-16969

REPORT SECURITY AND DISTRIBUTION

- COMMODITY INFORMATION CONTROLS COMPLIED WITH USDA PROCEDURES
- ESTIMATES PRODUCED IN CONTROLLED-ACCESS AREA WITH USER IDENTIFICATION CODE AND PASSWORD PROTECTED COMPUTER FILES
- MAXIMUM SECURITY – DAY AFTER OFFICIAL USDA RELEASE
- RESTRICTED SECURITY – 120 DAYS FROM MAXIMUM
- REPORTS DISTRIBUTED TO
  - ACCURACY ASSESSMENT, HOUSTON
  - INFORMATION EVALUATION, USDA/LACIE, WASHINGTON, D.C.
  - PARTICIPATING AGENCIES FOR EVALUATION:
    - NASA, WASHINGTON, D.C.
    - NOAA, WASHINGTON, D.C.
    - USDA, WASHINGTON, D.C.
- ANALYST PRESENTED LATEST AVAILABLE ESTIMATES AT U.S.S.R. GRAIN SITUATION TASK FORCE MEETINGS DURING PHASE III

NASA-S-78-16970

SYSTEM IMPLEMENTATION

- OPERATIONAL AGGREGATION AND REPORTING SYSTEM EVOLVED
- STAGE OF IMPLEMENTATION DETERMINED ANALYTICAL AND REPORTING CAPABILITIES
- PHASE I
  - EMPHASIS ON DEVELOPMENT OF SYSTEM REQUIREMENTS
  - DEVELOPMENT SOFTWARE IMPLEMENTED FOR USGP
  - PRODUCED WHEAT AREA ESTIMATES WITH COEFFICIENT OF VARIATION
  - FORMATTED OUTPUT FOR CROP REPORTING DISTRICTS AND STATES
- PHASE II
  - BATCH SYSTEM INITIALLY AVAILABLE FOR AREA, YIELD, AND PRODUCTION WITH STATISTICAL DESCRIPTORS FOR USGP, U.S.S.R., AND CANADA
  - PARTIAL INTERACTIVE SYSTEM DELIVERED IN MIDYEAR
  - HYBRID BATCH/INTERACTIVE SYSTEM USED FOR REMAINDER OF YEAR
- PHASE III
  - INTERACTIVE SYSTEM WITH FULL CAPABILITY BECAME AVAILABLE

NASA-S-78-16971

FINAL INTERACTIVE SYSTEM

- MAJOR SOFTWARE MODULES
  - DATA BASE MANAGEMENT
  - AREA, YIELD, AND PRODUCTION ESTIMATION
  - REPORT GENERATION
- ANALYST TUTORIAL PROMPT SYSTEM TO MINIMIZE TRAINING AND OPERATIONAL COMPLEXITY
- FOUR ANALYSTS STATIONS OPERATED SIMULTANEOUSLY
- CAPABLE OF PRODUCING TIMELY AGGREGATIONS
- USED FOR TECHNOLOGY DEVELOPMENT IN SUPPORT OF ACCURACY ASSESSMENT

NASA-S-78-16972

SUBSYSTEM OPERATIONS

- LEAD ANALYST ASSIGNED TO EACH COUNTRY WAS RESPON SIBLE FOR:
  - MAINTAINING DATA BASES, PRODUCING WHEAT ESTIMATI AND GENERATING REPORTS
  - ESTABLISHING PROCESSING PRIORITIES FOR SAMPLE SEGMENTS
  - OPERATING AGGREGATION SOFTWARE
  - EVALUATING RESULTS
  - PREPARING REPORT AND INCORPORATING INPUTS FROM OTHER LACIE ELEMENTS
- TIME LINE FOR REPORT GENERATION
  - BEGAN 7 WORKING DAYS BEFORE REPORT DATE
  - UPDATE DATA BASES
  - PRELIMINARY AGGREGATION PREPARED (SUBMITTED IF PRIMARY AND BACKUP COMPUTERS FAILED)
  - FINAL AGGREGATION AND PREPARE REPORT (24-72 HR)
  - LEAD TIME DECREASED TO 3 WORKING DAYS UNDER SPECIAL CIRCUMSTANCES TO INCLUDE LATEST DATA

NASA-S-78-16973

SUBSYSTEM OPERATIONS (CONT)

- REPORT INTERACTION
  - INFORMATION EVALUATION AND ACCURACY ASSESSMENT RETURNED REPORT EVALUATION TO SUBSYSTEM
  - PROBLEMS IDENTIFIED DURING REPORT PREPARATION WERE REWORKED WITH RESPONSIBLE PROJECT ELEMENT
- COUNTRY ANALYSTS BRIEFED PROJECT PERSONNEL ON RESULTS

NASA-S-78-16974

MAJOR ACHIEVEMENTS

- IDENTIFIED BASIC ELEMENTS NECESSARY TO PRODUCE CROP REPORTS ROUTINELY REGARDLESS OF THE OPERATIONAL ENVIRONMENT
- DEMONSTRATED THAT CROP REPORTS COULD BE PRODUCED MONTHLY AND ON SCHEDULE
- DEVELOPED AN INTERACTIVE SYSTEM THAT IS AVAILABLE FOR USE IN FUTURE LARGE-AREA TESTS
- USED THE INTERACTIVE SYSTEM TO SUPPORT EVALUATION TASKS AND RAPIDLY IMPLEMENT MODIFICATIONS TO AGGREGATION PROCEDURES

SYSTEM IMPLEMENTATION AND OPERATIONS SESSION

ACCURACY ASSESSMENT – SYSTEM IMPLEMENTATION AND OPERATION

D Pitts, JSC

NASA-S-78-16705

ACCURACY ASSESSMENT - SYSTEM IMPLEMENTATION AND OPERATION

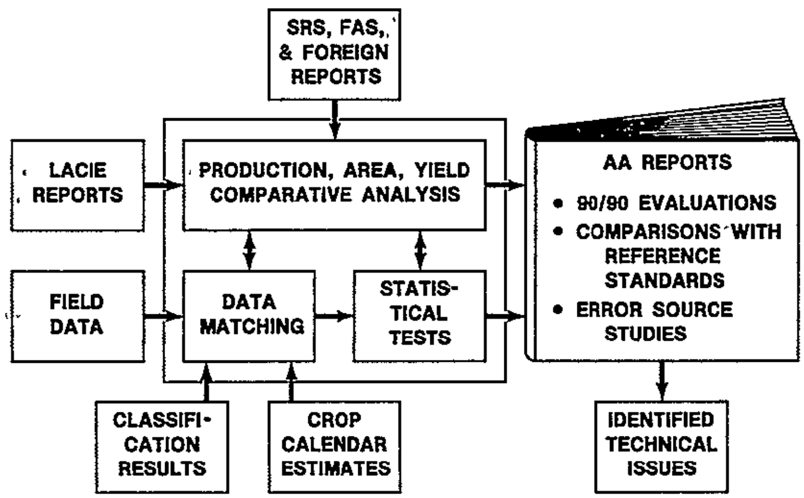
NASA-S-78-16706

ACCURACY ASSESSMENT

- NEED
  - TIMELY IDENTIFICATION OF MAJOR PROBLEM AREAS AND RECOMMENDATIONS FOR IMPROVEMENTS
- OBJECTIVES
  - TO DETERMINE THE ACCURACY AND RELIABILITY OF LACIE ESTIMATES OF PRODUCTION, AREA, AND YIELD MADE AT REGULAR INTERVALS THROUGHOUT A CROP SEASON
  - TO DETERMINE WHETHER OR NOT THESE ESTIMATES SUPPORT THE 90/90 ACCURACY GOAL
  - TO INVESTIGATE THE VARIOUS ERROR SOURCES OF THESE ESTIMATES AND TO QUANTIFY AND RELATE THESE ERROR SOURCES TO CAUSAL ELEMENTS IN THE LACIE ESTIMATION PROCESS

NASA-S-78-16707

DATA FLOW AND ANALYSIS



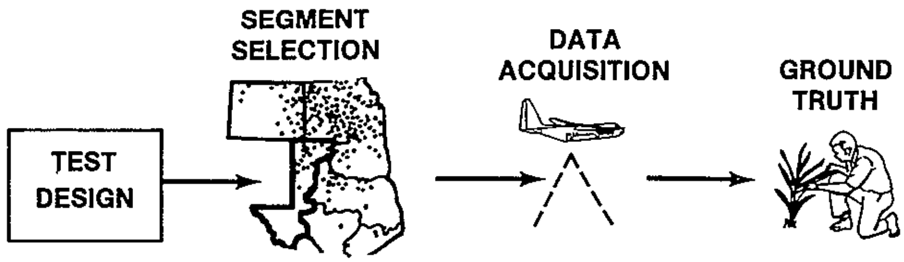
NASA-S-78-16708

AA REPORTING

- A BRIEF ACCURACY ASSESSMENT QUICK-LOOK REPORT IS PREPARED FOR EACH LACIE CROP REPORT
- COMPREHENSIVE ACCURACY ASSESSMENT REPORTS WERE PREPARED FOUR TIMES DURING THE CROP YEAR IN PREPARATION FOR A FINAL REPORT

NASA-S-78-16709

FIELD DATA ACQUISITION



NASA-S-78-16710

FIELD DATA ACQUISITION (CONT)

INTENSIVE TEST SITES
18-DAY OBSERVATIONS
- UP TO 50 FIELDS OF ALL CROPS
- COVER TYPE
- CROP HEIGHT
- % GROUND COVER
- GROWTH STAGE
- RAINFALL

↓

COMPLETE INVENTORY
- COVER TYPE
- FIELD SIZE
- PLANTING DATE
- IRRIGATION/FERTILIZER

→ JSC

BLIND SITES
18-DAY OBSERVATIONS
- 15 WHEAT FIELDS
- CROP HEIGHT
- % GROUND COVER

↓

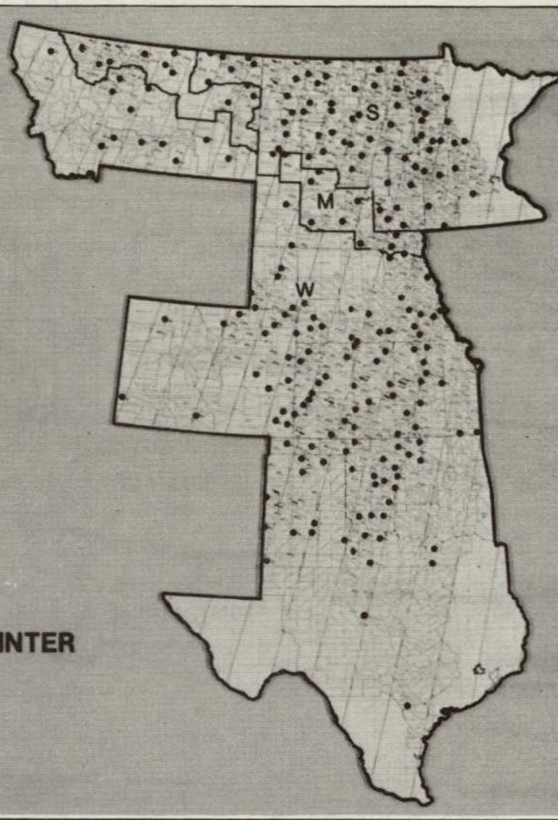
COMPLETE INVENTORIES
- COVER TYPE
- FALL & SPRING

↓

JSC

NASA-S-78-16711

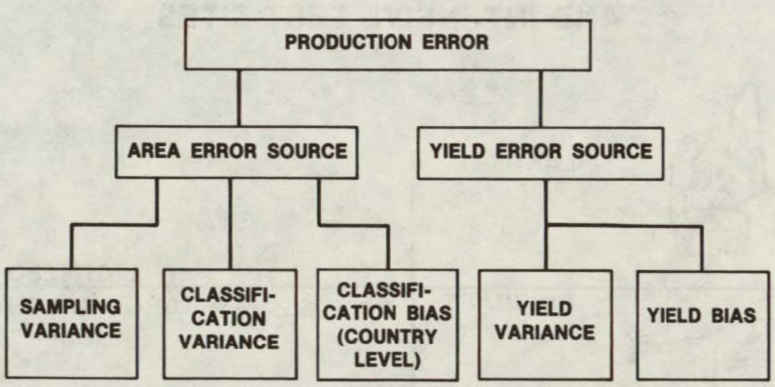
PHASE III LACIE BLIND SITES



S - SPRING WHEAT
W - WINTER WHEAT
M - MIXED SPRING AND WINTER
● - BLIND SITES

NASA-S-78-16712

PRODUCTION ERROR COMPONENTS



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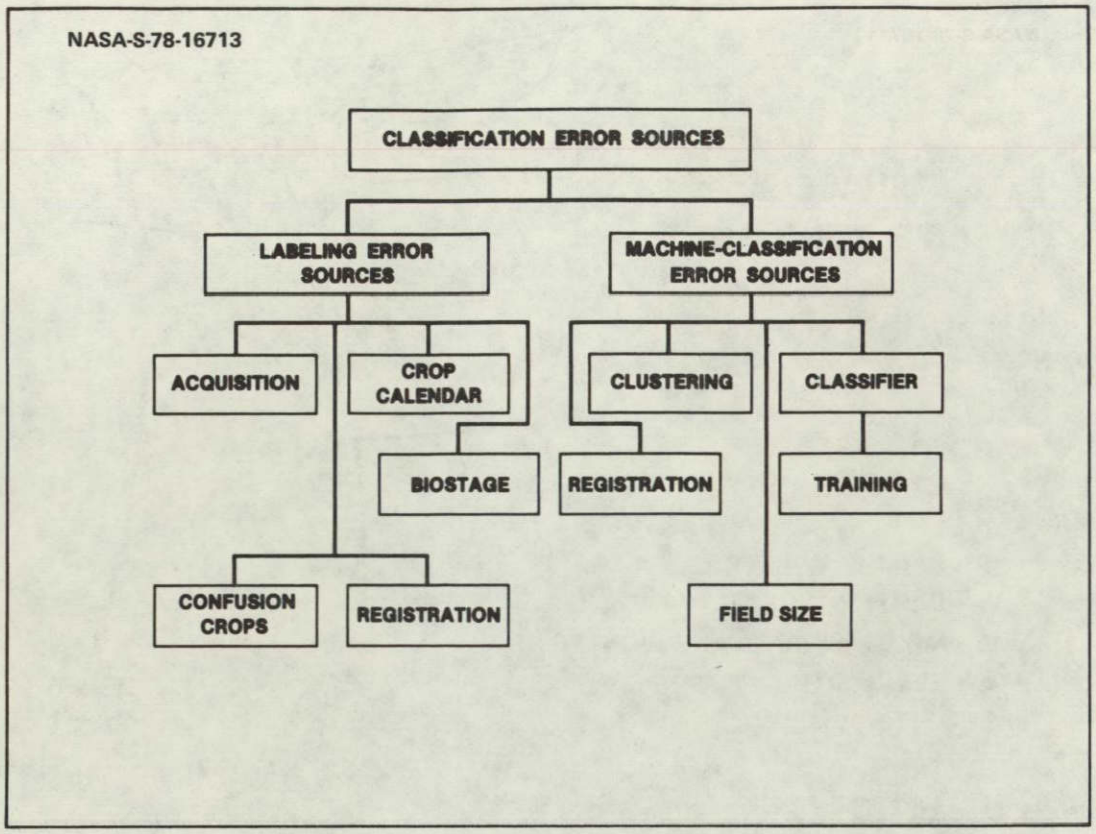
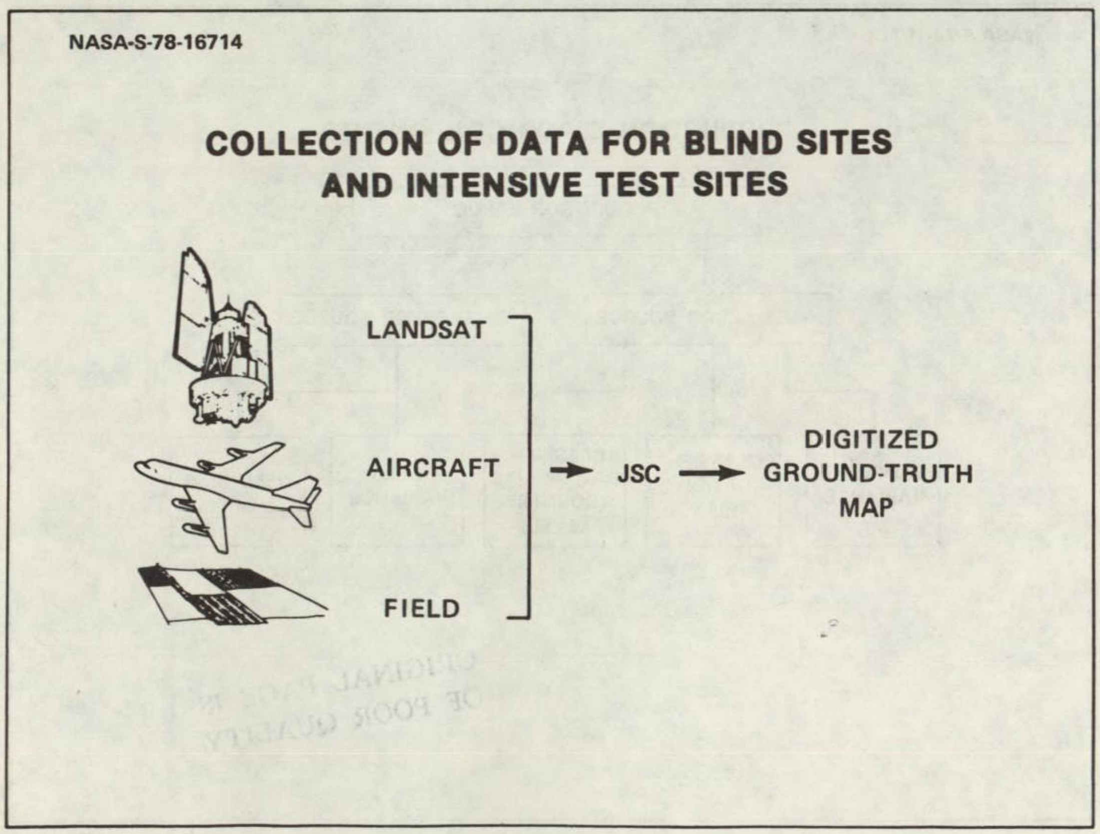
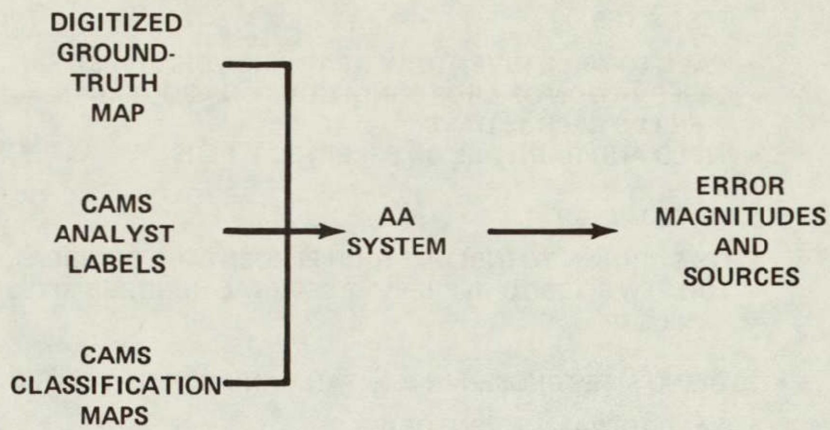

NASA-S-78-16713
CLASSIFICATION ERROR SOURCES
LABELING ERROR SOURCES
MACHINE-CLASSIFICATION ERROR SOURCES
ACQUISITION
CROP CALENDAR
CLUSTERING
CLASSIFIER
BIOSTAGE
REGISTRATION
TRAINING
CONFUSION CROPS
REGISTRATION
FIELD SIZE


NASA-S-78-16714
COLLECTION OF DATA FOR BLIND SITES AND INTENSIVE TEST SITES
LANDSAT
AIRCRAFT
FIELD
JSC
DIGITIZED GROUND-TRUTH MAP

NASA-S-78-16715

USE OF FIELD DATA TO EVALUATE CLASSIFICATION ACCURACY



NASA-S-78-16716

DATA QUANTITIES FOR BLIND SITES

- ABOUT 64 000 ANALYST LABELS
- 14 000 000 PIXELS IN CLASSIFICATION MAPS
- GROUND-TRUTH INVENTORIES = 6000 SQUARE MILES
  - THIS IS EQUIVALENT TO PRODUCING AN INVENTORY MAP OF THE STATE OF NEW JERSEY AT 1/6-ACRE RESOLUTION

NASA-S-78-16717

LACIE GROUND-TRUTH DATA

PHASE I

- 27 U.S. INTENSIVE TEST SITES AND 2 CANADIAN INTENSIVE TEST SITES
  - WALL-TO-WALL INVENTORY NEAR WHEAT HARVEST
  - OBSERVATION OF CROP CONDITIONS ON ABOUT 40 FIELDS EACH 18 DAYS
  - YIELD AND RAINFALL ON SELECTED FIELDS
- SHORTCOMINGS
  - ITS'S CHOSEN TO INCLUDE HIGH PERCENTAGE OF WHEAT
  - TOO FEW SITES TO REPRESENT SEVERAL HUNDRED SITES IN USGP
- 29 BLIND SITES CHOSEN IN MONTANA AND NORTH DAKOTA
  - WALL-TO-WALL INVENTORIES
  - PLANIMETRY USED TO DETERMINE SMALL GRAINS PROPORTION

NASA-S-78-10907

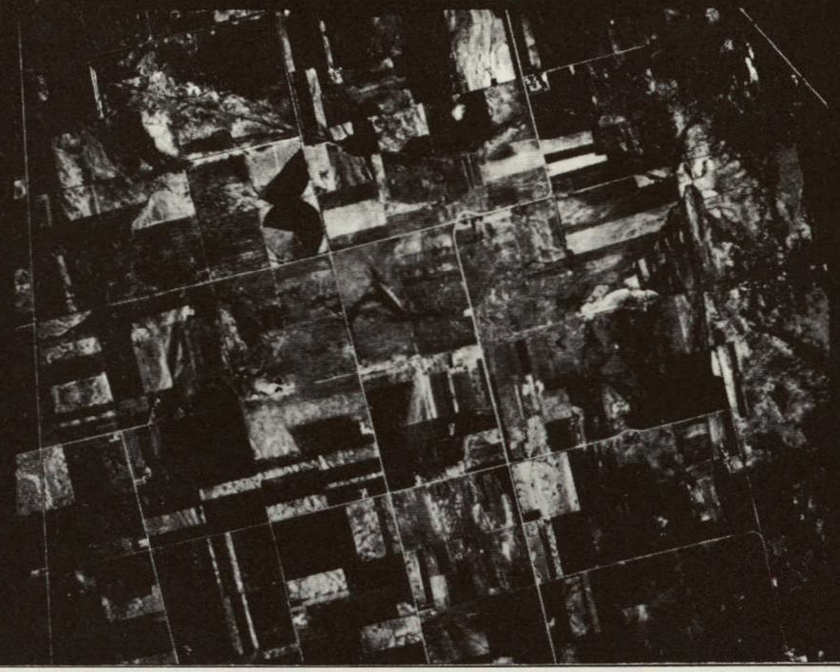
BLIND SITE EXAMPLE - SITE 1523

WILKIN COUNTY, MINNESOTA,
COUNTY INVENTORY - AUG 1, 1977

NASA-S-78-10904

BLIND SITE EXAMPLE - SITE 1523

WILKIN COUNTY, MINNESOTA - JUNE 1, 1977
AIRCRAFT PHOTOGRAPH



NASA-S-78-16718

LACIE GROUND-TRUTH DATA (CONT)

PHASE II

- 29 INTENSIVE TEST SITES
- 150 BLIND SITES IN THE 9 STATES IN USGP
- PLANIMETRY USED TO DETERMINE WHEAT AND SMALL GRAINS PROPORTION

NASA-S-78-16719

LACIE GROUND-TRUTH DATA (CONT)

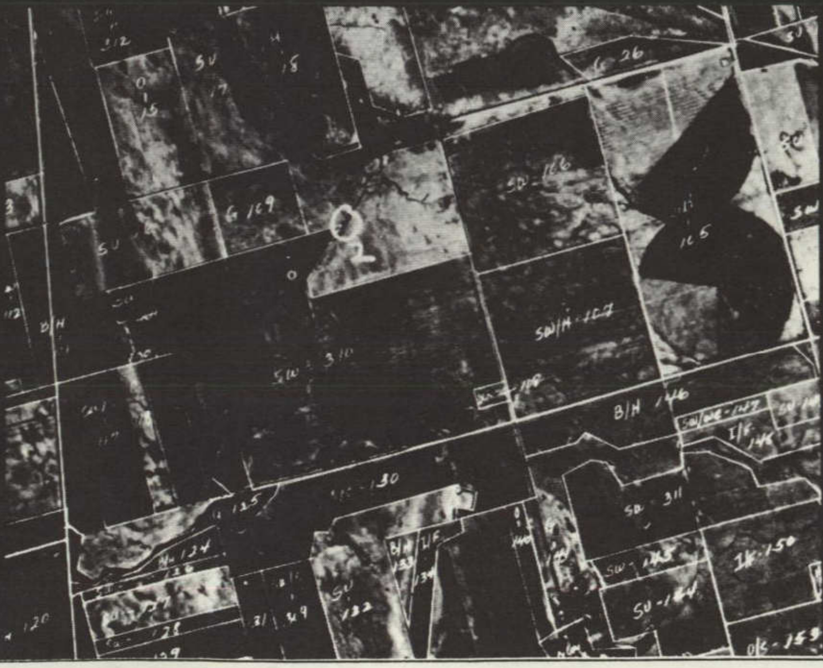
PHASE III

- 24 U.S. INTENSIVE TEST SITES
- 20 CANADIAN INTENSIVE TEST SITES
- 171 U.S. BLIND SITES
- 15 WHEAT FIELDS CHOSEN BY FIELD OBSERVATIONS EACH 18 DAYS
- 400-DOT PROCEDURE GIVES EARLY ESTIMATE OF WHEAT AND SMALL GRAINS
- ALL CROP PROPORTIONS ARE DETERMINED

NASA-S-78-10903

BLIND SITE EXAMPLE - SITE 1523

WILKIN COUNTY, MINNESOTA
FIELD DELINEATIONS - CARTOGRAPH LAB
PORTION EXPANDED

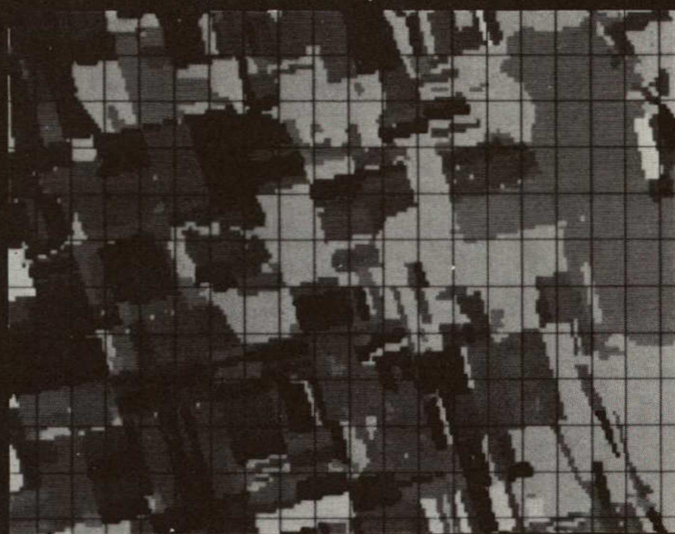


NASA-S-78-12518

DIGITIZED GROUND TRUTH REGISTERED TO LANDSAT IMAGERY

LACIE SEGMENT 1523, PHASE III, BLIND SITE

WILKIN COUNTY, MINNESOTA



INVENTORY DATE, AUGUST 1, 1977

NASA-S-78-16720

- SPRING WHEAT – SALMON PINK
- HARVESTED SPRING WHEAT – LIGHT PINK
- OTHER SPRING GRAINS – PINK
- HARVESTED OTHER SPRING GRAINS – GOLD
- OTHER CROPS (CORN, SUNFLOWER, SOYBEANS, SUGAR BEETS) – RED
- PASTURE, GRASS, HAY, ALFALFA – BLUE
- IDLE FALLOW, IDLE COVER CROPS, IDLE RESIDUE – GRAY
- NONAGRICULTURE (TREES, HOMESTEAD) – GREEN

NASA-S-78-12517

LACIE PHASE III, BLIND SITE 1523

WILKIN COUNTY, MINNESOTA

BIOWINDOW 1, BIOSTAGE 1.5 — BIOWINDOW 2, BIOSTAGE 4.3

PLANTED APR 30, 1977 — 16 - 30 IN. WHEAT, JUNE 23, 1977

NASA-S-78-16721

DOT-LABELING ACCURACY AND ESTIMATED PROPORTION ACCURACY FOR SEGMENT 1523

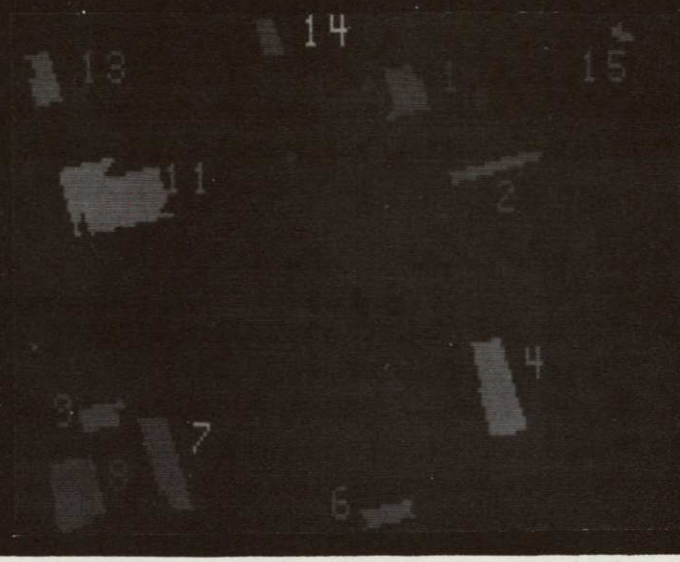
ACQUISITION DATES, 1977	ESTIMATED SW, PERCENT	DOT TYPE	SMALL GRAINS DOTS CORRECT, PERCENT	OTHER DOTS CORRECT, PERCENT
APR 30, MAY 18	11.0	2 1	25 80	97 76
APR 30, JUNE 5, JUNE 24	22.4	2 1	80 63	81 76
APR 30, JUNE 5, JUNE 24	24.0	2 1	82 80	85 76
APR 30, JUNE 24, JULY 29	24.3	2 1	79 93	83 100
GROUND TRUTH	20.3			

NASA-S-78-12516

DIGITIZED GROUND TRUTH REGISTERED TO LANDSAT IMAGERY

LACIE SEGMENT 1523, PHASE III, BLIND SITE

WILKIN COUNTY, MINNESOTA, 1977



NASA-S-78-16722

CROP DEVELOPMENT OBSERVATION FORM

COUNTY: WILKIN SEGMENT NUMBER: 1523

STATE: MINNESOTA SATELLITE PASS DATE: 6-24-77

FIELD OBSERVATION DATE: 6-24-77

FIELD NUMBER	PLANT HEIGHT, IN.	GROUND COVER, PERCENT	COMMENTS
1	18	80 – 100	
2	21	80 – 100	
3	22	80 – 100	
4	22	60 – 80	
5			WHEAT DESTROYED; RESEEDED SUNFLOWERS
14	24	60 – 80	
15	26	80 – 100	

NASA-S-78-16723

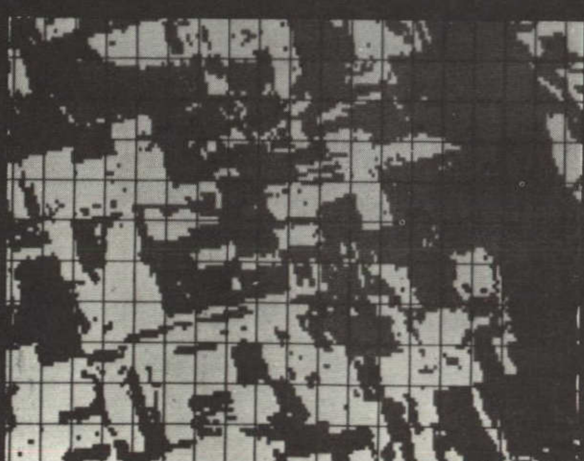
CLASSIFICATION ACCURACY USING BIOSTAGES 1.5, 3.5, AND 4.3 FOR SEGMENT 1523

FIELD NO.		PERCENT CORRECT SMALL GRAIN
BELOW AVERAGE	1	64
	2	68
	5	20
	6	95
	9	98
AVERAGE	4	96
	10	100
	11	100
	12	100
	14	96
ABOVE AVERAGE	3	95
	7	94
	8	98
	13	100
	15	100

NASA-S-78-16724

BLIND SITE EXAMPLE - SITE 1523
WILKIN COUNTY, MINNESOTA COMPUTER-GENERATED CLASSIFICATION MAP

JULY 29, 1977



CLASSIFICATION MAP

BLACK – THRESHOLD

GREEN – SPRING SMALL GRAINS

ORANGE – NONSPRING SMALL GRAINS

NASA-S-78-16725

OMISSION-COMMISSION ERROR RATES FOR SMALL GRAINS AND NON-SMALL-GRAINS

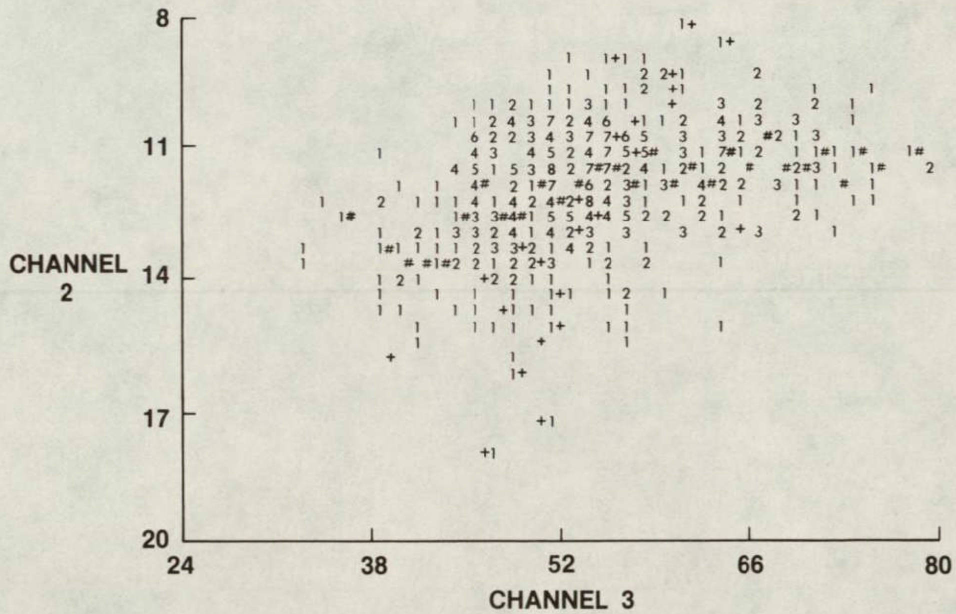
CODE:

$$\frac{\text{SUBPIXELS CLASSIFIED SMALL GRAINS}}{\text{SUBPIXELS GROUND-TRUTH SMALL GRAINS}} = 0.85$$

$$\frac{\text{SUBPIXELS CLASSIFIED NON-SMALL-GRAIN}}{\text{SUBPIXELS GROUND-TRUTH NON-SMALL-GRAINS}} = 0.81$$

NASA-S-78-16726

SCATTER PLOT OF SEGMENT 1523 FOR JUNE 24, 1977 SPRING WHEAT IN POORLY DRAINED SOIL



NASA-S-78-16727

MAJOR ERROR SOURCES FOUND IN LACIE SMALL GRAINS CLASSIFICATION

- MISLABELING DUE TO ABNORMAL SIGNATURE DEVELOPMENT CAUSED BY
  - LATE PLANTING
  - DROUGHT
  - CATTLE GRAZING
  - CROP ROTATION
  - VARIETY
  - DISEASE
  - SOIL VARIABILITY
  - OBSERVED OVER LARGE AREAS OF U.S. BUT NOT AS EVIDENT IN U.S.S.R.

(e.g., OKLAHOMA)
DROUGHT
IN PHASE II

- INADEQUACY OF THE LANDSAT SCANNER IN RESOLVING SMALL FIELDS (e.g., MONTANA AND NORTH DAKOTA)
- MISLABELING OF SMALL GRAINS, GRASSES, PASTURE, AND IDLE FALLOW WHEN KEY ACQUISITIONS ARE MISSING
  - ONE OR TWO SEGMENTS PER STATE ARE USUALLY AFFECTED

NASA-S-78-16728

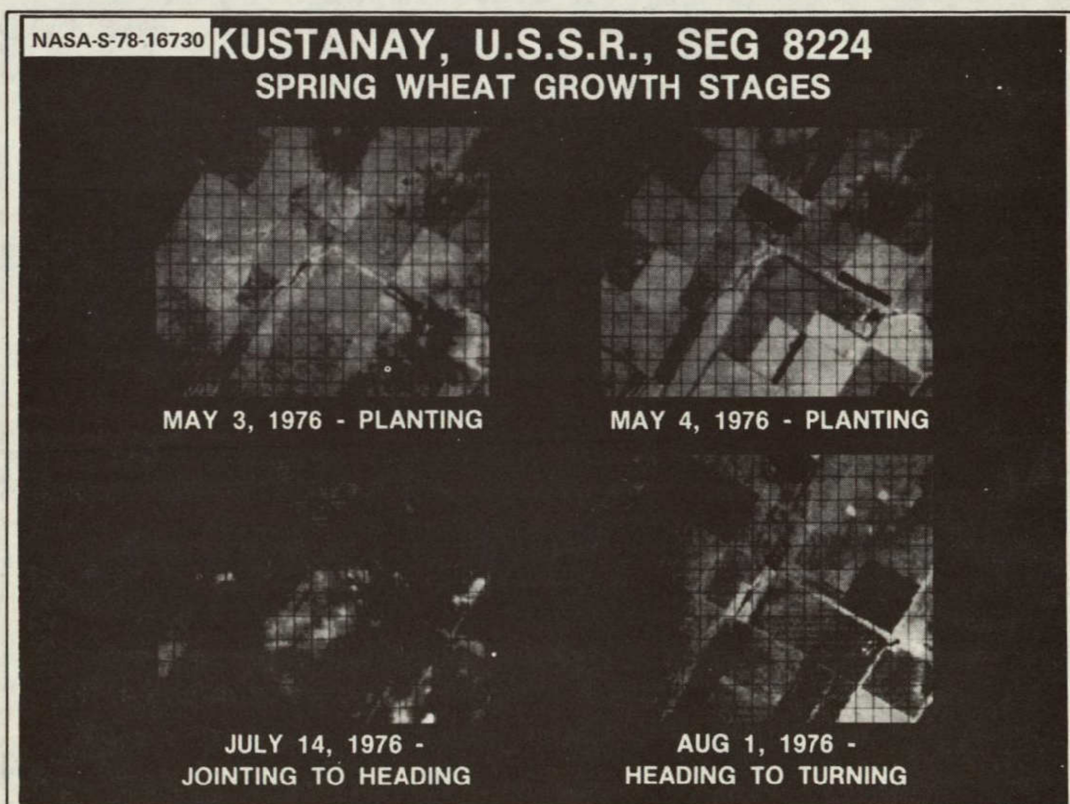
WHEAT SIGNATURE

VARIABILITY DUE TO DROUGHT
SEGMENT 1232 KIOWA, OKLAHOMA
1976 CROP YEAR

NOV 24, 1975 APR 16, 1976

NUMBER INDICATES BIOWINDOW


NASA-S-78-16729
STRIP-FALLOW FIELDS IN MONTANA
AUG 8, 1977


NASA-S-78-16730
KUSTANAY, U.S.S.R., SEG 8224
SPRING WHEAT GROWTH STAGES
MAY 3, 1976 - PLANTING
MAY 4, 1976 - PLANTING
JULY 14, 1976 - JOINTING TO HEADING
AUG 1, 1976 - HEADING TO TURNING

NASA-S-78-16731

DIGITAL GROUND TRUTH

- USABLE FOR STUDIES OF ALL LACIE DATA RECORDED AT PIXEL LEVEL
  - GROUND TRUTH
  - LANDSAT DATA
  - ANALYST LABELING
  - CLASSIFICATION MAPS
  - CLUSTER MAPS
- AS WELL AS LACIE DATA RECORDED AT THE FIELD LEVEL
  - CROP STAGE DEVELOPMENT
  - YIELD
  - RAINFALL
  - FERTILIZER EFFECTS
  - IRRIGATION EFFECTS
  - SOIL TYPES
  - ATMOSPHERIC OPTICAL DEPTH

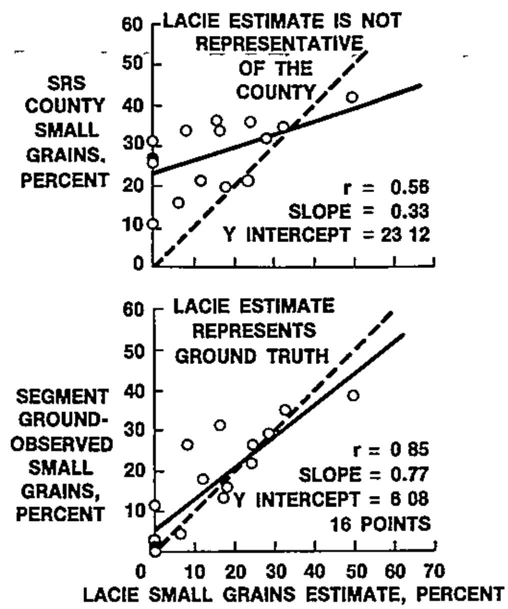
NASA-S-78-16732

DIGITAL GROUND TRUTH

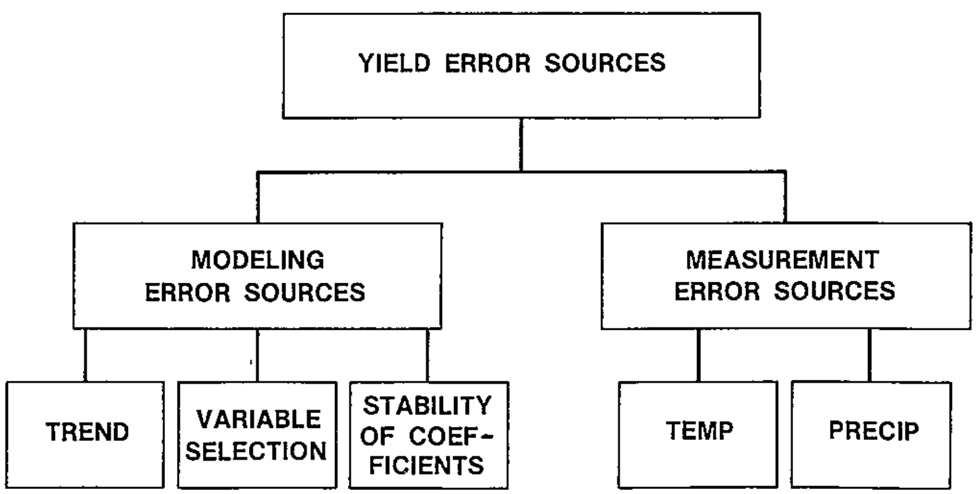
- IMPORTANT FOR NON-ACCURACY ASSESSMENT ACTIVITIES
  - CLASSIFICATION TECHNIQUE DEVELOPMENT
  - SPECTROMET YIELD MODEL DEVELOPMENT
  - SPECTROMET CROP DEVELOPMENT MODELING
  - NASA SUPPORTING RESEARCH AND TECHNOLOGY

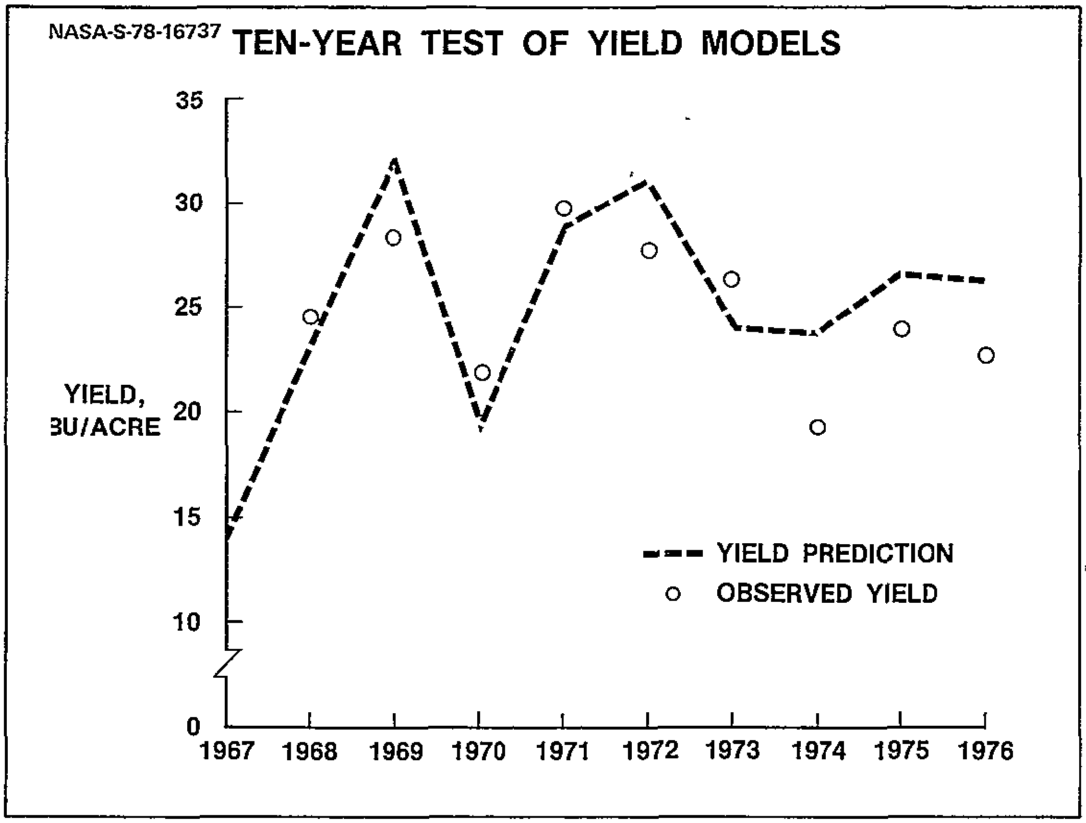
NASA-S-78-16735

PHASE I EXAMPLE OF SAMPLING ERROR FOUND IN NORTH DAKOTA

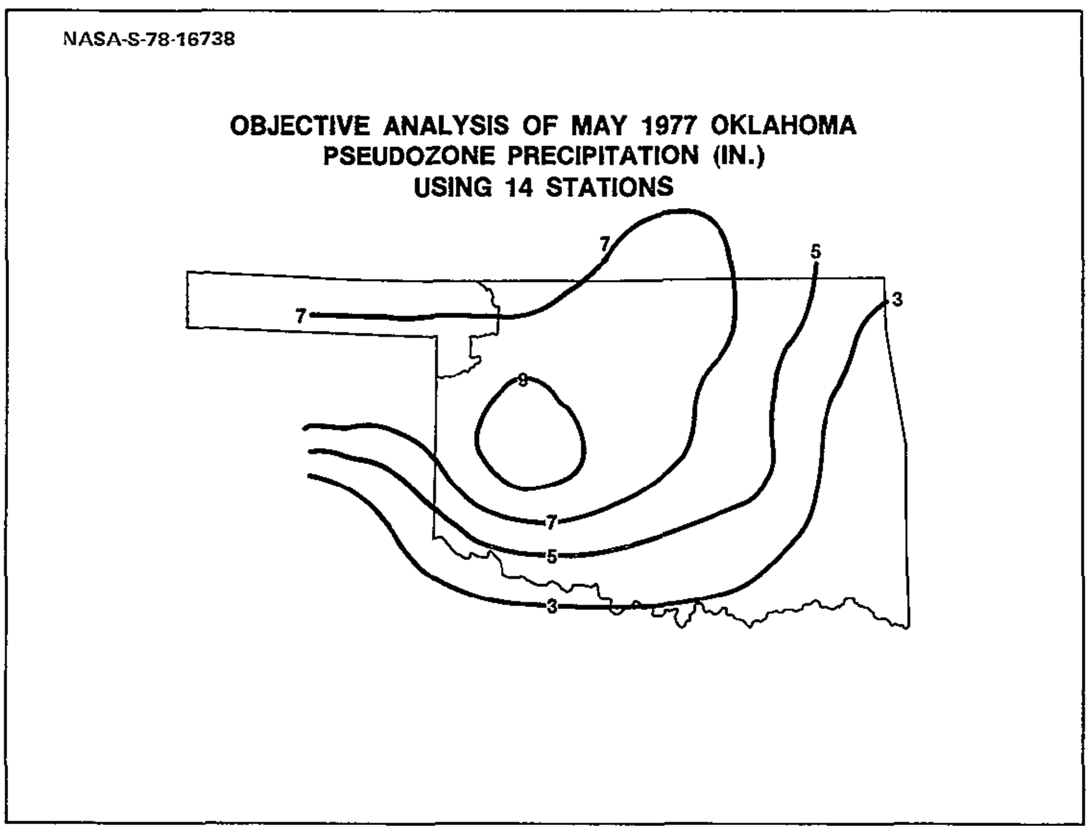


NASA-S-78-16736





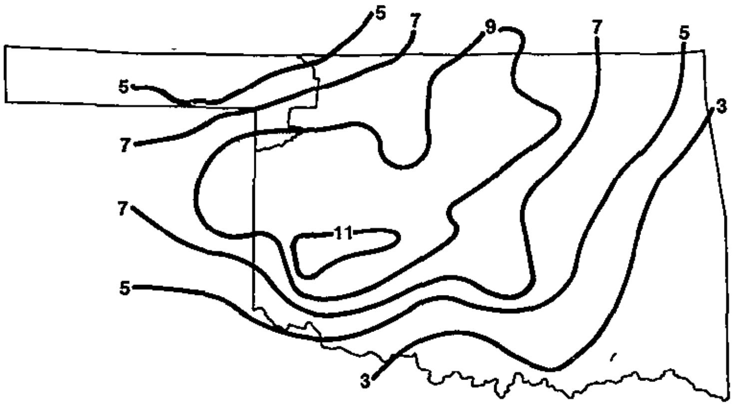
NASA-S-78-16737
TEN-YEAR TEST OF YIELD MODELS
YIELD, BU/ACRE
35
30
25
20
15
10
0
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
YIELD PREDICTION
OBSERVED YIELD



NASA-S-78-16738
OBJECTIVE ANALYSIS OF MAY 1977 OKLAHOMA
PSEUDOZONE PRECIPITATION (IN.)
USING 14 STATIONS
7
5
3
9

NASA-S-78-16739

OBJECTIVE ANALYSIS OF MAY 1977 OKLAHOMA PSEUDOZONE PRECIPITATION (IN.) USING 147 STATIONS



NASA-S-78-16740

ANALYSIS OF SAMPLE ERROR OKLAHOMA - MAY 1977 PRECIPITATION

CLIMATIC DISTRICT	PRECIPITATION (IN.) OBJECTIVE ANALYSIS		LACIE SYNOPTIC ANALYSIS
	SPARSE	DENSE	
SC	4.68	5.08	–
SE	2 31	3 10	–
NC	8 05	9.08	–
C	7.34	8.13	–
WC	9.01	10.17	–
SW	7.33	8.64	–
NE	5.13	6.02	–
STATE	7.71	8.76	8.90

NASA-S-78-16741

OKLAHOMA YIELD MODEL FOR PHASE III

- OBJECTIVE SELECTION OF VARIABLES BY AA AGREED WELL WITH LACIE VARIABLES

LATENT ROOT VARIABLES SELECTED	LACIE PHASE III VARIABLES SELECTED
OCTOBER PRECIPITATION	AUGUST—FEBRUARY PRECIP
MARCH PRECIPITATION	MARCH PRECIP – EVAPOTRANSPIRATION
MAY PRECIPITATION	MAY PRECIPITATION
	MAY PRECIPITATION SQUARED
JUNE PRECIPITATION	JUNE PRECIPITATION
MARCH TEMPERATURE	–
JUNE TEMPERATURE	–
	MAY DEGREE DAYS ABOVE 90°

- TECHNOLOGY TREND WAS FOUND TO BE MAJOR SOURCE OF ERROR IN THE LACIE ESTIMATES

SYSTEM IMPLEMENTATION AND OPERATIONS SESSION

LACIE AES EFFICIENCY REPORT

T. White, JSC

NASA-S-78-16975

LACIE AES EFFICIENCY REPORT

NASA-S-78-16976

LACIE EFFICIENCY ASSESSMENT

- OBJECTIVES
  - MONITOR SYSTEM EFFICIENCY IN RELATIONSHIP TO PROJECT GOALS
  - COLLECT INFORMATION FOR DESIGN OF FUTURE SYSTEM
- APPROACH
  - MONITOR THE OPERATION OF ALL SUBSYSTEMS
  - FOCUS ON THROUGHPUT AND TIMELINESS OF DATA AND PRODUCTS

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SUBSYSTEM TURNAROUND TIME

AGGREGATION AND REPORTING

- PRODUCED TIMELY CROP ASSESSMENT REPORTS ON A MONTHLY BASIS
- 3- TO 7-DAY TURNAROUND TIME
  - UPDATE DATA BASES
  - AGGREGATE AREA AND YIELD ESTIMATES
  - PREPARE NARRATIVE AND PRODUCE REPORT

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SUBSYSTEM TURNAROUND TIME (CONT)

YIELD

- PRODUCED TIMELY YIELD ESTIMATES ON A MONTHLY BASIS
- TURNAROUND TIME: 4 DAYS DOMESTIC, 9-12 DAYS FOREIGN
  - PROCESS METEOROLOGICAL DATA FROM END-OF-MONTH SUMMARY
  - OPERATE YIELD MODELS AND TRANSMIT DATA TO JSC

NASA-S-78-16979

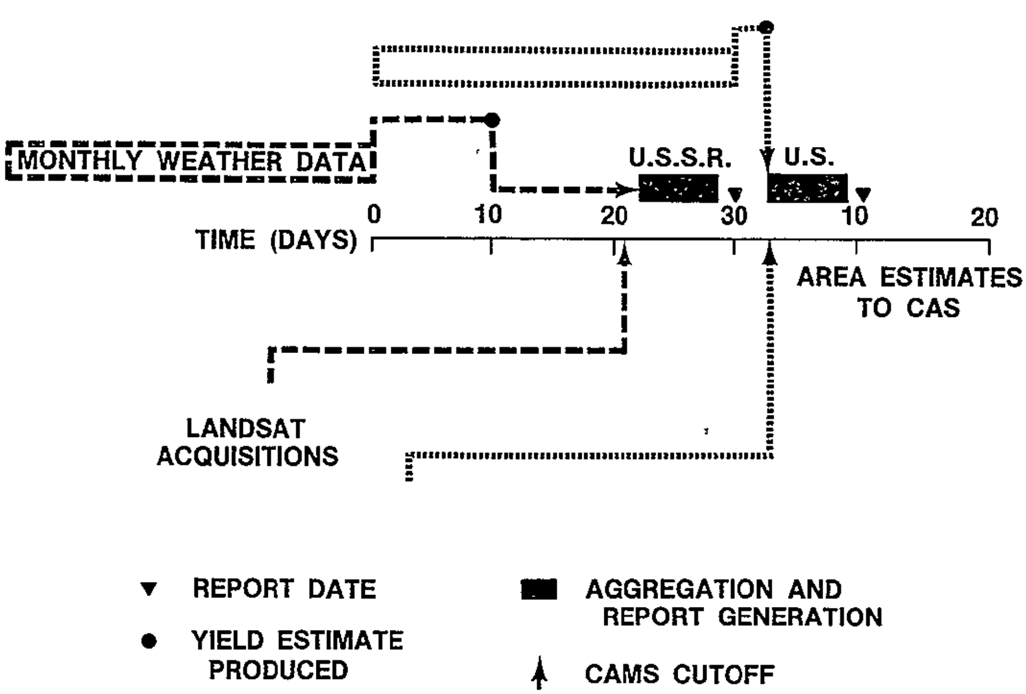
SUBSYSTEM TURNAROUND TIME (CONT)

AREA

- CONTINUOUS FLOW OF DATA FROM LANDSAT
- SPECIFIC DATA COLLECTED DEPENDED ON WEATHER
- 30-DAY NOMINAL TURNAROUND TIME
- RESOURCE CONSTRAINTS ENCOUNTERED
- NOMINAL TURNAROUND TIME EXCEEDED

NASA-S-78-16980

LACIE DATA/TIME FLOW



NASA-S-78-16981

LACIE AVERAGE THROUGHPUT TIME

- TURNAROUND TIME EXCESSIVE DUE TO BACKLOGS AT GSFC AND IN CLASSIFICATION AREA CAUSED BY AVERAGE LOAD STAFFING

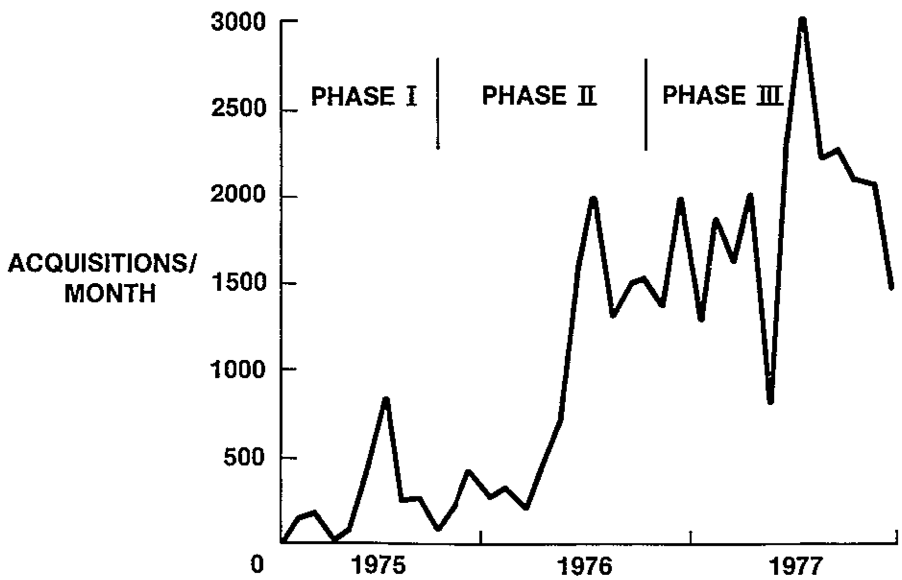
PHASE I – 40 DAYS (10-DAY CAMS BACKLOG)

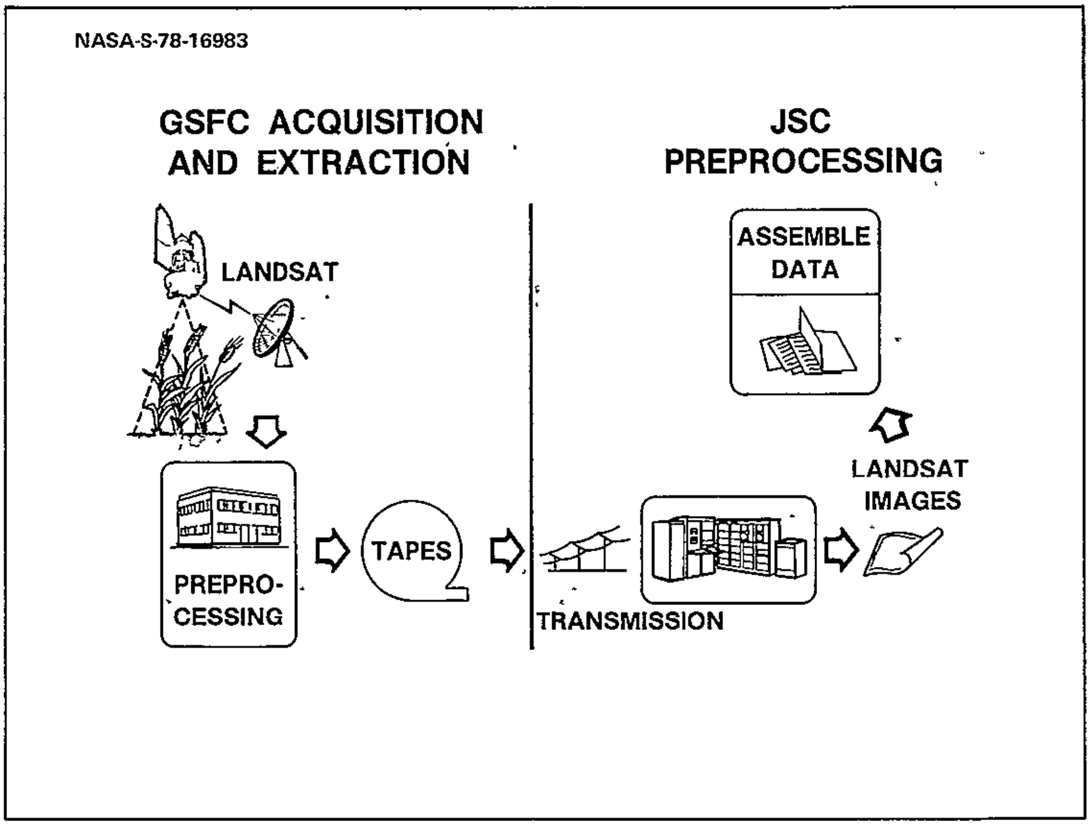
PHASE II – 33 DAYS (4-DAY GSFC BACKLOG)

PHASE III – 50 DAYS (12-DAY GSFC BACKLOG AND 8-DAY CAMS BACKLOG)

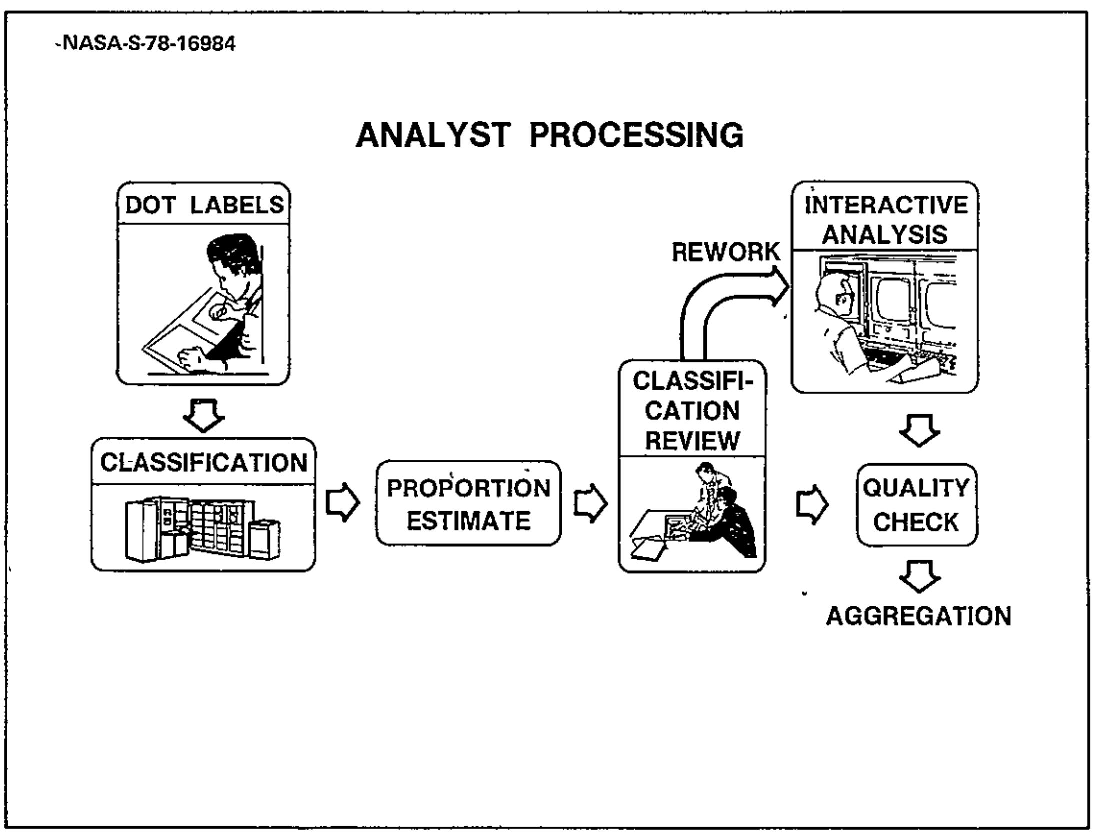
NASA-S-78-16982

LANDSAT ACQUISITIONS RECEIVED AT JSC





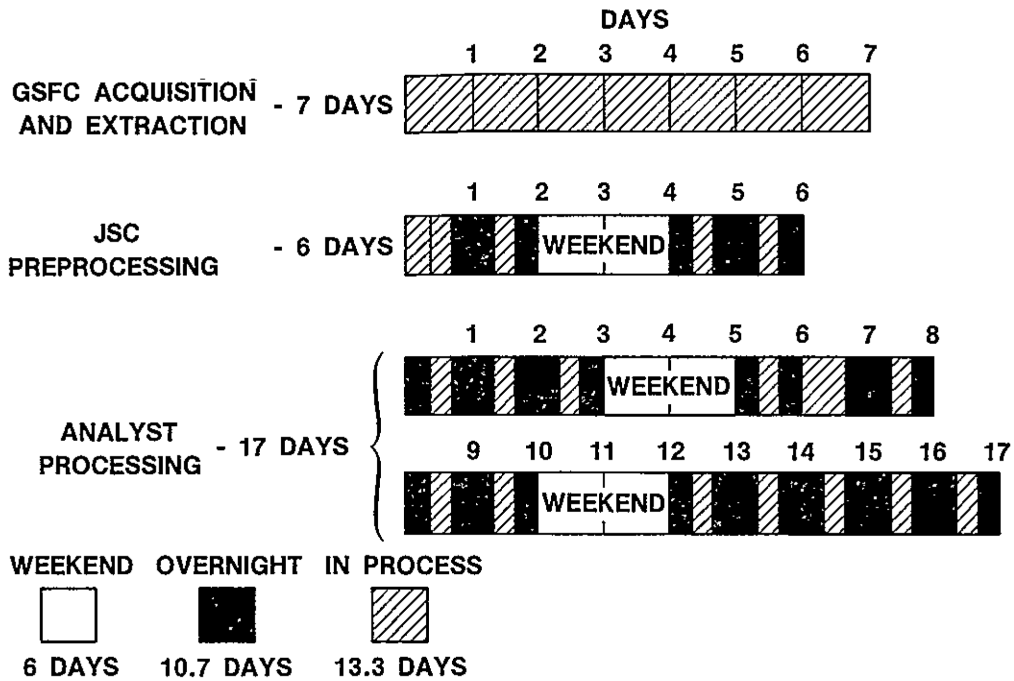
NASA-S-78-16983
GSFC ACQUISITION AND EXTRACTION
JSC PREPROCESSING
LANDSAT
PREPRO-CESSING
TAPES
TRANSMISSION
ASSEMBLE DATA
LANDSAT IMAGES



NASA-S-78-16984
ANALYST PROCESSING
DOT LABELS
CLASSIFICATION
PROPORTION ESTIMATE
CLASSIFI-CATION REVIEW
REWORK
INTERACTIVE ANALYSIS
QUALITY CHECK
AGGREGATION

NASA-S-78-16985

LANDSAT DATA PROCESSING TIME LINE



NASA-S-78-16986

NOMINAL THROUGHPUT TIME

- LACIE THROUGHPUT TIME FOR ALL PHASES (WITHOUT BACKLOGS) WAS APPROXIMATELY 30 DAYS
  - RESULTED FROM MOST COMPONENTS WORKING ONE SHIFT 5 DAYS PER WEEK
  - A VERY FRAGMENTED DATA PROCESSING SYSTEM
  - NUMEROUS MANUAL ACTIVITIES

	NOMINAL LACIE PROCESSING TIME	GOAL
GSFC ACQUISITION AND EXTRACTION	7 DAYS	5 DAYS
JSC PREPROCESSING	6 DAYS	4 DAYS
ANALYST PROCESSING	17 DAYS	5 DAYS

NASA-S-78-16987

EFFICIENCY OBSERVATIONS

- LACIE PROCESSING SYSTEM ENCOUNTERED SIGNIFICANT INCREASES IN SCOPE, DATA LOAD, AND COMPLEXITY
  - MANY SYSTEM COMPONENTS DID NOT HAVE SIGNIFICANT INCREASES IN RESOURCES
  - CONSEQUENTLY, SYSTEM EFFICIENCIES WERE IMPLEMENTED
- YIELD ESTIMATION AND PRODUCTION ESTIMATION OPERATIONAL GOALS WERE MET WITH IMPLEMENTED SYSTEMS

NASA-S-78-16988

EFFICIENCY OBSERVATIONS (CONT)

- TIMELINESS GOAL FOR AREA ESTIMATION WAS NOT ACCOMPLISHED
  - DISPERSIVE SYSTEM
  - MANUAL ACTIVITIES
  - ONE SHIFT/DAY 5 DAYS/WEEK
- INDICATIONS ARE THAT A CONSOLIDATED/ INTERACTIVE DATA PROCESSING SYSTEM WITH ADEQUATE RESOURCES COULD MEET THE 14-DAY TURNAROUND GOAL

DATA PROCESSING SYSTEMS DESIGN SESSION

DATA PROCESSING SYSTEMS OVERVIEW

D Hay, JSC

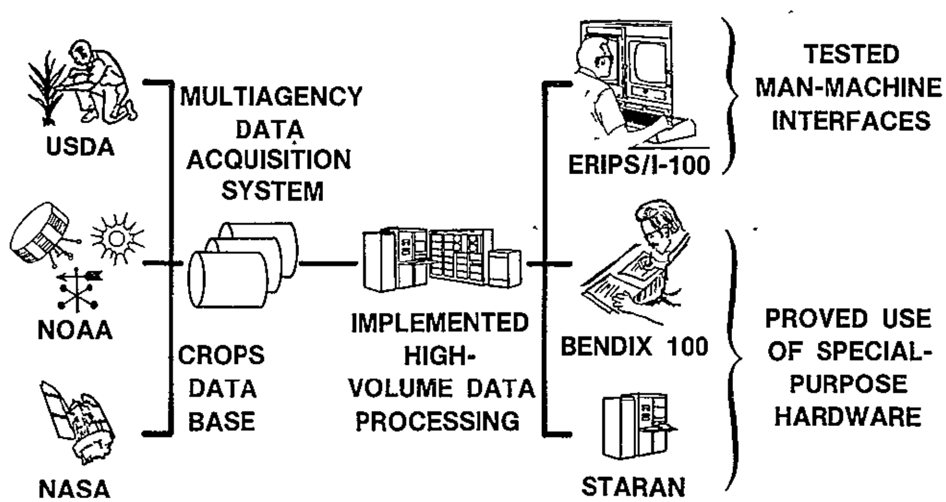
NASA-S-78-16640

DATA PROCESSING SYSTEMS IN SUPPORT OF LACIE AND FUTURE AGRICULTURAL RESEARCH PROGRAMS

NASA-S-78-16641

DATA PROCESSING HIGHLIGHTS

- IMPLEMENTED THE FIRST COMPLETE DATA SYSTEM TAILORED TO LARGE-SCALE AGRICULTURAL INVENTORY USE



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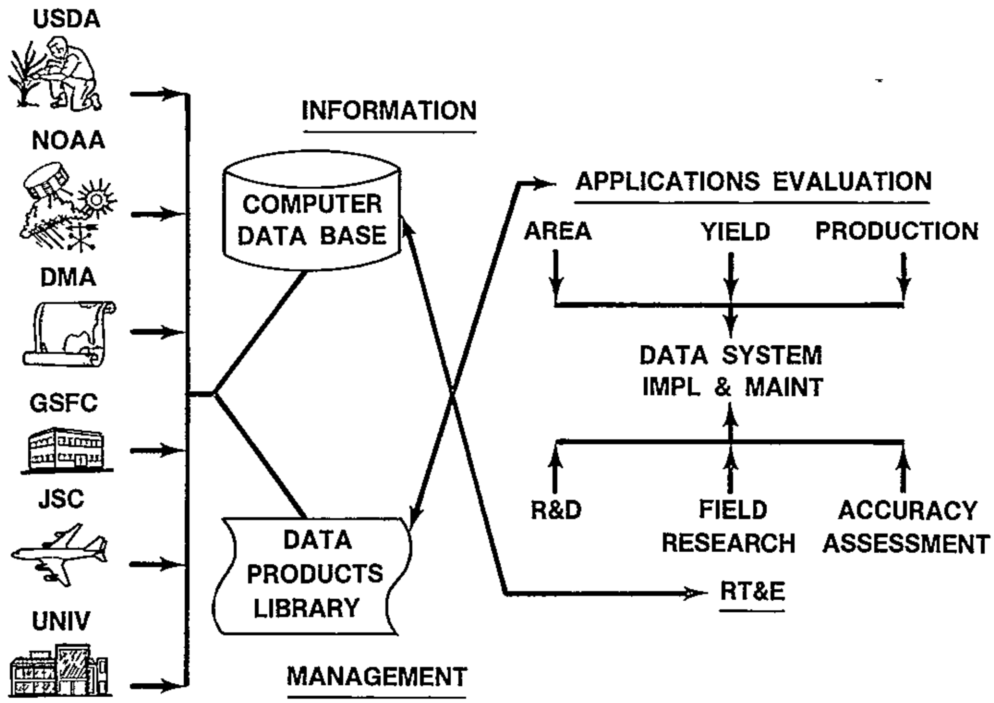
DATA SYSTEM TASKS



NASA-S-78-16643

THE INITIAL SITUATION

- NO DATA COLLECTION PROCEDURES
- NO LACIE IMAGERY "SEGMENTS"
- RUDIMENTARY MET SUMMARIES
- FEW MAP OR FILM PRODUCTS
- SMALL-SCALE DATA BASES
- LITTLE CONFIGURATION CONTROL
- LITTLE SYSTEMS INTEGRATION

- INVESTIGATIVE AREA ESTIMATION TOOLS
- NO YIELD CAPABILITY
- NO PRODUCTION CAPABILITY

NASA-S-78-16644

DATA PROCESSING SYSTEM SCOPE

ORIGINAL SCOPE

- 2-YEAR PROJECT
- 8 COUNTRIES
- 4800 LANDSAT SEGMENT CAPACITY IN 2ND YEAR
- 14-DAY SEGMENT THROUGHPUT
- MONTHLY PRODUCTION REPORTING
- INTEGRATED SYSTEM

NASA-S-78-16645

DATA PROCESSING SYSTEM SCOPE

ORIGINAL SCOPE

- 2-YEAR PROJECT
- 8 COUNTRIES
- 4800 LANDSAT SEGMENT CAPACITY IN 2ND YEAR
- 14-DAY SEGMENT THROUGHPUT
- MONTHLY PRODUCTION REPORTING
- INTEGRATED SYSTEM

ISSUES

- INSUFFICIENT LOCAL CAPABILITY
- LIMITED FUNDS
- LIMITED SKILLS
- LONG IMPLEMENTATION SCHEDULES

NASA-S-78-16646

DATA PROCESSING SYSTEM SCOPE

ORIGINAL SCOPE

- 2-YEAR PROJECT
- 8 COUNTRIES
- 4800 LANDSAT SEGMENT CAPACITY IN 2ND YEAR
- 14-DAY SEGMENT THROUGHPUT
- MONTHLY PRODUCTION REPORTING
- INTEGRATED SYSTEM

ISSUES

- INSUFFICIENT LOCAL CAPABILITY
- LIMITED FUNDS
- LIMITED SKILLS
- LONG IMPLEMENTATION SCHEDULES

REVISED SCOPE

- 3-YEAR PROJECT
- DISPERSED SYSTEM
- 8 COUNTRIES
- 4800 LANDSAT SEGMENT CAPABILITY IN 3RD YEAR
- DEMONSTRATE 14-DAY THROUGHPUT
- MONTHLY PRODUCTION REPORTING

NASA-S-78-16647

DATA SYSTEMS EVOLUTION

PHASE I (1974-75)

GSFC/LACIE LANDSAT-2 SYSTEM	4800 SEGMENT PREPROCESSOR
PROTOTYPE MET SUMMARIES	YIELD & CC MODEL TEST DATA
INTENSIVE STUDY SITE OPERATIONS	INITIAL AA AND FIELD RESEARCH DATA BASE
ERIPS INFO MGT SYSTEM; STANDARD FILM PRODUCTS; DATA PRODUCTS LIBRARY; LOW INTERACTION S/W	INCREASED THROUGHPUT
PROTOTYPE CAS	STATE/CRD AGGREGATIONS
IMAGE-100	R&D INTELLIGENT TERMINAL

NASA-S-78-16648

DATA SYSTEM EVOLUTION

PHASE II (1975-76)

GSFC HARDLINE	INCREASED RELIABILITY
STARAN AUTOMATED STATUS AND TRACKING	INCREASED THROUGHPUT
MULTIYEAR DATA BASES	OVERLAPPING CROP YEAR PROCESSING
WMO DATA BASE SYNOPTIC MET DATA	FOREIGN CROP CALENDARS
SEMI-INTERACTIVE PROD EST	MULTICOUNTRY PROD EST
INCREASED FIELD STUDY SITES	STUDY ABNORMAL SIGNATURES BROADER FIELD RESEARCH DATA BASES
LANDSAT-2 RECORDER FAILURE	DELAYED U.S.S.R. DATA

NASA-S-78-16649

DATA SYSTEMS EVOLUTION

PHASE III (1976-77)

INCREASED ACQUISITIONS	INCREASED ACCURACY DELAYED GSFC PROCESSING
MORE MET STATIONS DAILY PRECIPITATION	MORE SENSITIVE YIELD MODELS
FULLY INTERACTIVE PROD EST SYSTEM	TIMELY MULTICOUNTRY REPORTING
INCREASED AA SITES AUTOMATED AA PROCEDURES	REPRESENTATIVE AA COVERAGE INCREASED AA ACCURACY
REDUCED LANDSAT-2 TAPE RECORDER USE	DELETED SOUTHERN HEMI-SPHERE DATA

NASA-S-78-16650

SYSTEM EVOLUTION SUMMARY

- EXTENSIVE DATA COLLECTION SYSTEM
- AUTOMATED IMAGERY PREPROCESSING
- WORLDWIDE MET DATA
- EXTENSIVE PHOTO BASE
- ADEQUATE MAP BASE

- AUTOMATED DATA BASES
- AUTOMATED INFO MGT
- EXTENSIVE CONFIGURATION CONTROL
- INTEGRATED PROCEDURES

- PROCEDURE 1
- CORRELATED DATA SETS
- TERMINAL ACCESS TO MET DATA
- COMPUTERIZED YIELD AND CROP CALENDAR
- INTERACTIVE PROD EST
- AUTOMATED AA

NASA-S-78-16651

FUTURE SYSTEM SCOPE

LACIE INFLUENCE

- APPLICATIONS RESEARCH SYSTEM
- INTEGRATED DATA BASE
- MULTIYEAR DATA RETENTION
- COMPONENTS TAILORED TO REMOTE SENSING

FUTURE PROGRAM SCOPE

- MULTICROP ANALYSIS
- BROADER PARTICIPATION
- BUDGETS

TECHNOLOGY UPDATES

- IMPROVED PROCEDURES
- SENSOR RESOLUTION
- LOW-COST ELECTRONICS
- INCREASED AUTOMATION

FACILITIES ROLES

- GSFC SYSTEM MODS
- DOMSAT
- CHANGING AGENCY ROLES

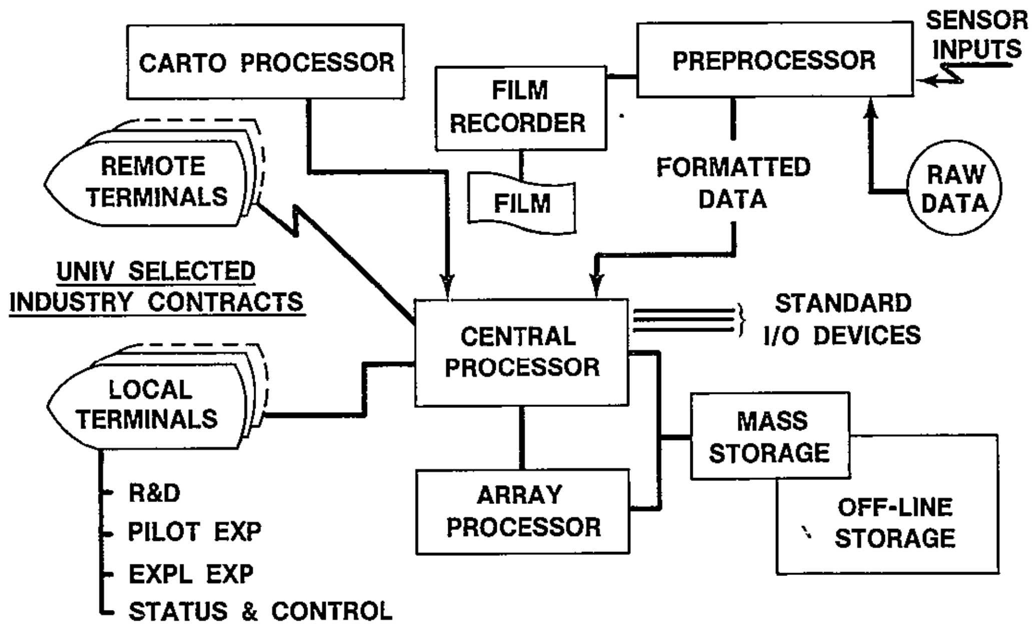
NASA-S-78-16652

THE R&D DATA SYSTEM TASK

- R&D DATA BASE MANAGEMENT
- ALGORITHM IMPLEMENTATION AND TEST
- LIMITED INTEGRATED TEST
- SELECTED UNIVERSITY AND INDUSTRY DATA AND PROCEDURES INTERFACE
- TECHNOLOGY TRANSFER

NASA-S-78-16653

FUTURE REMOTE-SENSING DATA PROCESSING FUNCTIONS



DATA PROCESSING SYSTEMS DESIGN SESSION

EVOLUTION OF THE EARTH RESOURCES INTERACTIVE PROCESSING SYSTEM (ERIPS)

J Lyon, JSC

NASA-S-78-16989

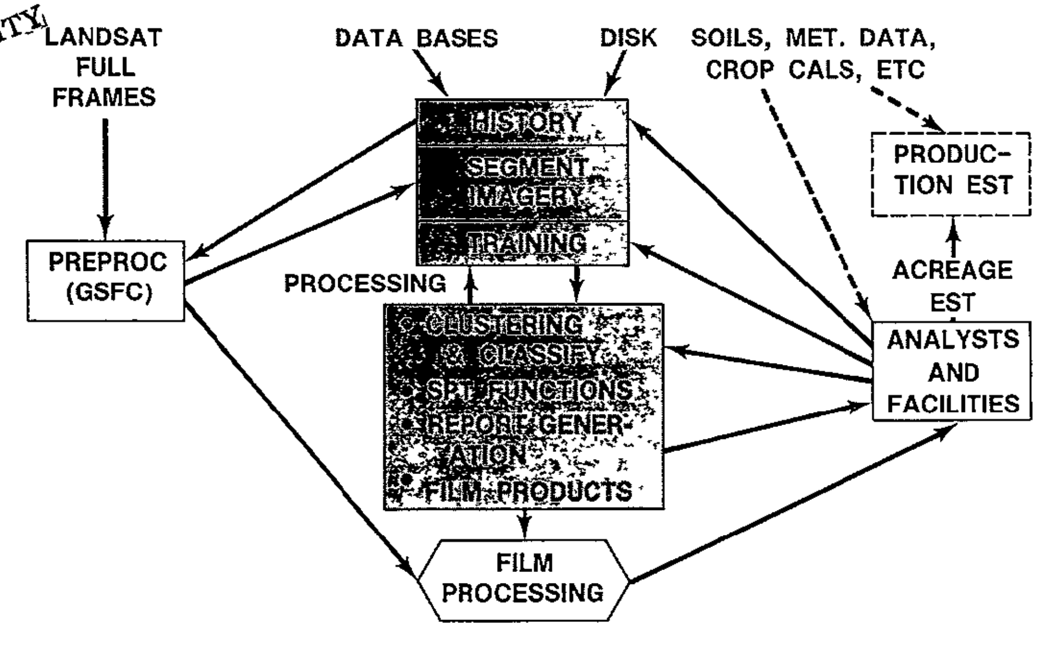
EARTH RESOURCES INTERACTIVE PROCESSING SYSTEM (LACIE/ERIPS) SYSTEM OVERVIEW

PRESENTATION OBJECTIVES

- DEFINITION OF SYSTEM: ITS FUNCTION WITHIN LACIE
- DEVELOPMENT SUMMARY: SIGNIFICANT MILESTONES
  - CONVERSION OF ORIGINAL ERIPS TO LACIE SUPPORT
  - SUBSEQUENT SYSTEM EVOLUTION
- ESTABLISHMENT OF LACIE CONTEXT FOR THE THREE FOLLOWING ERIPS SUBSYSTEM PRESENTATIONS
  - DATA BASES
  - MAN/MACHINE INTERFACES
  - PERIPHERAL PROCESSING

NASA-S-78-16990

ERIPS IN LACIE



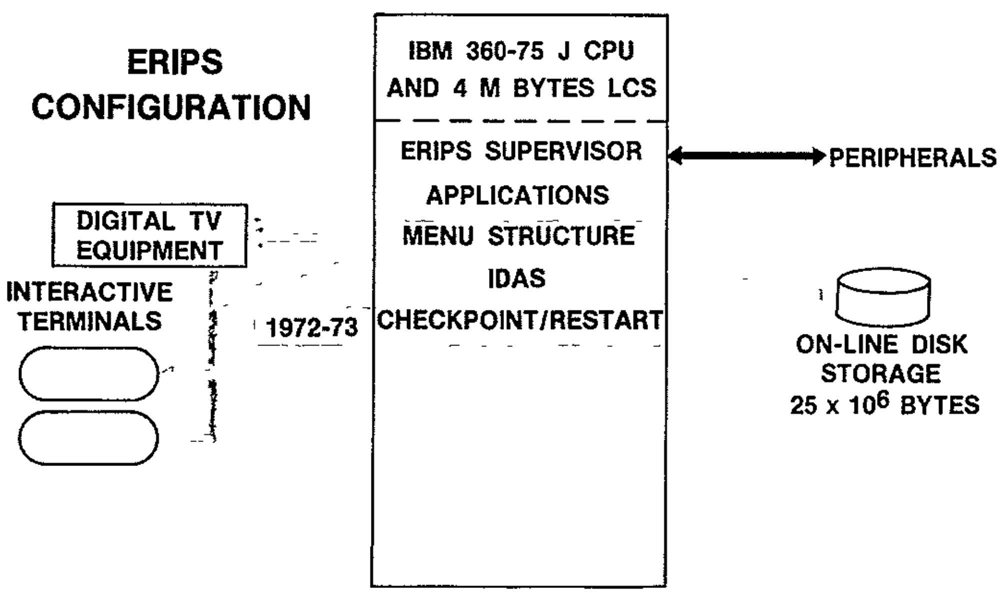
NASA-S-78-16991

PRE-LACIE ERIPS

- CONCEPT: INTERACTIVE IMAGE ANALYSIS USING LARGE PROCESSOR
- DEVELOPMENT
  - LARSYS BASELINE – 1971 TO 1973
  - MENU-BASED INTERFACE TO TWO TERMINALS
  - APPLICATIONS MODIFICATIONS AND AUGMENTATIONS
  - DISK-BASED IMAGE STORAGE
  - ONLY RUDIMENTARY BATCH FEATURES
  - CHECKPOINT/RESTART AND ERROR RECOVERY
- LACIE APPLICABILITY
  - COMPREHENSIVE ANALYSIS FEATURES
  - SCHEDULE MANDATES
  - STRONG EQUIPMENT BASELINE
- LACIE DEFICIENCIES
  - LIMITED ON-LINE DATA STORAGE
  - INADEQUATE THROUGHPUT
    - NO USEFUL BATCH FEATURES
    - CPU CONSTRAINTS

NASA-S-78-16992

ERIPS CONFIGURATION



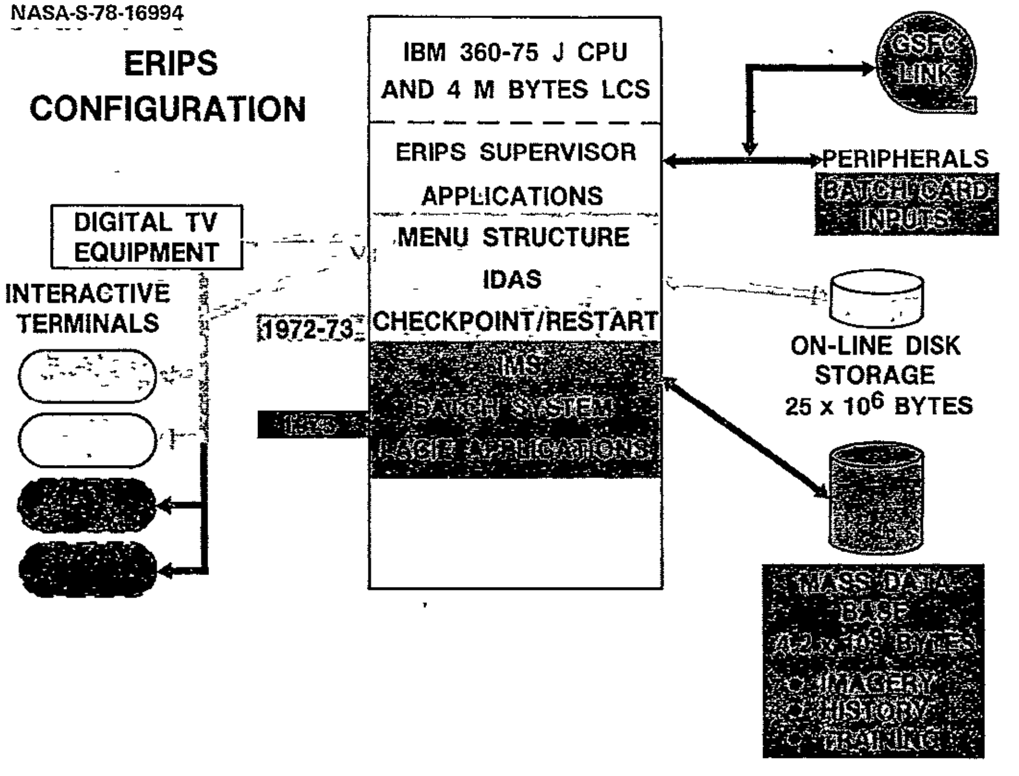
NASA-S-78-16993

EARLY LACIE SUPPORTING DEVELOPMENT

- ESTABLISH COMPLETE BATCH SYSTEM
  - MENU-ANALOG CARD INPUTS
  - SUBSET OF INTERACTIVE SYSTEM
  - IMPROVE SYSTEM THROUGHPUT
- DESIGN AND IMPLEMENT DATA BASES (4 + BILLION BYTES)
  - SIMPLIFY DATA MANAGEMENT PRACTICES
  - PROVIDE OPERATIONAL AND RESEARCH SUPPORT EASILY
  - BUILD GSFC LINKAGE AND SERVICE CONTROL
  - IMPROVE SYSTEM THROUGHPUT
- INTRODUCE NECESSARY APPLICATIONS CHANGES
  - MODIFIED CLASSIFICATION PROCESSING
  - COMPREHENSIVE REPORT AND PRODUCT PREPARATION
- STRENGTHEN SYSTEM INTEGRITY

NASA-S-78-16994

ERIPS CONFIGURATION

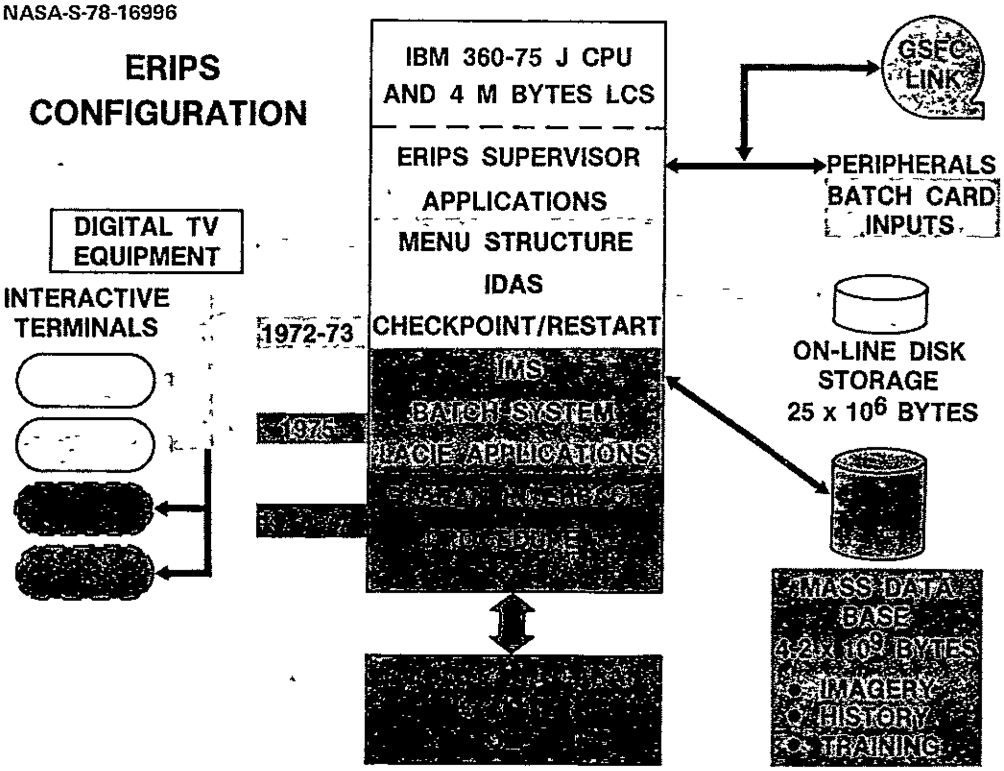


NASA-S-78-16995

CONTINUING LACIE DEVELOPMENT

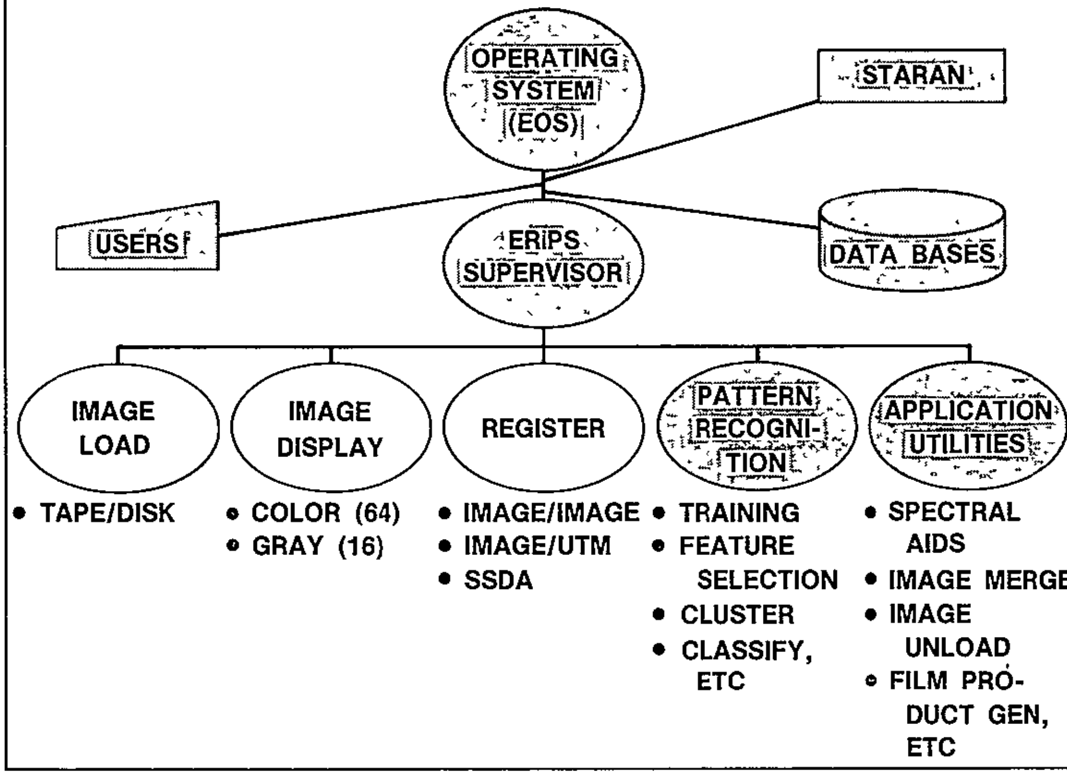
- ADDITION OF SPECIAL-PURPOSE ARRAY PROCESSOR
  - OFF-LOAD OF PATTERN RECOGNITION FUNCTIONS
  - INCREASE OF SYSTEM THROUGHPUT BY 6 TIMES
- CONTINUING APPLICATIONS CHANGES
  - PROCEDURE 1 AND RELATED ANALYSIS SOFTWARE
  - STREAMLINING OF PRODUCTION SOFTWARE

NASA-S-78-16996



NASA-S-78-16997

ERIPS SOFTWARE STRUCTURE



NASA-S-78-16998

SUMMARY

- SUCCESSFUL CONVERSION OF A PRIMARILY INTERACTIVE TOOL WITH LIMITED THROUGHPUT TO A COMPREHENSIVE PRIMARILY BATCH-PRODUCTION SYSTEM
- EXTREME IMPROVEMENT IN SYSTEM CAPACITY DUE LARGELY TO PERIPHERAL PROCESSOR
- HIGHLY RELIABLE SOFTWARE AND PROCEDURES HAVE RESULTED IN MINIMAL DATA LOSS AND MAXIMUM PRODUCTIVITY

THREE SIGNIFICANT COMPONENTS OF THIS DEVELOPMENT ARE DESCRIBED IN THE FOLLOWING PRESENTATIONS

C-3

N79-14474

DATA PROCESSING SYSTEMS DESIGN SESSION

DATA BASE DESIGN CONSIDERATIONS

L. Westberry, IBM/JSC

NASA-S-78-16621

ERIPS DATA BASES-
DESIGN CONSIDERATIONS

NASA-S-78-16622

ERIPS DATA BASES-DESIGN CONSIDERATIONS

- THE ERIPS PROCESSES THAT REQUIRE DATA BASES
- THE IMAGE DATA BASE AS THE CHALLENGE
- THE DESIGN DECISIONS FOR THE IMAGERY DATA BASES
- CONCLUSIONS

NASA-S-78-16623

WHY DIRECT ACCESS DATA BASES

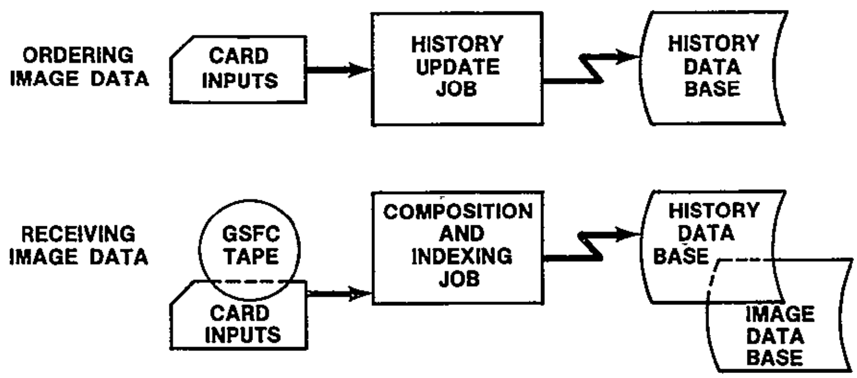
- TO PROVIDE TECHNOLOGY DEMONSTRATION AND PROOF OF CONCEPT
  - BEFORE ERIPS:
    - BATCH MODE, SINGLE USER WITH TAPE AND CARD INPUTS
  - ERIPS OBJECTIVES
    - MULTIPLE USERS
    - INTERACTIVE (REAL-TIME) DECISION
    - COMPLETE DATA AVAILABILITY

NASA-S-78-16624

- ERIPS DATA BASES SHOULD BE OF SUFFICIENT SIZE TO STORE:
  - 4 ACQUISITIONS FOR 3840 SITES
  - 16 ACQUISITIONS FOR 960 SITES
  - THUS, THE MAXIMUM NUMBER OF ACQUISITIONS WAS 30 720

NASA-S-78-16625

ERIPS PROCESSES THAT REQUIRE DATA BASES



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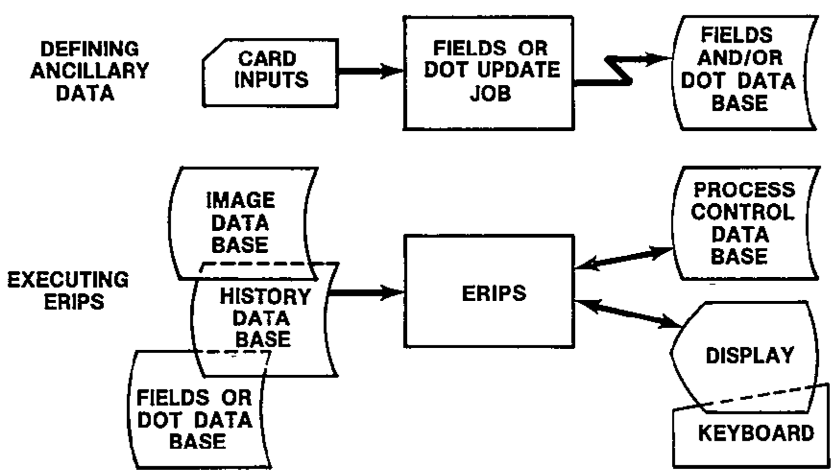
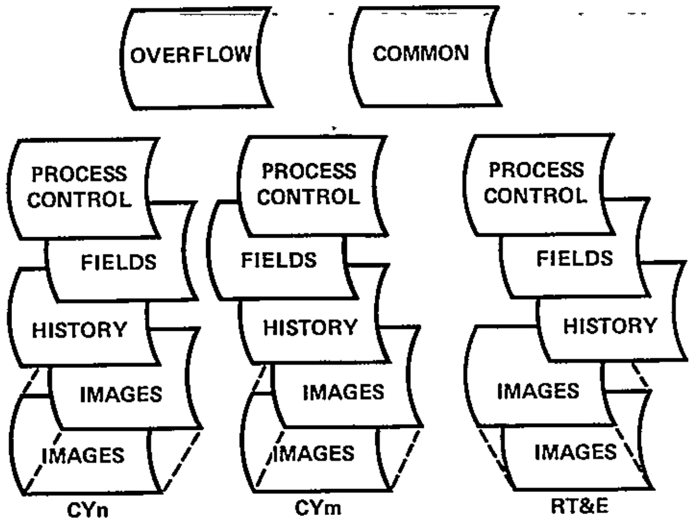
ERIPS PROCESSES THAT REQUIRE DATA BASES (CONT)



NASA-S-78-16627

DATA BASES ON-LINE DURING A SUPPORT PERIOD



NASA-S-78-16628

IMAGE DATA BASE AS THE CHALLENGE

IMAGE DATA BASE SIZE

94 790 BYTES/ACQ
x 30 720 ACQ'S
2 911 948 000 BYTES

FIELDS DATA BASE SIZE

146 FIELDS/SEGMENT
x 120 BYTES/FIELD
17 520 BYTES/FIELD DATA
+ 340 BYTES – HEADER
17 860 BYTES/SITE
x 4 800 SITES
85 728 000 BYTES

NASA-S-78-16629

IMAGE DATA BASE
AS THE CHALLENGE (CONT)

HISTORY DATA BASE SIZE

```
   154 BYTES/SITE – SITE DATA
 +  28 BYTES/SITE – STRATA
   182 BYTES OF SITE INFO
 x 4 800 SITES
873 600 BYTES
     +98 BYTES x 30 720 ACQ'S
3 884 160 BYTES
```

PROCESS CONTROL DATA BASE SIZE

```
  2 334 BYTES/REQUEST
  x 120 REQUESTS
280 080 BYTES
```

NASA-S-78-16630

IMAGE DATA BASE AS THE CHALLENGE

- CROSS REFERENCING
  - ALLOW INVESTIGATORS TO DETERMINE DATA AVAILABILITY
  - CORRELATE ANCILLARY DATA TO IMAGE DATA
- DATA INTEGRITY
  - DATA MUST BE AVAILABLE
- PROCESSING CONSTRAINTS
  - THROUGHPUT TARGETS OF 120 SEGMENTS PER 16-HOUR PERIOD
- COST OBJECTIVES
  - COST EFFECTIVENESS WAS IMPORTANT

NASA-S-78-16631

THE PROBLEM

- DESIGN AND IMPLEMENT A COST-EFFECTIVE DATA BASE STRUCTURE WHICH IS ERROR-PROOF TO SUPPORT THE LACIE IN SUCH A MANNER AS TO ALLOW ANY GIVEN SEGMENT TO BE PROCESSED IN NO MORE THAN 8 MINUTES

NASA-S-78-16632

DESIGN DECISIONS FOR THE IMAGERY DATA BASES

- SIZE CONSIDERATIONS
  - ELIMINATION OF DUPLICATE HEADER INFORMATION SAVED 79 MILLION BYTES
- TWO DESIGNS INITIALLY PROPOSED
  - A MULTIVOLUME, SINGLE-INTEGRATED-IMAGE DATA BASE
  - MULTIPLE-IMAGE DATA BASES

NASA-S-78-16633

DESIGN DECISIONS FOR THE IMAGERY DATA BASES (CONT)

- DATA BASE INTEGRITY CONSIDERATIONS
  - ERROR RECOVERY PROVIDED BY IMS/360 CHECKPOINT/ RESTORE UTILITIES
    - CHECKPOINT TIME WAS THE SAME FOR BOTH DESIGNS – 8.8 HOURS
    - RECOVERY FROM A SINGLE DISK FAILURE (THE MOST PROBABLE)
      - 8 8 HOURS FOR THE MULTIPLE-VOLUME INTEGRATED DATA BASE
      - 18.6 MINUTES FOR THE MULTIPLE-IMAGE DATA BASE DESIGN

THE MULTIVOLUME, SINGLE-DATA-BASE DESIGN ELIMINATED DUE TO RECOVERY CONSIDERATIONS

NASA-S-78-16634

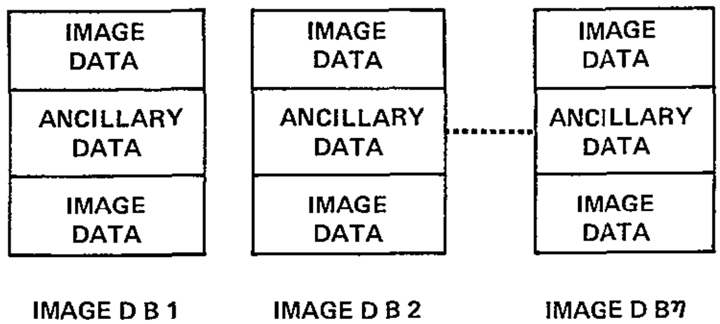
DESIGN DECISIONS FOR THE IMAGERY DATA BASES

- EXPANDING THE MULTIPLE-IMAGE DATA BASE DESIGN
  - ISOLATE THE APPLICATION PROGRAMS FROM MULTIPLE DATA BASES BY USING A MASTER INDEX
  - RANDOMLY DISTRIBUTE THE SITES ACROSS THE DATA BASES TO FORCE EVEN LOADING
  - RANDOMLY DISTRIBUTE THE DATA OVER THE TRACKS ON EACH DATA BASE
  - OPTIMIZE DATA STORAGE AND RETRIEVAL BY CONSIDERING DEVICE TRACK SIZE, INTERNAL BUFFERING, AND PROCESSING LOGIC WHEN ASSIGNING BLOCKING FACTORS

NASA-S-78-16635

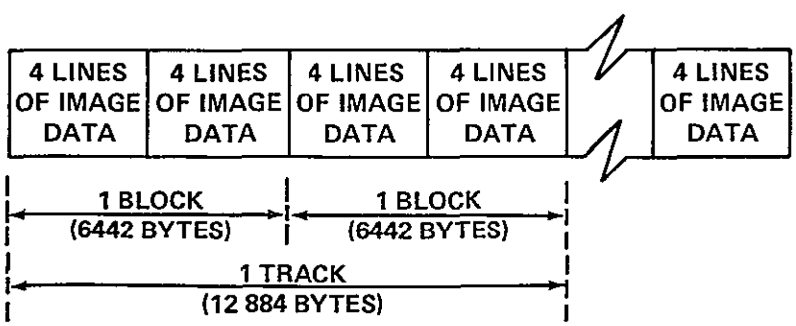
DESIGN DECISIONS FOR THE IMAGERY DATA BASES

- BLOCKING FACTOR – THE SOLUTION
  - TWO DATA SET GROUPS WERE DEFINED TO ALLOW EFFICIENT BLOCKING OF IMAGE DATA AND ANCILLARY DATA



NASA-S-78-16636

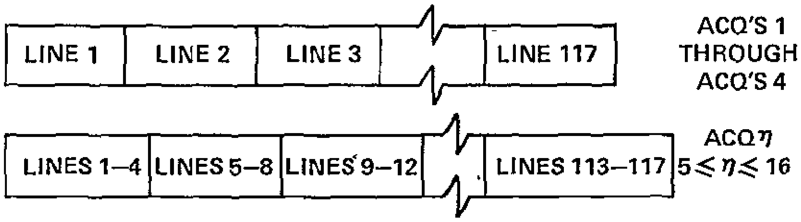
- BLOCKING FACTOR (CONT) – THE SOLUTION
  - IMAGE DATA BLOCKING



NASA-S-78-16637

DESIGN DECISIONS FOR THE IMAGERY DATA BASES

- IMAGE DATA BLOCKS – INTERNAL
  - THE FIRST STRUCTURE



THIS STRUCTURE MATCHED APPLICATION LOGIC BUT WAS INEFFICIENT FOR ACQ'S 5 THROUGH 16

- THE SECOND STRUCTURE
  – ACQUISITIONS 1 THROUGH 4 WERE STORED THE SAME AS ACQUISITIONS 5 THROUGH 16 IN THE EARLIER STRUCTURE

NASA-S-78-16638

CONCLUSIONS

IN SUPPORT OF AN INTERACTIVE, MULTIPLE-USER SYSTEM:

- IMAGE AND ANCILLARY DATA EFFICIENTLY STORED AND RETRIEVED
- THROUGHPUT OBJECTIVES MET
- DATA LOSSES NEGLIGIBLE
- DISK SPACE EFFECTIVELY UTILIZED

THE ERIPS DATA BASES IN CONJUNCTION WITH INTERACTIVE PROGRAMING CONCEPTS PROVIDED A PROOF-OF-CONCEPT DEMONSTRATION FOR EARTH RESOURCES PROCESSING

NASA-S-78-16639

FUTURE CHALLENGES

- NEW LANDSAT'S
  - MORE SENSORS AND HIGHER RESOLUTION MEAN MORE DATA FOR ANALYSTS
- NEW APPLICATIONS
  - AIR QUALITY, LAND USE, WATER QUALITY, ETC , MEAN MORE ANALYSTS NEEDING ACCESS TO DATA
- PROBLEMS TO BE SOLVED
  - DATA STORAGE ON A GLOBAL SCALE FOR:
    - LANDSAT'S, SEASAT'S
    - SOIL MOISTURE SATELLITES
    - GEOLOGY APPLICATION SATELLITES
  - DATA DISTRIBUTION
- POSSIBLE SOLUTIONS
  - MASS STORAGE DEVICES
  - DISTRIBUTED DATA BASES

N79-14475

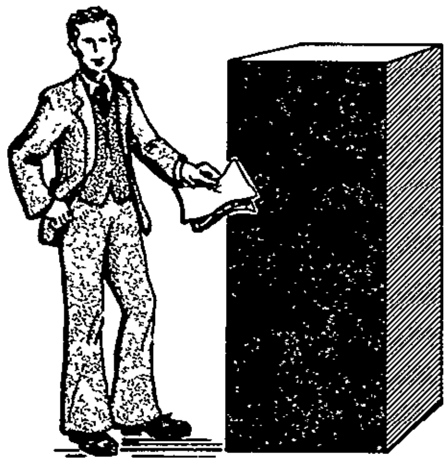
DATA PROCESSING SYSTEMS DESIGN SESSION

MAN-MACHINE INTERFACE IN LACIE ERIPS

B. Duprey, IBM/JSC

NASA-S-78-16552

MAN-MACHINE INTERFACES IN LACIE/ERIPS



- MENUS
- ERROR RECOVERY
- CHECKPOINT/RESTART

NASA-S-78-16553

MAN-MACHINE INTERFACES

- INTERACTIVE MENUS
  - WHAT THEY ARE
  - WHY WE CHOSE THEM
  - HOW THEY ARE USED
  - WHAT THEY COST
- NONINTERACTIVE USE OF MENUS
  - WHY BATCH MODE WAS NEEDED
  - HOW IT IS USED
  - WHAT IT COST

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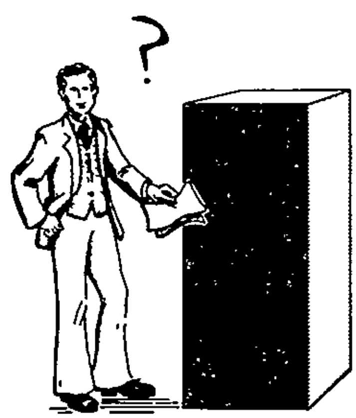
NASA-S-78-16554

MAN-MACHINE INTERFACES (CONT)

- ERROR RECOVERY
  - WHY IT IS NEEDED
  - WHAT IT DOES
  - WHAT IT COSTS
- CHECKPOINT/RESTART
  - WHY IT IS NEEDED
  - WHAT IT DOES
  - WHAT IT COSTS
- CONCLUSIONS
  - WHAT WE LEARNED
  - WHAT WE WOULD CHANGE

NASA-S-78-16555



- THE PROBLEM
  - ALLOW INTERACTIVE USERS AT ALL LEVELS OF EXPERIENCE TO COMMUNICATE PRODUCTIVELY WITH THE COMPUTER
- OUR SOLUTION
  - MENUS

NASA-S-78-16556

- ADVANTAGES
  - TUTORIAL – CAN BE USED WITHOUT EXTENSIVE TRAINING
  - MODULAR – EASILY MODIFIED AS SYSTEM CHANGES
  - PROTECTIVE – PROVIDES SYSTEM INTEGRITY
- DISADVANTAGES
  - MANY REQUIRED INTERACTIONS
  - FRONT-END COST HIGH
- COST IN LACIE/ERIPS
  - 30 000 LINES OF CODE (12.5 PERCENT)

NASA-S-78-16557

ITERATIVE INITIALIZATION MENU

INPUT YOUR ITERATIVE PARAMETERS:

DEFAULT	0	R2	___
CO	_	NMIN2	___
PERCENT	___	ITMAX	___
SEP	___	P OF N	___
STDMAX	___	MATCH THRS	___
DLMIN	___	SPLIT/COMBINE SEQUENCE	___

☐ WL2 MATCH ☐ L1 MATCH ☐ L2 MATCH

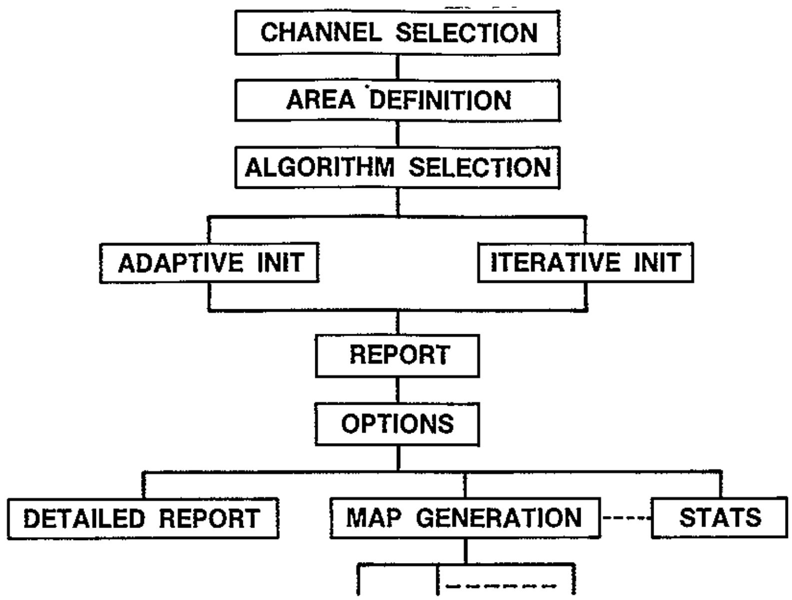
STARTING VECTORS:

☐ SELF GENERATING VECTORS
☐ SUBCLASS STATISTICS VECTORS
☐ VECTORS FROM RUN NUMBER ___
☐ EXTERNAL VECTORS
☐ DOTS AS STARTING VECTORS

IMD
SCR
RET
EOF
EOT

NASA-S-78-16558

CLUSTERING MENU TREE



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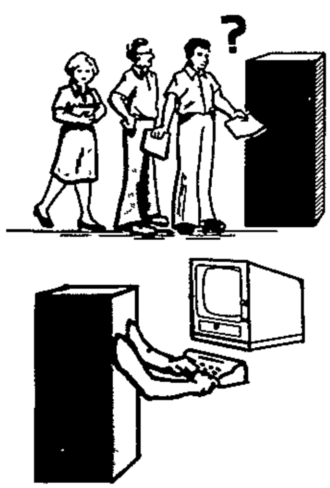
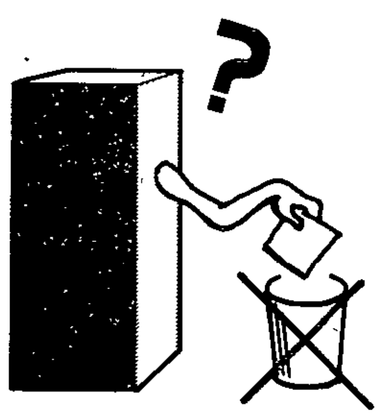


- THE PROBLEM –
  - PROVIDE FOR HIGH-VOLUME PRODUCTION MODE ACTIVITY
- OUR SOLUTION –
  - NONINTERACTIVE USE OF MENUS

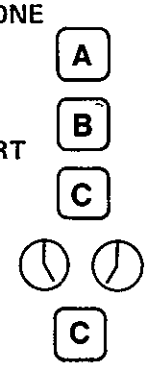
NASA-S-78-16560

- ADVANTAGES
  - HANDLES LARGE WORKLOAD
  - EASY TO USE
  - PROVIDES ACCURATE REPETITION FOR COMPARISONS
  - FREES PERSONNEL FOR OTHER WORK
- DISADVANTAGES
  - SOME FLEXIBILITY LOST
  - FRONT-END COST
- COST IN LACIE/ERIPS
  - 10 500 LINES OF CODE (4.5 PERCENT)

NASA-S-78-16561



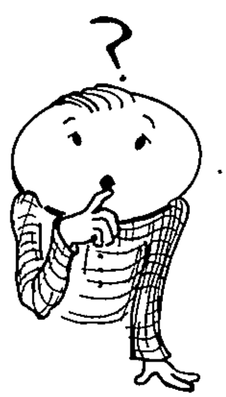
- THE PROBLEM–
  - LET ONE SESSION START WHERE THE LAST ONE ENDED
- OUR SOLUTION–
  - CHECKPOINT/RESTART



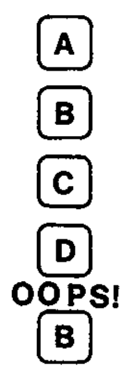
NASA-S-78-16562

- ADVANTAGES
  - AVOIDS REWORK – REESTABLISHES PREVIOUS ENVIRONMENT
  - AUTOMATIC – USER NEED NOT BE CONCERNED WITH MECHANICS OF THE PROCESS
  - NOT IMPACTED BY OTHER USER
- DISADVANTAGES
- COST IN LACIE/ERIPS
  - 2400 LINES OF CODE (1 PERCENT)

NASA-S-78-16563



- THE PROBLEM
  - BE FORGIVING OF HUMAN ERROR
- OUR SOLUTION
  - ERROR RECOVERY



NASA-S-78-16564

- ADVANTAGES
  - AVOIDS REWORK-SYSTEM IS RETURNED TO MOST RECENT GOOD STATUS
  - DOES NOT IMPACT OTHER USER
  - ALLOWS WORK TO CONTINUE IMMEDIATELY
- DISADVANTAGE
  - SOMETIMES MAKES PROBLEM INVESTIGATION DIFFICULT
- COST IN LACIE/ERIPS
  - 1200 LINES OF CODE (0.5 PERCENT)

NASA-S-78-16565

IF WE WERE DOING IT NOW

- MENUS WOULD STILL BE A GOOD CHOICE
- WE WOULD CONTINUE TO SUPPORT BOTH INTERACTIVE AND NONINTERACTIVE USERS
- MORE TERMINALS, PROBABLY WITH MORE LOCAL INTELLIGENCE, WOULD BE SUPPORTED
- AN INTERACTIVE USER WOULD BE ABLE TO SPECIFY WHEN BATCH MODE ASSUMPTIONS APPLY
- ERROR RECOVERY AND CHECKPOINT/RESTART WOULD BE MAINTAINED, EXTENDED TO MORE TERMINALS
- TIE-IN TO USER TRIAL ALGORITHMS WOULD BE PROVIDED

NASA-S-78-16566

SUMMARY

- MENUS PROVIDE USERS AT ALL LEVELS OF EXPERIENCE WITH THE CAPABILITY TO COMMUNICATE PRODUCTIVELY WITH THE COMPUTER
- ERROR RECOVERY REDUCES THE IMPACT OF SERIOUS ERRORS TO ALMOST NOTHING
- CHECKPOINT/RESTART ALLOWS AN ENVIRONMENT SET UP AT ONE TIME TO BE USED AT ANOTHER WITHOUT REWORK
- THE LESSONS WE HAVE LEARNED CAN BE USED TO STRENGTHEN STILL FURTHER THE COMMUNICATION BETWEEN MAN AND MACHINE

N79-14476

DATA PROCESSING SYSTEMS DESIGN SESSION

VERY HIGH SPEED PROCESSING AS RELATED TO PIXEL-DEPENDENT TASKS

J. Lyon, JSC

NASA-S-78-16605

VERY-HIGH-SPEED PROCESSING: APPLICABILITY OF PERIPHERAL DEVICES TO PIXEL-DEPENDENT TASKS

PROBLEM STATEMENT
LOCAL EXPERIENCE
PROGNOSIS

NASA-S-78-16606

THE IMAGE PROCESSING ENVIRONMENT

- OPERATIONAL ENVIRONMENT MAY INCLUDE COMPONENTS OF
  - RESEARCH AND TEST
  - PRODUCTION
  - TECHNOLOGY TRANSFER
- SYSTEMS ENVIRONMENT CHARACTERIZED BY MAJOR SIGNIFICANCE OF
  - DATA MANAGEMENT
    - MANIPULATION OF AND TRAFFIC CONTROL FOR (MANY) LARGE DATA SETS
  - PIXEL PROCESSING
    - REPETITIVE, INDEPENDENT, OR AGGREGATIVE COMPUTATIONS
      - RADIOMETRIC AND GEOMETRIC CORRECTIONS
      - TRAINING
      - UNSUPERVISED CLASSIFICATION
      - SUPERVISED CLASSIFICATION
      - FILTERING
- PIXEL PROCESSING CAN DOMINATE CONVENTIONAL SERIAL DEVICES

NASA-S-78-16607

MAXIMUM LIKELIHOOD CLASSIFICATION

- OBJECTIVE· MINIMIZE

$$H_c(X) = S_c + 1/2(X-\mu_c)^T \Lambda_c^{-1}(X-\mu_c)$$

FOR C CLASSES AND N-CHANNEL STATISTICS

- THE REQUIRED NUMBER OF ARITHMETIC OPERATIONS IS GIVEN BY·

ADDS	$(N^2 + 2N + 1)$ C	PER VECTOR
MULTIPLIES·	$1/2(N^2 + 3N)$ C	PER VECTOR

- FOR REPRESENTATIVE CASES

N	4	4	16	16	16
C	10	20	10	20	60
ADDITIONS	250	500	2890	5780	17 340
MULTIPLIES	140	280	1520	3040	9 120

- INNER-LOOP OPERATIONS PER SAMPLE SEGMENT APPROACH OR EXCEED 10^9

NASA-S-78-16608

IBM 360-75 MAXIMUM LIKELIHOOD PERFORMANCE

JUNE 1973

IMAGE CONTAINING L LINES, P PIXELS/LINE, N CHANNELS, WITH C CLASSES
COMPUTED TIMINGS FOR LACIE SEGMENTS (SECONDS)

PROCESS	TIME, μsec	C = 10, N = 4	C = 20, N = 4	C = 10, N = 16	C = 20, N = 16
SYSTEM OVERHEAD	3000L	0 351	0 351	0.351	0 351
DATA MOVEMENT	(6 49N + 8 82)LP	.797	.797	2 583	2 583
GEN STATS	5 03 C^2LP	11 535	46 140	11 535	46 140
QUADRATIC FORM	[7 46 + N(4N + 16 21)] CLP	31 256	62 512	296 010	592 020
STORE BEST Q	2 92 CLP	700	1 400	700	1 400
STORE BEST C	5 9 LP	135	.135	135	.135
TOTAL		44 780	111 335	311 314	642 629
PERCENT IN QUADRATIC FORM (PURE COMPUTE)		70	56	95	92

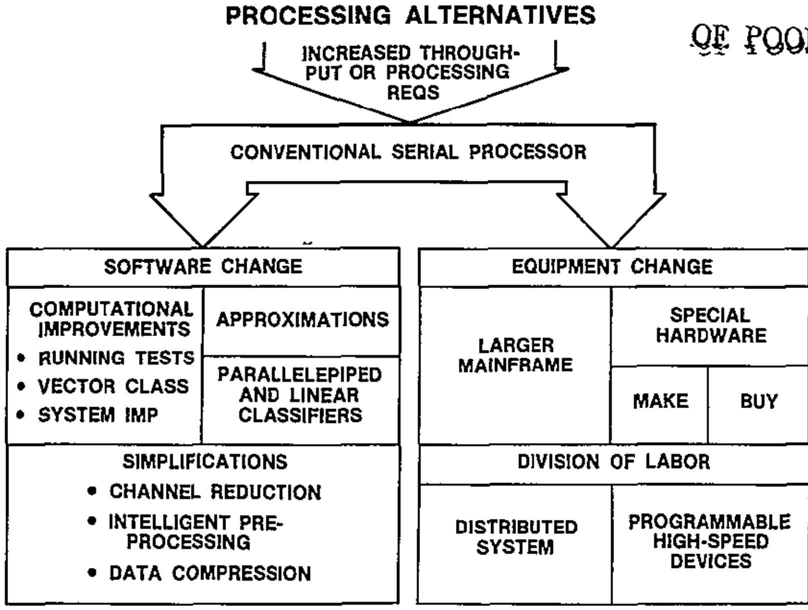
NASA-S-78-16609

LACIE THROUGHPUT PROJECTION

- 4800-SEGMENT PROJECT IMPLIED UP TO 60 HOURS/DAY OF IBM 360-75 TIME IN PEAK GROWING SEASON

NASA-S-78-16610

PROCESSING ALTERNATIVES



NASA-S-78-16611

PROGRAMMABLE PERIPHERAL HIGH-SPEED PROCESSORS

- GENESIS IN SEISMIC AND RADAR SIGNAL REDUCTION
- ALL APPLIED IN SOME FORM TO SIGNAL-PROCESSING PROBLEMS
- ARCHITECTURES
  - PARALLEL
  - PIPELINED
  - ARRAY
  - DISTRIBUTED LOAD SHARING
- RANGE OF CAPABILITY UP TO SEVERAL x 10^8 MFLOPS (10×10^9 ANTICIPATED)
- ARITHMETIC BOTH FIXED AND FLOATING POINT
- PRICE RANGES FROM $50K TO $10M+

NASA-S-78-16612

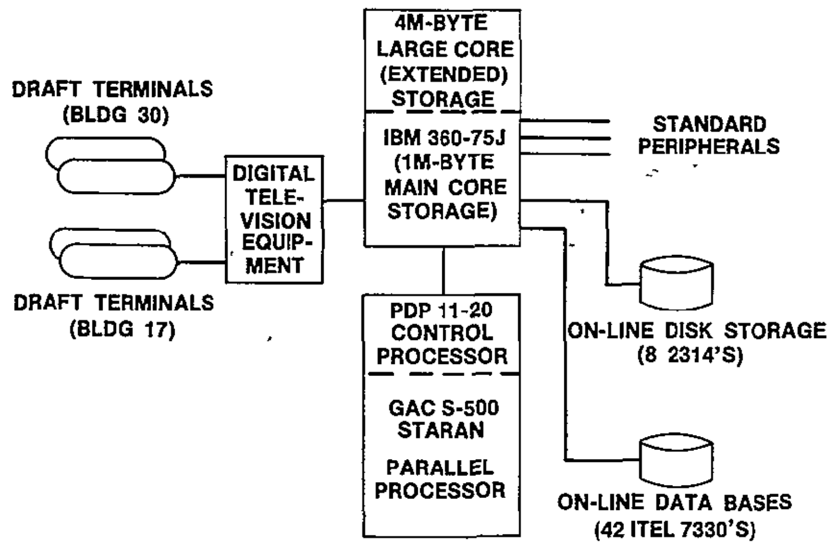
HIGH-SPEED PROCESSORS
EXAMPLES

• ILLIAC IV	IBM 3838, 2938, ASP
• GOODYEAR STARAN B AND E	ESL ASAP
• FPS AP120B AND AP190L	GE IMAGE 100
• CDC MAP III AND FP	(BURROUGHS SCIENTIFIC PROCESSOR)
• CSPI MAP 300	(GSFC MASSIVELY PARALLEL PROCESSOR)

AND OTHERS

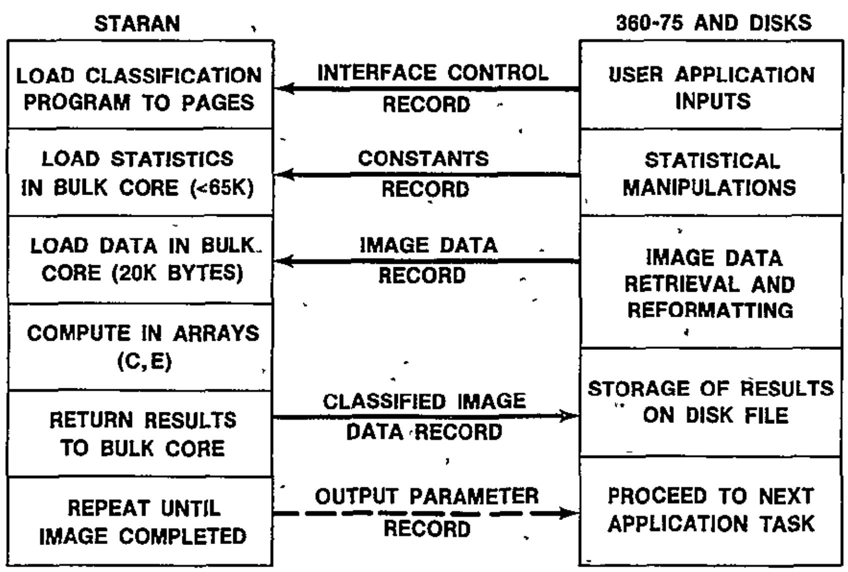
NASA-S-78-16613

EXISTING LACIE/ERIPS FACILITY



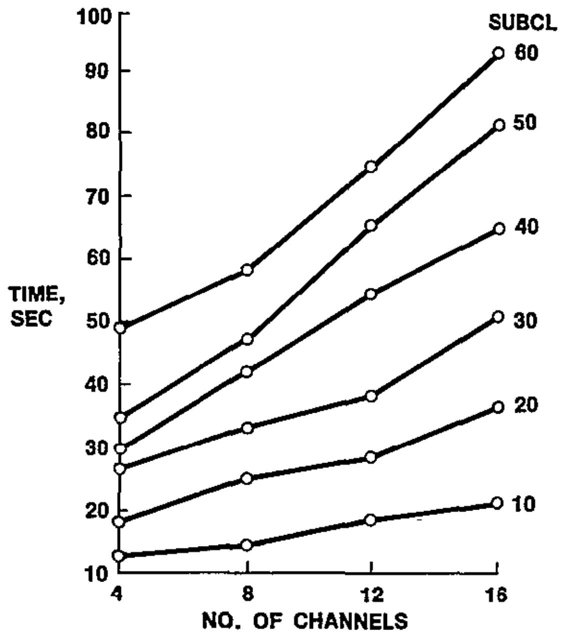
NASA-S-78-16614

ALGORITHM EXECUTION SPP MAXIMUM LIKELIHOOD



NASA-S-78-16615

LACIE CLASSIFICATION TIMINGS WITH SPP



NASA-S-78-16616

LACIE THROUGHPUT IMPROVEMENTS

- ASSUMING 40 CLASSES PER SEGMENT
- SPP PERFORMANCE OF STATS, ITCLUS, MIXDEN

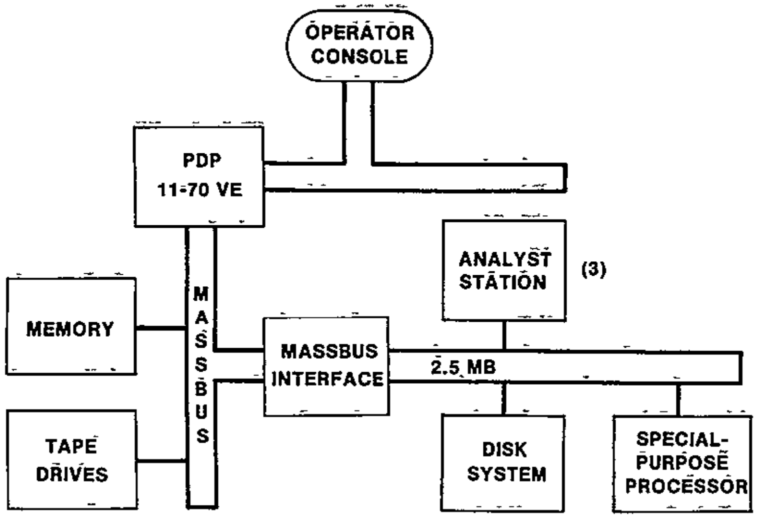
TIME (SEC) PER SEGMENT

NO OF CHANNELS	360 75	WITH SPP	RATIO	ONLY SPP TASKS
4	386	201	1 92	3 6
8	921	260	3 54	7 5
12	1941	323	6 00	13 25
16	2738	396	6 91	14 8

- WITHOUT SPP, AT PEAK PHASE III, ABOUT 40 HR/DAY OF 360-75 WOULD HAVE BEEN REQUIRED FOR SEGMENT PROCESSING
- WITH SPP, ABOUT 8 HR/DAY WERE REQUIRED FOR SAME TASKS
- MULTITEMPORAL OPERATION JUSTIFIES SPECIAL-PURPOSE PROCESSOR

NASA-S-78-16617

ATS ORGANIZATION



NASA-S-78-16618

AES/ATS PERFORMANCE COMPARISONS — EQUIVALENT SPP TASKS

- PROCESS TOPOLOGY IS CRUCIAL TO SPECIAL-DEVICE PERFORMANCE
- CODING PROBLEMS ARE OFTEN CONCEPTUALLY DIFFERENT
  - AP120 TIME DOMAIN (PIPELINE)
  - STARAN SPACE DOMAIN (ARRAY)

TASK	IBM 360/STARAN	PDP 11-70/AP120 B
512 x 512 MAXLIK 4 CHAN , 8 CLASSES	41 SEC	56 SEC
117 x 196 ITCLUS 4 CHAN , 30 CLASSES (PER PASS)	8 SEC	18 SEC

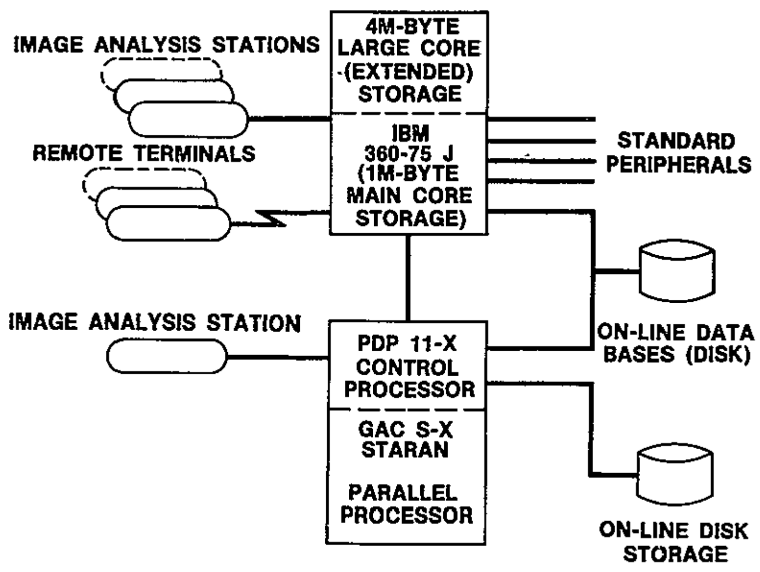
NASA-S-78-16619

FUTURE PROCESSING TRENDS
APPLICABILITY OF PERIPHERAL DEVICES

- LANDSAT-D: EQUIVALENT GROUND COVERAGE IMPLIES A SEVEN-FOLD INCREASE OVER LANDSAT-3 USING THEMATIC MAPPER
- MUTUAL REGISTRATION OF DIFFERENT SENSORS SUGGESTS SIGNIFICANT INCREASE IN PREPROCESSING VOLUME TRANSCENDING CURRENT LEVELS BY SIGNIFICANT FACTORS
- ANALYSIS FLOW TRENDS TOWARD MORE COMPLEX USES OF DATA
- SYSTEM REORGANIZATIONS TO EXPLOIT PERIPHERAL PROCESSORS IN THE SOLUTION OF DATA MANAGEMENT PROBLEMS ARE REQUIRED
- DEVELOPMENT OF EFFICIENT HIGH-LEVEL LANGUAGES AND CONVENIENT LIBRARY MODULES MUST CONTINUE

NASA-S-78-16620

PROPOSED EARTH RESOURCES FACILITY



N79-14477

DATA PROCESSING SYSTEMS DESIGN SESSION

THE CARTOGRAPHIC LABORATORY

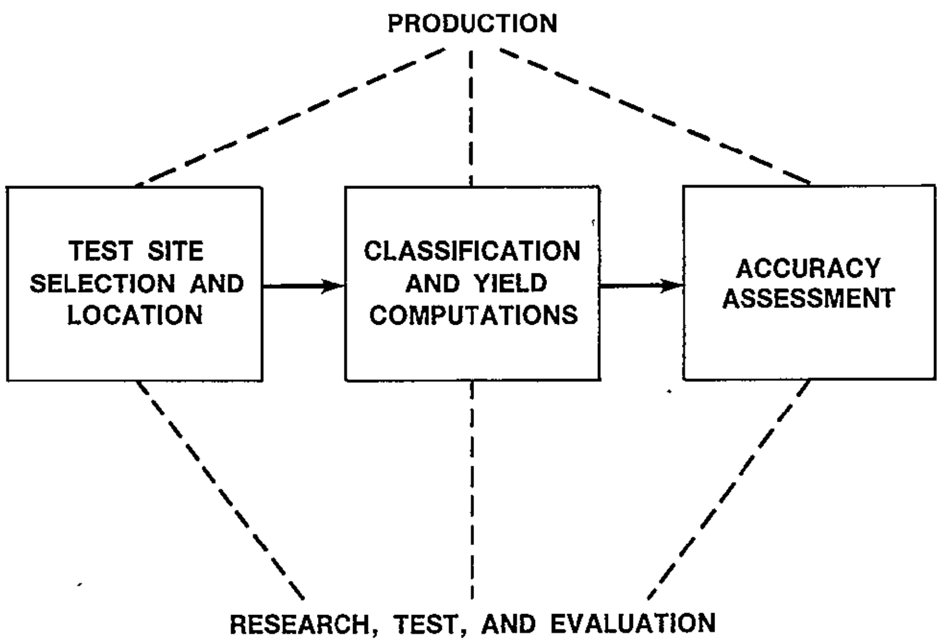
M Rader, Lockheed/JSC

NASA-S-78-16783

CARTOGRAPHY - LACIE'S SPATIAL PROCESSOR

NASA-S-78-16784

LACIE PROCESS FLOW



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NASA-S-78-16785

TRANSITION FROM PHOTOGRAPHIC TO DIGITAL IMAGE PROCESSING

- CONCEPTUAL DIFFERENCES
- SKILLS PROBLEMS
- HARDWARE OBSOLESENCE

NASA-S-78-16786

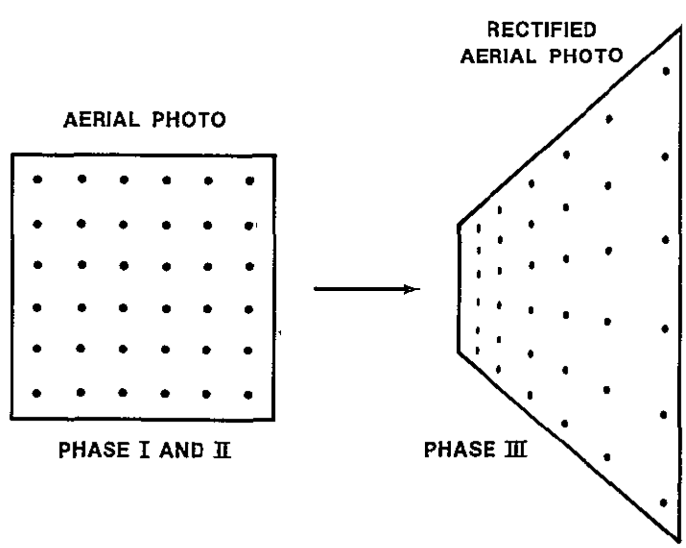
THE CARTOGRAPHIC ROLE IN LACIE

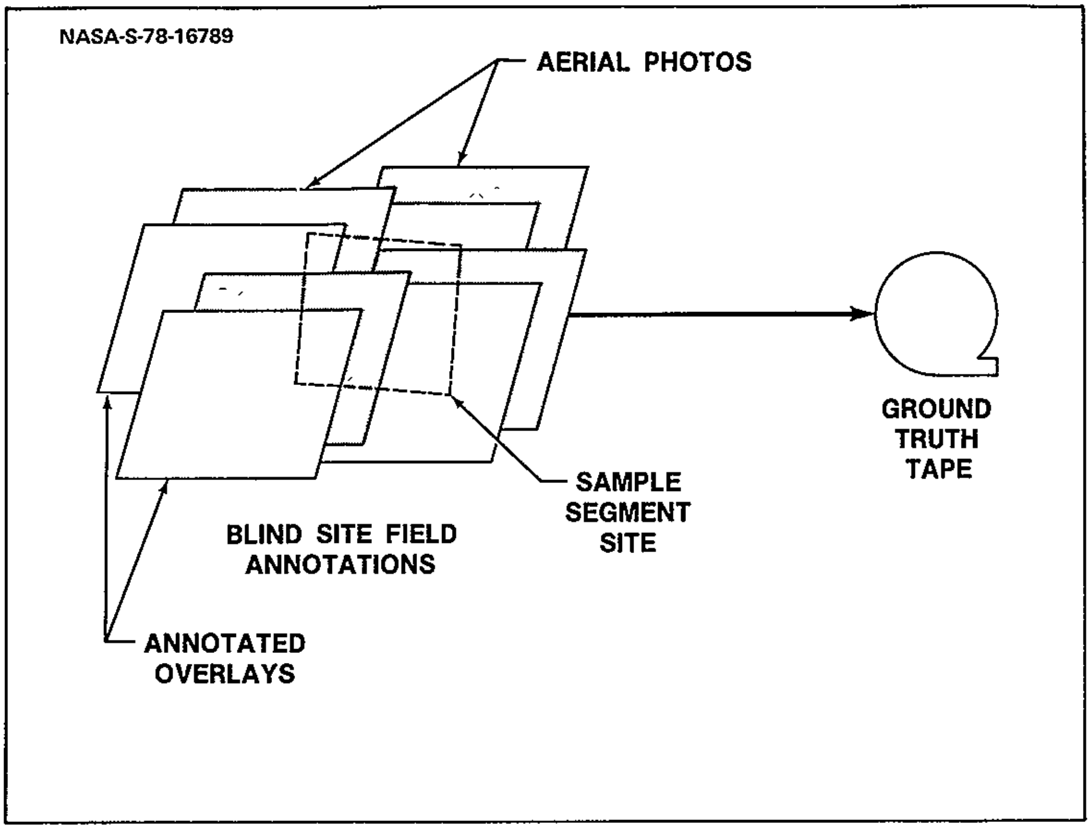
- TEST SITE SELECTION
- MEASURING LACIE PERFORMANCE
- LACIE RESEARCH, YIELD ANALYSIS, AND PHOTOINTERPRETATION GRAPHIC AIDS

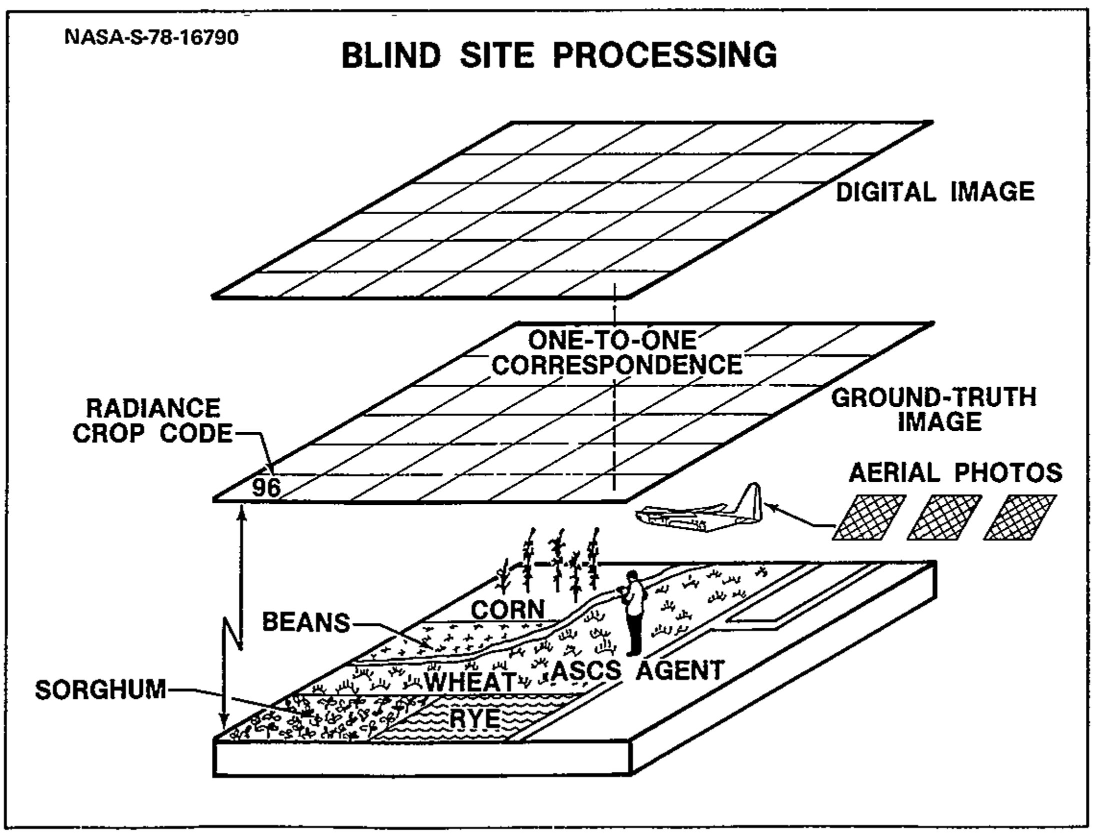
NASA-S-78-16787

TEST SITE SELECTION

NASA-S-78-16788




NASA-S-78-16789
AERIAL PHOTOS
GROUND
TRUTH
TAPE
SAMPLE
SEGMENT
SITE
BLIND SITE FIELD
ANNOTATIONS
ANNOTATED
OVERLAYS

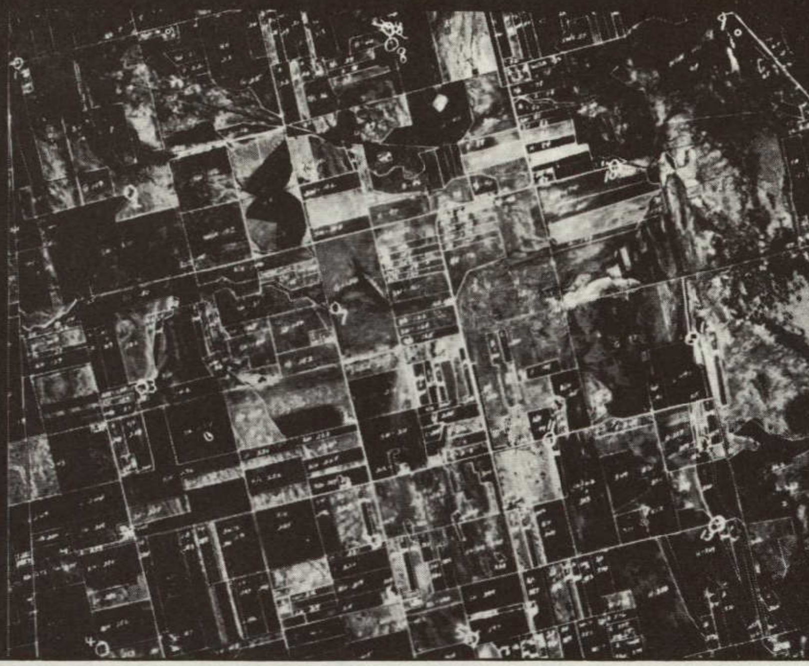

NASA-S-78-16790
BLIND SITE PROCESSING
DIGITAL IMAGE
ONE-TO-ONE
CORRESPONDENCE
GROUND-TRUTH
IMAGE
RADIANCE
CROP CODE
96
AERIAL PHOTOS
CORN
BEANS
WHEAT
ASCS AGENT
SORGHUM
RYE

NASA-S-78-10902

BLIND SITE EXAMPLE - SITE 1523

WILKIN COUNTY, MINNESOTA

FIELD DELINEATIONS - CARTOGRAPH LAB

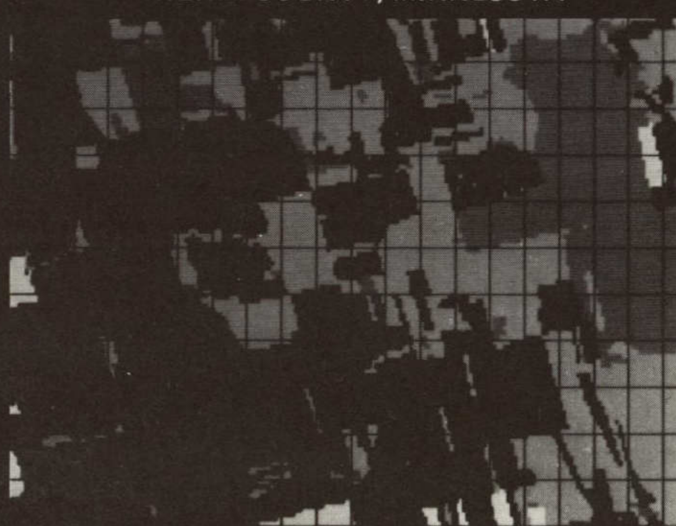


NASA-S-78-12521

DIGITIZED GROUND TRUTH REGISTERED TO LANDSAT IMAGERY

LACIE SEGMENT 1523, PHASE III, BLIND SITE

WILKIN COUNTY, MINNESOTA



INVENTORY DATE, AUGUST 1, 1977

NASA-S-78-12504

BLIND SITE EXAMPLE - SITE 1523

WILKIN COUNTY, MINNESOTA COMPUTER-GENERATED CLUSTER AND CLASSIFICATION MAPS

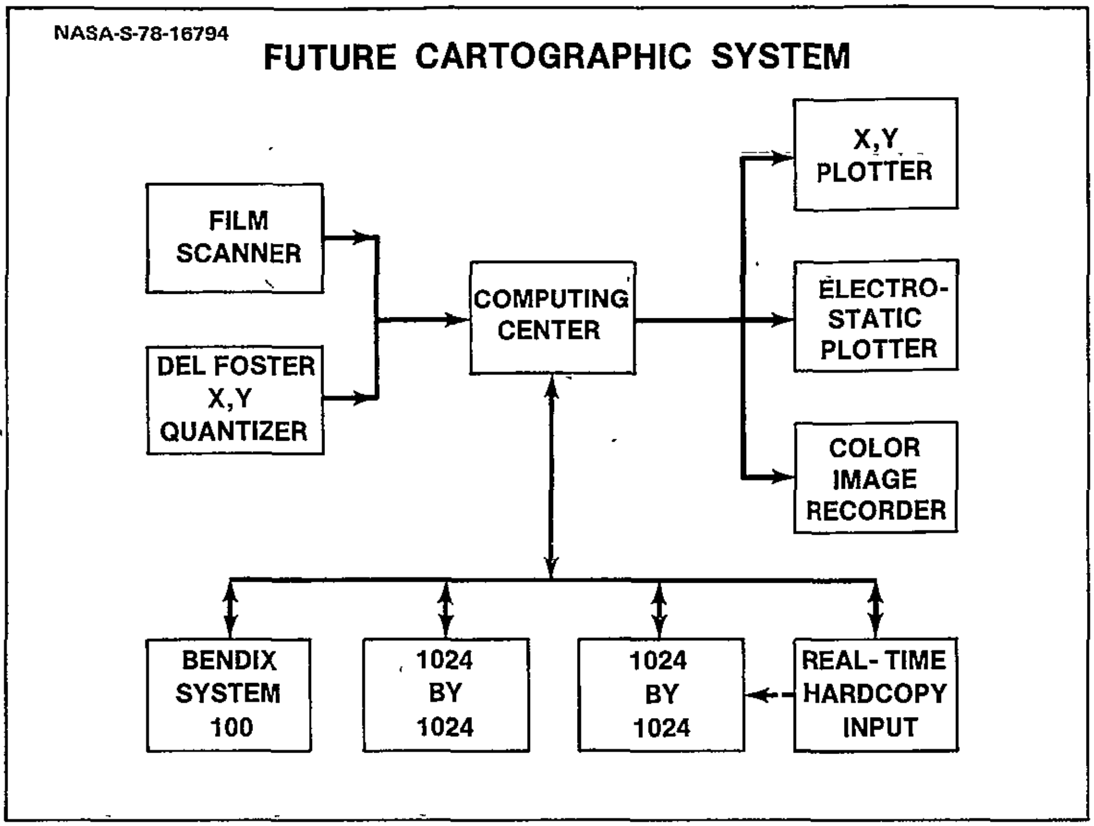
AUGUST 17, 1977

CONDITIONAL CLUSTER MAP

BLACK - THRESHOLD, DO, DU
YELLOW - NONSPRING SMALL GRAINS
GREEN - SPRING SMALL GRAINS
OTHER - CONDITIONAL CLUSTERS

NASA-S-78-16791

OTHER SUPPORT


NASA-S-78-16794
FUTURE CARTOGRAPHIC SYSTEM
FILM SCANNER
DEL FOSTER X,Y QUANTIZER
COMPUTING CENTER
X,Y PLOTTER
ELECTRO-STATIC PLOTTER
COLOR IMAGE RECORDER
BENDIX SYSTEM 100
1024 BY 1024
1024 BY 1024
REAL-TIME HARDCOPY INPUT

DATA PROCESSING SYSTEMS DESIGN SESSION

SOME COST PERFORMANCE CHARACTERISTICS OF SEVERAL DATA SYSTEM CONFIGURATIONS FOR PROCESSING REMOTELY SENSED DATA

P. Gregor, MITRE Corporation

NASA-S-78-16760

SOME COST-PERFORMANCE CHARACTERISTICS OF SEVERAL DATA SYSTEM CONFIGURATIONS FOR PROCESSING REMOTELY SENSED DATA

THE MITRE CORPORATION
HOUSTON, TEXAS

NASA-S-78-16761

BACKGROUND

- TREND TOWARD LARGE REMOTE-SENSING DATA SYSTEMS BECAUSE OF
  - SUCCESSFUL EXPERIENCE
  - COMPUTER TECHNOLOGY IMPROVEMENTS – MORE POWER, LOWER PRICE
  - LARGE VOLUMES OF DATA
- NASA JSC
  - PLANNING FOR NEW DATA SYSTEM TO SUPPORT CONTINUING POST-LACIE R&D & QUASI-OPERATIONAL REMOTE-SENSING ACTIVITIES
  - CONSIDERING CONSOLIDATION OF LACIE DATA SYSTEM

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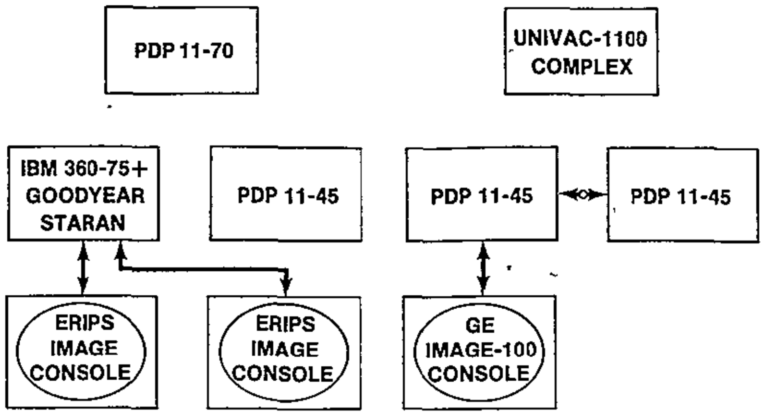
NASA-S-78-16762

BACKGROUND - LACIE DATA SYSTEM

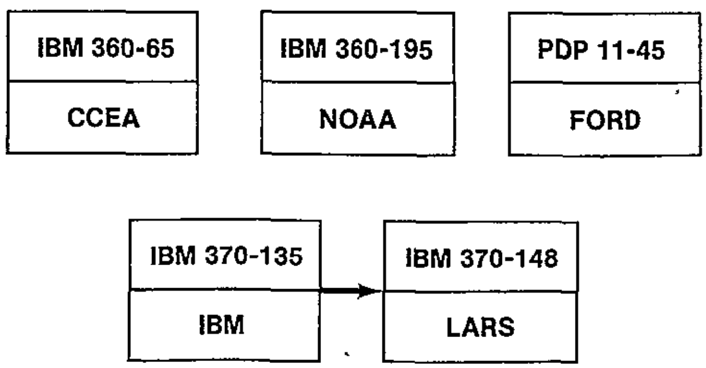
JSC ON-SITE COMPUTERS



NASA-S-78-16763

BACKGROUND - LACIE DATA SYSTEM (CONT)

OFF-SITE COMPUTERS



NASA-S-78-16764

OVERVIEW

OBJECTIVE — EXPLORE SEVERAL ALTERNATIVE APPROACHES TO CONSTRUCTING A LARGE REMOTE-SENSING DATA SYSTEM FOR JSC

PROCEDURE.

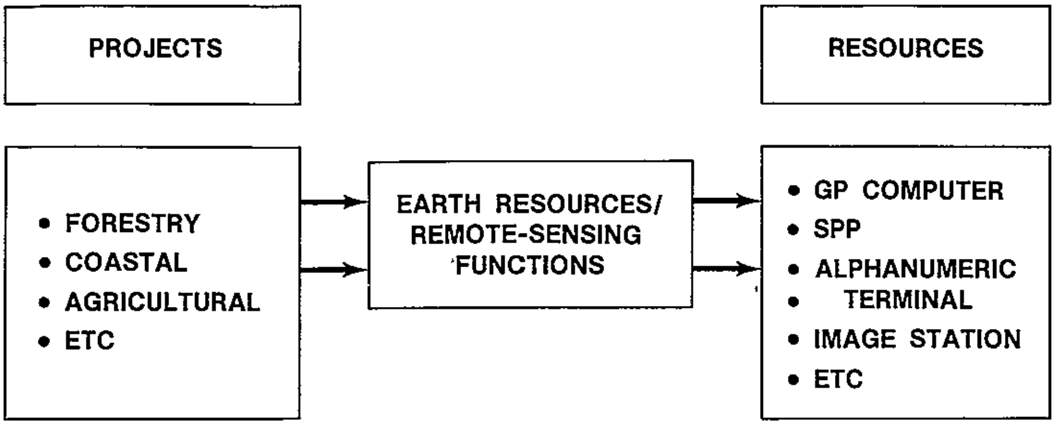
1) IDENTIFY DATA SYSTEM USAGE
2) PROPOSE HARDWARE ALTERNATIVES
3) IDENTIFY COST ITEMS
4) EVALUATE COST-EFFECTIVENESS

NASA-S-78-16765

DATA SYSTEM USAGE

NASA-S-78-16766

MAPPING ACTIVITIES TO RESOURCES



NASA-S-78-16767

MEASUREMENT OF WORK AND RESOURCES

- GOAL QUANTIFY WORK IN TERMS COMPARABLE TO EQUIPMENT CAPABILITIES
- MEASURES·
  - TERMINALS AND IMAGE STATIONS
    - TIME PERSON WILL REQUIRE DEVICE; i.e., "CONNECT HOUR"
  - SPECIAL-PURPOSE PROCESSORS
    - TIME A PARTICULAR MODEL WILL BE USED, i.e , "CONNECT HOUR"
  - GENERAL-PURPOSE PROCESSORS
    - WEIGHTED SUM OF CPU TIME, I/O ACTIVITY, AND MEMORY UTILIZATION (AUTOMATICALLY CALCULATED BY MOST OPERATING SYSTEMS, e.g., SRU OF CONTROL DATA CORPORATION, SUP-Hr OF UNIVAC), i.e., "RESOURCE UNIT"

NASA-S-78-16768

FY77 SYSTEM USAGE MATRIX

FY77 JSC EOD DATA SYSTEM USAGE – WEEKLY AVERAGE DURING PEAK PERIOD

ACTIVITY \ RESOURCE	GP	SPP	A/N* TERMINAL	IMAGE TERMINAL
	RESOURCE UNITS	STARAN CONNECT HR	CONNECT HR	CONNECT HR
SOFTWARE DEVELOPMENT & QUALITY ASSURANCE	27	11	65	38
RT&E	30		26	4
SYSTEM SUPPORT	10		24	
LACIE PRODUCTION	34	12	105	67
OTHER	16		36	22
TOTAL	117	23	256	131

*ALPHANUMERIC

NASA-S-78-16769

FORECAST SYSTEM USAGE

- EXACT PROJECTION OF USAGE DIFFICULT
  - VARIABLE PROGRAM SCOPES
  - ALGORITHM/PROCEDURE OPTIONS
  - UNCERTAIN IMPACT OF DATA VOLUME
- FOUR POSSIBLE PER-WEEK PEAK USAGE LEVELS IDENTIFIED

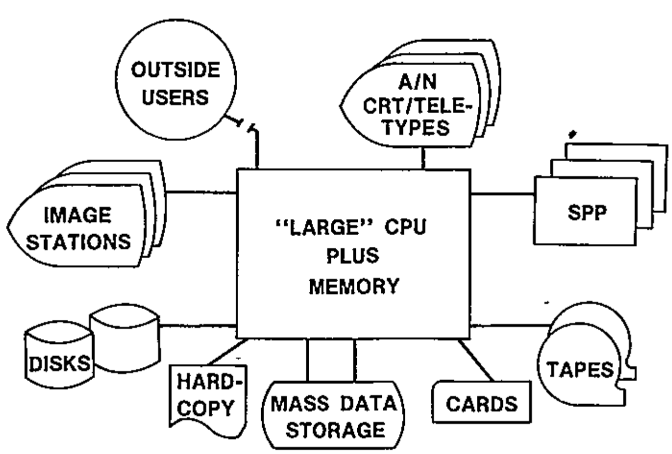
  A – 200 GP RESOURCE UNITS
  B – 250 GP RESOURCE UNITS
  C – 300 GP RESOURCE UNITS
  D – 400 GP RESOURCE UNITS

NASA-S-78-16770

DATA SYSTEM ARCHITECTURE

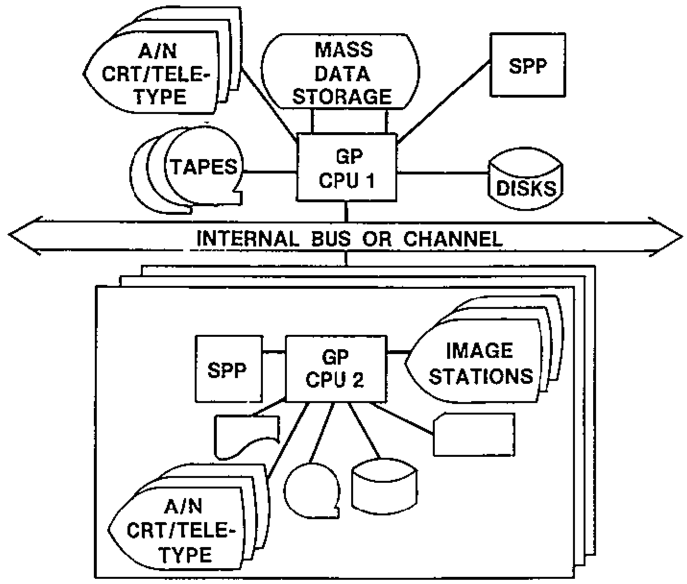
NASA-S-78-16771

SINGLE LARGE-MACHINE ARCHITECTURE



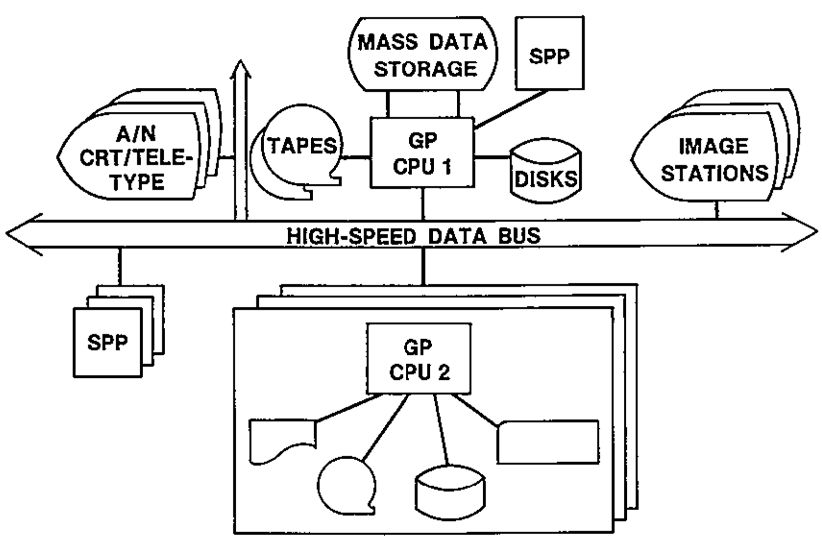
NASA-S-78-16772

BASIC MULTIPLE-MACHINE ARCHITECTURE



NASA-S-78-16773

BUS-ORIENTED MULTIPLE-MACHINE ARCHITECTURE



NASA-S-78-16774

HARDWARE ALTERNATIVES

SYSTEM ARCHITECTURES	SIZE GROUP	HARDWARE CPU'S	SPP'S	OTHER
SINGLE	A OR B C OR D >D	AMDAHL 470/V5 470/V6 II 470/V7	2 3 3	TAPES, DISKS, MDSF, CRT'S, 7 IMAGE TERMINALS
MULTIPLE & MULTIPLE WITH BUS	A B C D	2 x SEL 32-75 IBM 370-148 + 3 32-75 4 32-75 6 32-75	2 3 3 4	

NASA-S-78-16775

DATA SYSTEM COSTS

NASA-S-78-16776

DATA SYSTEM COST ITEMS

ONE TIME COSTS

- HARDWARE PURCHASE AND DEVELOPMENT
- SYSTEM SOFTWARE PURCHASE AND DEVELOPMENT
- APPLICATIONS SOFTWARE DEVELOPMENT AND CONVERSION
- FACILITY MODIFICATIONS
- COMMUNICATIONS INSTALLATION
- TRAINING
- PROCUREMENT AND SYSTEM ENGINEERING SUPPORT
- SYSTEM INTEGRATION AND TEST

NASA-S-78-16777

DATA SYSTEM COST ITEMS (CONT)

RECURRING COSTS

- HARDWARE MAINTENANCE
- SOFTWARE LEASE
- OPERATIONS, INCLUDING SYSTEM MANAGEMENT AND SUPPORT SERVICES
- COMMUNICATIONS
- CONSUMABLES

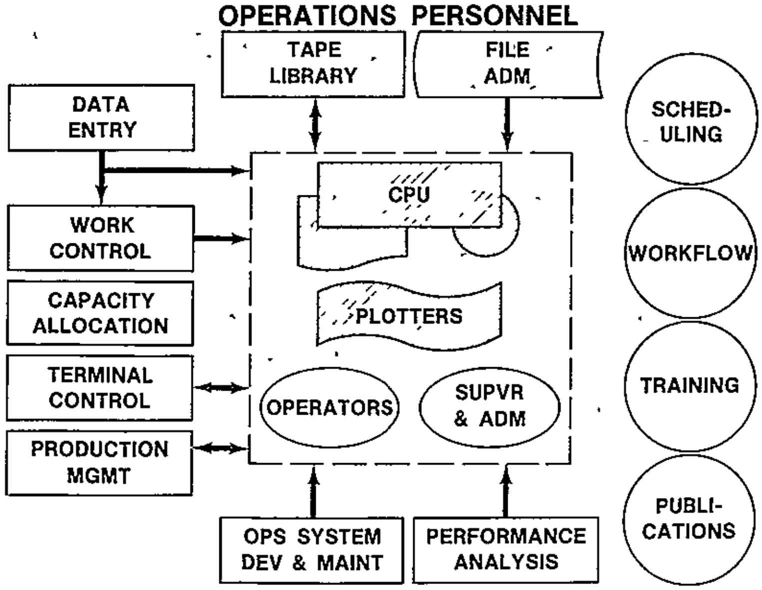
NASA-S-78-16779

SELECTED COST ITEMS (PART I)

- HARDWARE PURCHASE AND MAINTENANCE
  - INFORMATION FROM VENDORS
  - IN GENERAL, ANNUAL MAINTENANCE COSTS WERE
    - 5% OF PURCHASE PRICE FOR LARGE MAINFRAMES
    - 10-15% FOR MINICOMPUTERS
- SOFTWARE CONVERSION
  - DIFFICULT BECAUSE
    - VARIETY OF LANGUAGES
    - VARIETY OF MACHINES
    - AGE OF SOME SOFTWARE (TIED TO OLD EQUIPMENT)
  - COST COULD EXCEED $3 MILLION ($6 TO $7 PER LINE)
    - COMPARES WITH OTHER GOVERNMENT EXPERIENCE ($2 TO $7 PER LINE)

NASA-S-78-16778

SELECTED COST ITEMS (PART II)
OPERATIONS PERSONNEL



NASA-S-78-16780

COST EFFECTIVENESS

NASA-S-78-16781

LIFE CYCLE COSTS

IN FY78 ($1000'S)

SYSTEM ARCHITECTURE		INITIAL COST	ANNUAL M&O	10 YR COST
SINGLE	A OR B	9 000	1417	23 170
	C OR D	9 870	1537	25 240
	>D	10 500	1575	26 250
MULTIPLE	A	7 870	1481	22 680
	B	8 320	1528	23 600
	C	8 680	1712	25 800
	D	9 490	1841	27 900
MULTIPLE WITH BUS	A	8 980	1620	25 180
	B	9 460	1688	26 340
	C	9 850	1851	28 360
	D	10 720	1980	30 520

- IN COMPARISON, FY77 DATA SYSTEM COSTS WERE $3 164 000

NASA-S-78-16782

CONCLUSIONS

- FINDINGS
  - ALL SYSTEMS CONSIDERED WOULD BE BETTER THAN CURRENT SYSTEM
    - QUANTITATIVELY (CAPACITY, THROUGHPUT) AND
    - QUALITATIVELY (UNIFIED OPERATIONS, EASE OF USE)
  - NEW SYSTEM DEVELOPMENT COSTS RECOVERED IN LOWER OPERATING COSTS
  - RECURRING COSTS SLIGHTLY FAVOR SINGLE MACHINE ARCHITECTURE
- RECOMMENDATION TO JSC
  - CONSOLIDATE DATA PROCESSING AND ESTABLISH SINGLE-MACHINE SYSTEM
- GENERALIZATION
  - IN A DIFFERENT SITUATION, OTHER FACTORS MAY INFLUENCE A FINAL CHOICE
    - SOFTWARE CONVERSION COST
    - REQUIRED APPROVAL CYCLE
    - FLEXIBILITY
    - ETC

N79-14479

DATA PROCESSING SYSTEMS DESIGN SESSION

EQUIPMENT SELECTION CRITERIA FOR R&D IMAGE PROCESSING

E. Poole, IBM/JSC

NASA-S-78-16999

A LOOK AT COMPUTER SYSTEM SELECTION CRITERIA

PRESENTED AT
1978 LACIE SYMPOSIUM

SESSION: DATA PROCESSING SYSTEMS DESIGN

NASA-S-78-17000

OUTLINE

1. INTRODUCTION
2. CONFIGURATION ADEQUACY
3. EVALUATION RATING
4. SUMMARY

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PROBLEM DEFINITION

- SELECTION OF A COMPUTER SYSTEM TO SOLVE A PARTICULAR PROBLEM IS A COMPLEX TASK
- COMPARISON OF VARIOUS SYSTEMS IS DIFFICULT
- THIS OFTEN RESULTS IN SELECTION OF THE WRONG SYSTEM

THERE IS A NEED FOR A FORMALIZED SYSTEM SELECTION PROCESS BASED ON QUANTIFIABLE CRITERIA

NASA-S-78-17002

PROPOSED SOLUTION

IBM FSD-HOUSTON HAS DEVELOPED A FORMALIZED EVALUATION PROCESS (MODEL) WHICH CONSIDERS THE FOLLOWING SET OF GENERIC SELECTION CRITERIA

- ADEQUACY
- COST
- ADAPTABILITY
- AVAILABILITY
- TRANSPORTABILITY
- USABILITY

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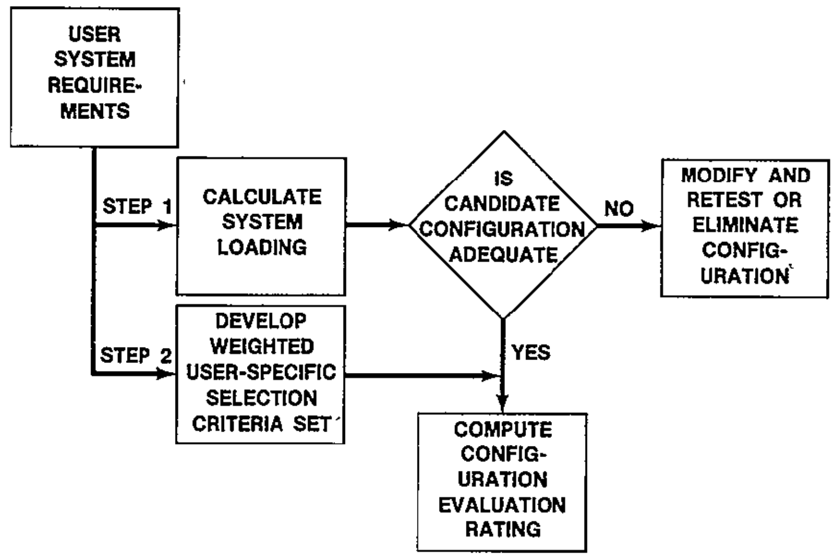
SYSTEM SELECTION PROCESS



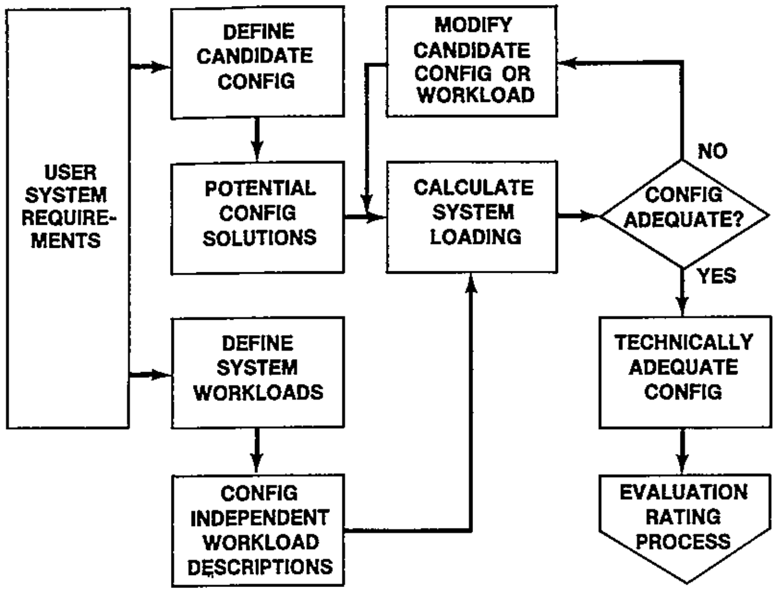
NASA-S-78-17004

OUTLINE

1. INTRODUCTION
2. CONFIGURATION ADEQUACY
3. EVALUATION RATING
4. SUMMARY

NASA-S-78-17005

STEP I
CONFIGURATION ADEQUACY



NASA-S-78-17006

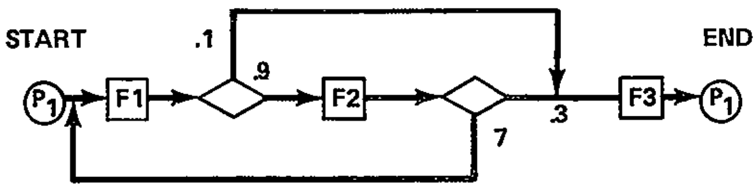
WORKLOAD DEFINITION EXAMPLE

FUNCTION	RESOURCE DEFINITION VARIABLES	
CLASSIFICATION	CPU.	608 000 + (NO. FIELDS) x (45 000 + (NO SUBCLASSES) x (42 500 + (NO. CHANNELS) x 2500))
	MEMORY	16 700 + 80 x (NO. FIELDS)
	I/0:	46 250 + 22 932 x (NO. CHANNELS) + 240 x (NO. SUBCLASSES) + (NO. FIELDS) x (20 x (NO. SUB-CLASSES))

NASA-S-78-17007

WORKLOAD DEFINITION EXAMPLE

PROCESS 1 – CLUSTERING ALGORITHM RESEARCH



BENCHMARK A (PEAK LOAD)

$2P_1 + 8P_3 + 21P_4 + 6P_8 + \ldots$

BENCHMARK B (AVERAGE LOAD)

$P_1 + 3P_2 + 6P_3 + 15P_5 + \ldots$

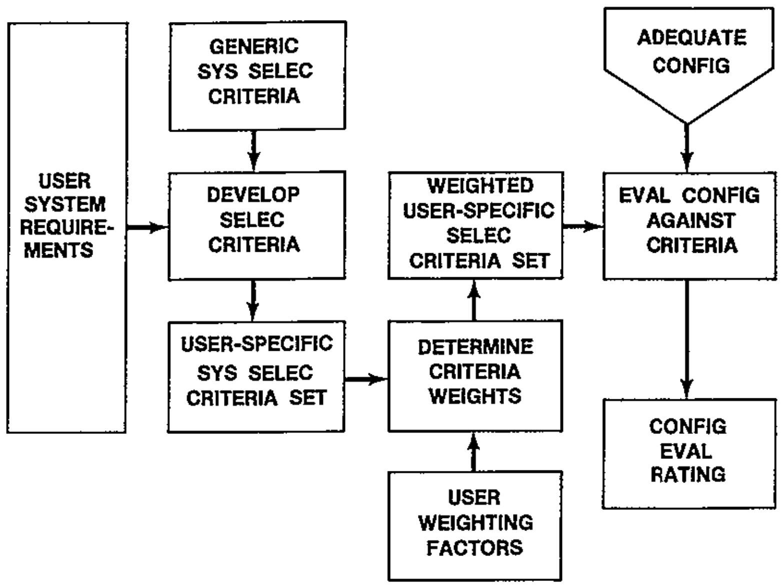
NASA-S-78-17008

OUTLINE

1. INTRODUCTION
2. CONFIGURATION ADEQUACY
3. ➧ EVALUATION RATING
4. SUMMARY

NASA-S-78-17009

STEP II
EVALUATION RATING



NASA-S-78-17010

USER-SPECIFIC SELECTION CRITERIA FOR AN EARTH RESOURCES DATA SYSTEM

FOR EACH TECHNICALLY ADEQUATE CONFIG EVALUATE:

- COST
  - INITIAL DEV COSTS (NONRECURRING)
  - OPS COSTS (RECURRING – 10-YR LIFE CYCLE)
  - CONFIG FLEXIBILITY
- EXPERIMENTAL FLEXIBILITY
  - NEW TECHNIQUE/TECHNOLOGY EVAL FLEXIBILITY
  - EASE OF TECHNOLOGY ACCESS
- TECHNOLOGY TRANSFER
  - RELEVANCE TO USER REQS
  - TRANSITION AND OPS COSTS
  - SUPPORT TECH TO AID NEW USER
- CONFIGURATION USABILITY
  - USER PRODUCTIVITY
  - EVOLUTIONARY DEV CAPABILITY
  - OPS ACCEPTABILITY
- SCHEDULES
  - TIMELY DEV SUPPORT
  - PLANABLE CONFIG EXPANSION

NASA-S-78-17011

EXAMPLE

CRITERIA CATEGORIES FOR EARTH RESOURCES DATA SYSTEMS

CRITERIA CATEGORY	WEIGHT, PERCENT
1. COST (10-YR LIFE CYCLE)	50
2. INTERACTIVE SUPPORT CAPABILITIES	20
• OVERALL SYSTEM ARCHITECTURE	40
• EXPANDABILITY	20
• AVAILABILITY/MAINTAINABILITY	40
3. GENERAL SUPPORT CAPABILITIES	30
• OPERATIONAL MANAGEMENT AND FLEXIBILITY	50
• EXPANDABILITY	30
• TRANSPORTABILITY OF TECHNOLOGY	20

NASA-S-78-17012

EXAMPLE OF CRITERION RATING

CRITERION	WEIGHT, PERCENT	RATING
GENERAL SUPPORT CAPABILITIES	30	
• OPERATIONAL MANAGEMENT AND FLEXIBILITY	50	
A. EXPERIMENTAL FLEXIBILITY	25	
– SUPPORT HIGH-LEVEL LANGUAGES		9
– EASY ADDITION OF NEW PROGRAMS		5
– TRANSFER PROGRAMS/DATA TO/ FROM REMOTE LOCATIONS		2
– EASE CREATION OF NEW DATA SETS		8
– REMOTE SOURCE CODE EDITION		5
– REMOTE JOB INITIATION		5
– SUPPORT MULTI-USERS SIMUL- TANEOUSLY		8
– TERMINAL CONTROL PROGRAM		
B		
.		
.		

NASA-S-78-17013

OUTLINE

1. INTRODUCTION
2. CONFIGURATION ADEQUACY
3. EVALUATION RATING
4. SUMMARY

NASA-S-78-17014

SUMMARY

CURRENT STATUS

- CONCEPTS DEFINED
- VALIDATION IN PROCESS
- INVESTIGATING WEAK AREAS

NASA-S-78-17015

SUMMARY

CONCLUSIONS

- FORMALIZATION OF THE COMPUTER SYSTEM SELECTION PROCESS IS FEASIBLE
- NASA MAY USE THE MODEL TO EVALUATE CONFIGURATIONS PROPOSED BY VARIOUS VENDORS
- VENDORS MAY USE THE MODEL TO HELP DETERMINE THE BEST SYSTEM TO PROPOSE
- COMPUTER IMPLEMENTATION OF THE MODEL IN A LANGUAGE SUCH AS APL IS A RELATIVELY SIMPLE TASK